

Assessment of BEP Action Points 3 (Interim Stage)

Summary of Assessment Report

Issue date of Assessment Report: 16 December 2016

Background

Radioactive Waste Management Limited (RWM), formerly NDA¹ Radioactive Waste Management Directorate, has undertaken an assessment of the submission by the Sellafield Ltd (SL) Box Encapsulation Plant (BEP) project, to address 19 of the outstanding Action Points arising from the reports below:

1. Packaging of Sellafield Legacy MBGW² at the Box Encapsulation Plant³ (completed in 2013);
2. Ponds Solids Legacy Isotope Cartridges: Encapsulation, CVD⁴ and Pre-treatment Options⁵ (completed in 2013), arising from the Solid Treatment Plant Technical Underpinning Project (STPTUP);
3. Interim stage assessment of Action Points Part 2⁶, arising from 1 and 2 above.

The Action Points addressed within this report exist across a range of maturities i.e. Conceptual, Interim and Final stages. Of the 19 Action Points submitted; 15 arose from the BEP assessment, one Action Point arose from the STPTUP assessment and three Action Points arose from the Action Points Part 2 assessment.

RWM Reference Basis for Assessment and Endorsement

The Disposability Assessment process considers the compatibility of the proposed packages with the requirements for safe long-term management, including interim storage at the site of arising, transport, emplacement and potentially extended storage underground, and disposal. The current reference basis for such an assessment is the documented disposal system concept and safety case for a Geological Disposal Facility (GDF) derived from the generic Disposal System Safety Case (DSSC).

The general requirements placed on waste packages for disposal in a GDF are embodied in the Generic Waste Package Specification (GWPS)⁷. Further

¹ Nuclear Decommissioning Authority.

² Miscellaneous Beta Gamma Waste.

³ NDA, *Packaging of Sellafield Legacy MBGW at the Box Encapsulation Plant (Conceptual stage)*, NXA/18760019, (RWM document reference LL/18760019).

⁴ Cold Vacuum Drying.

⁵ NDA, *Ponds Solids Legacy Isotope cartridges: Encapsulation, CVD and Pre-treatment Options (Conceptual stage)*, NXA/19504022, (RWM document reference LL/19504022).

⁶ RWM, *Assessment of BEP Interim Stage Action Points (Part 2)*, NXA/23789427, Issue 1, November 2015 (RWM document reference LL/23789427).

⁷ NDA, *Generic Waste Package Specification*, NDA Report NDA/RWMD/067, March 2012.

requirements for particular types of waste package are embodied in the relevant Waste Package Specification (WPS)⁸.

Scope of the Assessment

The assessment is limited to SL responses to Action Points B13/009, B13/013, B13/014, B13/015, B13/016, B13/018, B13/022, B13/023, B13/027, B13/032, B13/036, B13/040, B13/042, B13/043, B13/045, B13/059, B15/043, B15/044, B15/046 and the review of the report on the '*Management of the Effect of Gas Generation from Waste on the Formation of Wormholes in Grout*'⁹ hereafter referred to as the Wormholes report. It is understood that if the gas generation rate of a grouted wasteform is sufficiently high during setting, then permanently open gas release channels, known as wormholes, may form.

In addition Action Point B12/009 was assessed. RWM took the opportunity to assess Action Point B12/009, although not formally requested, because it is encompassed within the requirements of Action Point B13/023. It is important to note that Action Point B13/023 and Action Point B12/009 are based on 'opportunistic feeds' to BEP. These have been assessed at a summary level because it is recognised that SL will make a separate formal submission for these wastes should they become part of the baseline feed for BEP.

The assessment seeks to:

- assess progress against the 19 BEP related Action Points and the encompassed Action Point B12/009, with a view to their closure or to identify any additional requirements to support their resolution;
- conduct a review of the Wormholes report⁹.

Consideration has been given to the compatibility of the proposed packages with the requirements for safe long-term management including storage, transport, emplacement and extended storage underground, and disposal in a GDF. Further information on the Disposability Assessment process is available elsewhere¹⁰. A complete Assessment of Disposability has not been prepared at this time, but will be provided once all Action Points associated with the Interim Letter of Compliance (iLoC) stage have been addressed.

Description and Origin of the Waste

The waste feeds addressed by the two previous Conceptual stage assessments are MBGW which originate from the Magnox Swarf Storage Silo (MSSS), the First Generation Magnox Storage Pond (FGMSP), the Pile Fuel Storage Pond (PFSP), the Solid Waste Storage Cells (SWSC), together with any sludge carried over with these wastes. Plant operational wastes arising from MSSS, SWSC and BEP are also considered.

The MBGW comprises of 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 clean-up 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.

⁸ NDA, *Waste Package Specification for corner-lifting variants of the 3 cubic metre box waste package*, July 2014, WPS/315/05.

⁹ Cridge, J., *Desktop Study Management of the Effect of Gas Generation from Waste on the Formation of Wormholes in Grout*, RP_BEP-B873_Tech_00199_C, July 2015 (RWM document reference LL/24258153).

¹⁰ NDA, *Waste Package Specification and Guidance Documentation: WPS/650 Guide to the Letter of Compliance Assessment Process*, WPS/650/03, April 2014.

The waste addressed by these proposals consists of the following, which includes details of the waste stream identifiers relevant to the 2013 UKRWI.

Baseline Wastes:

- MBGW from the Magnox Swarf Storage Silos (MSSS) Compartments 4,6,7,8,9,10,12 and 15. These form part of the waste streams 2D08, 2D09 and 2D25;
- Oxide fuel hulls from MSSS Compartment 11 (referred to as MSSS C11). Waste stream 2F31;
- MBGW from MSSS Void Space. Waste stream 2D73;
- Zeolite Skips from the First Generation Magnox Storage Pond (FGMSP). Waste stream 2D96.4 (Ion Exchange Material in Skips (AW500)), previously 2D13;
- Ionsiv Cartridges from the Pile Fuel Storage Pond (PFSP). Waste stream 2D74 (PFSP Ion Exchange Material);
- MBGW from FGMSP. Waste stream 2D96.1 (FGMSP Bay Solid Waste to BEP), previously 2D14;
- MBGW from PFSP. Waste stream 2D12 (Miscellaneous Solid Waste in Ponds and Bays);
- Isotope Cartridges from FGMSP and PFSP. These form part of waste streams 2D12 and 2D96.1 (FGMSP Bay Solid Waste to BEP), previously 2D14;
- MBGW from the Solid Waste Storage Cells (SWSC). Waste stream 2D21;
- Sludge from MSSS. This forms part of the waste streams 2D08 and 2D09;
- Sludge from PFSP. This forms waste stream 2D11;
- Sludge from FGMSP. This forms waste stream 2D95.1, previously 2D16.

Opportunistic/Non-baseline Wastes:

- Uranium fuel bit bins, cemented from FGMSP. Waste stream 2D96.2 (FGMSP Pond Solid Waste to BEP), previously 2D17. This excludes uncemented uranium fuel bit bins;
- Tokai Mura End Crops (TMECs) in bins, cemented and uncemented, from FGMSP. These form part of 2D45, previously part of 2D59;
- Uranium fuel bit bins from the Fuel Handling Plant (FHP). These form part of waste stream 2D45.

Packaging Proposals

The proposals for waste package production are based upon the loading of wastes into 3m³ box waste containers, followed by infiltration using a fluid cementitious grout based on Ground Granulated Blast Furnace Slag (GGBS)/Ordinary Portland Cement (OPC).

The proposed waste container is based on a corner lifting variant of the 3m³ box waste package design⁸, incorporating a liner/skip, which results in the formation of an annulus surrounding the wasteform when the package is completed. The 3m³ stainless steel box would be lidded and decontaminated. The annulus would remain unfilled during interim storage at the Sellafield site, to accommodate the potential for wasteform expansion. The waste package annulus would be grouted prior to the transport from the Sellafield site to a GDF. The current proposed operational date of a GDF is 2040.

Wherever possible, aluminium nitride (AlN) and Atomic Material (AM) isotope cartridges, irradiated in the Windscale Piles and subsequently stored in the legacy ponds, are to be identified, and then separated from other types of isotope cartridge for pre-treatment prior to packaging.

SL proposes to extract the C-14 in AlN cartridges using a thermal process, producing CO₂, which would be converted to a low solubility, thermally stable, barium carbonate. The barium carbonate would then be incorporated into the cementitious BEP wasteform.

AM cartridges would be loaded into stainless steel Post Irradiation Examination (PIE) bottles and sealed to prevent the escape of tritium from the waste during transport. The PIE bottles would be incorporated directly into the BEP wasteform.

Assessment of Action Points

The status of the Action Points following completion of this Assessment is presented in the following table.

Current status of the Action Points

| Number | Description | Status |
|----------------|--|---------------|
| B13/009 | Provide a radionuclide fingerprint(s) for irradiated fuel assembly materials in MSSS C11, taking into account alloying elements and impurities, to facilitate iLoC assessment. (Interim) | OPEN |
| B13/013 | Confirm extent of waste treatment at donor plants, and what residual treatment processes are needed at BEP. (Interim) | CLOSED |
| B13/014 | If SWSC wastes are to be treated at SWSC, improve historical proposals to propose how particulate wastes will be treated to ensure radionuclides can be adequately immobilised. (Conceptual) | CLOSED |
| B13/015 | Define WRATs, and then develop the waste inspection processes to be used to identify and segregate WRATs and waste items/types that may need to be treated, controlled or segregated. Specify and justify WRAT definitions and identification methods for the range of waste feeds to BEP, paying particular attention to: <ul style="list-style-type: none"> • accumulations of particulates, including in filters; • voidage in enclosed items and in hard to infiltrate materials; • sludge; • aqueous and non-aqueous liquids. (Interim) | CLOSED |
| B13/016 | Specify and justify WRAT treatments and demonstrate the extent of waste solidification and immobilisation that will be achieved. (Interim) | CLOSED |
| B13/018 | Define the grout encapsulant, wasteform production methods and the design of liner furniture, and show that BEP can successfully solidify and immobilise the range of waste feeds. (Interim) | CLOSED |

| Number | Description | Status |
|----------------|--|--|
| B13/022 | Define and justify the formulation envelopes for the box annulus and show that the annulus can be manufactured. (Interim) | CLOSED |
| B13/023 | Estimate, with justification, the extent of uranium corrosion in cemented bit bins and TMEC bins. Address Action Point B12/009, raised in advice to STPTUP, if significant residual uranium is expected. (Interim) | CLOSED |
| B12/009 | Provide evidence to demonstrate a suitable understanding of the extent and effects of corrosion. Justify the maximum wasteform expansion and maximum rate of gas production from a package. (Conceptual) | CLOSED |
| B13/027 | Provide evidence to demonstrate that (zeolite) skips are likely to drain potentially mobile free liquids, and propose measures to demonstrate success during the packaging process. (Interim) | CLOSED |
| B13/032 | Confirm the materials of construction for the liner and furniture, taking account of necessary performance requirements. (Interim) | CLOSED |
| B13/036 | Develop an appropriate draft 'package record' system, based on the requirements in WPS/400, including how and where donor plant waste information and information on the design of the box, liner and furniture will be recorded. (Interim) | CLOSED |
| B13/040 | Develop a package inspection and monitoring protocol, considering the benefits of monitoring the space between the box and liner. (Interim) | CLOSED |
| B13/042 | Supply draft documentation to allow a review of the expected Quality Management System for donor plants and BEP. The following documents and information should be provided in the Interim stage submission: <ul style="list-style-type: none"> • a draft WPrS(s); • a draft quality plans for donor plant waste treatment processes and the BEP treatment and packaging processes; • a draft procedure for the identification, assessment and disposition of any nonconforming product; • a draft CCAD(s), detailing the packaging strategy and explaining how SFMs would be generated. (Interim) | CLOSED |
| B13/043 | Describe outline management arrangements for delayed package completion. (Interim) | DEFERRED to Final stage Action Point |

| Number | Description | Status |
|----------------|--|---------------|
| B13/045 | The proposal to entomb Zeolite skips and Ionsiv cartridges is novel, but does not represent best practice. 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. (Conceptual) | CLOSED |
| B13/059 | Revise the radionuclide inventory to take account of expected sludge and liquor carry over. Create appropriate fingerprints for this waste. (Interim) | CLOSED |
| B15/043 | Define the process arrangements for the management of asymmetric loading of large bulky waste items. (Final) | CLOSED |
| B15/044 | Provide a final approved drawing of the package support frame for Zeolite skips and Ionsiv cartridges and a short qualification that this will not adversely affect the assessed Impact Accident Performance. (Final) | CLOSED |
| B15/046 | Confirm that EURATOM and/or ONR have been engaged regarding the Safeguards arrangements for BEP waste packages. (Final) | CLOSED |

As a result of this assessment, Action Point B13/009 remains open, as sufficient evidence has not been supplied to satisfy the requirements of the Action Point. In addition, some new issues have emerged and additional Action Points have been placed, one at Interim stage and four at Final stage.

The Interim stage Action Point B16/007 has arisen through the closure of Action Point B13/023; the scope of which is associated with expansive corrosion and gas production from uranium fuel bit bins and TMECs in bins. Currently, these wastes are not included in the BEP treatment baseline and are considered 'opportunistic wastes'. If these opportunistic wastes were to be incorporated into the treatment baseline then, Action Point B16/007 would need to be addressed.

The five additional Action Points which have been raised by this Assessment are presented in the following table.

New Action Points raised by this Assessment.

| Number | Description | Stage |
|----------------|---|---------|
| B16/007 | Detail the requirements which underpin the maximum rate of gas generation from the encapsulation of uranium fuel bit bins and TMECs in bins, with particular focus on the rate of production of C-14. (Interim) | Interim |
| B16/008 | Establish a threat/risk based CM&I methodology for BEP waste packages, including how the space between the box and liner would be monitored and how wasteform evolution and ageing effects of the container would be addressed. (Final) | Final |
| B16/009 | Provide a coherent suite of, Sellafield approved, Management System documents covering the entire management of wastes within the BEP process accounting for comments made by RWM. (Final) | Final |

| Number | Description | Stage |
|----------------|---|-------|
| B16/010 | Describe outline management arrangements for delayed package completion. (Final) | Final |
| B16/011 | Provide a Management System document for BEP packaging operations for review by RWM, in order to demonstrate how the 4% weight distribution within the container will be managed. (Final) | Final |

In addition RWM has reviewed the '*Management of the Effect of Gas Generation from Waste on the Formation of Wormholes in Grout*⁹' report and concluded that the presence of wormholes in the cap of the BEP waste packages would not adversely affect package performance based on the multiple barrier disposal concept for a GDF.

Conclusions

The current assessment has considered the third of the proposed batches of responses to the outstanding Action Points and the review of the '*Desktop Study Management of the Effect of Gas Generation from Waste on the Formation of Wormholes in Grout*' report. This third batch encompasses 19 outstanding Action Points that arose from three separate assessments below:

1. the original BEP Conceptual stage assessment³;
2. the subsequent assessment which focused on the management of specific challenging wastes, denoted by the STPTUP assessment⁵ and
3. the Interim stage assessment of Action Points Part 2⁶ (arising from 1 and 2 above).

SL is continuing to engage with RWM, seeking to close out the outstanding Interim stage issues related to the proposed packaging of wastes in the Box Encapsulation Plant at Sellafield. A complete Assessment of Disposability has not been prepared at this time, but will be provided once all Action Points associated with the Interim Letter of Compliance (iLoC) stage have been addressed.

Action Points

On the basis of the current assessment of the Action Points RWM concludes:

- 18 Action Points can be closed (including one deferred to Final stage i.e. Action Point B13/043).
- In addition Action Point B12/009 can be closed (although this was not formally part of the submission).
- One Action Point (B13/009) remains open.
- Five additional Action Points have been placed. Four at Final stage and one at Interim stage (which is associated with opportunistic wastes).

The Wormholes report

On the basis of the review of the Wormholes report, RWM concludes:

- the presence of wormholes in the cap of the BEP waste packages would not adversely affect package performance based on the multiple barrier disposal concept for a GDF.

Data Recording

It is recognised that the task to define and produce the appropriate records for such diverse wastes is complex and that development of the system is still ongoing. SL has recognised this and stated that further draft documents would be produced prior

to the system being finalised. RWM encourages SL to interact on the proposals as they develop, even in draft form.

It is recommended that the proposals (documents) are revised prior to Final stage to align with the most current specification and guidance (currently WPS/400/03 and WPS/850/03 respectively); this should include recognition and provision of a Disposability Record Specification (DRS), or similar, which takes account of all information to be retained, not just package-scale data.

Re-issue of cLoC

The closure of Conceptual stage Action Point B13/045 satisfies RWM that the following exclusions may be removed from the Conceptual stage LoC for packaging of MBGW through BEP at Sellafield¹¹ and the cLoC re-issued (updated to cLoC Issue 4):

- QFN/B/017 – Zeolite skips – exclusion removed from cLoC;
- QFN/B/018 – Ionsiv cartridges – exclusion removed from cLoC.

¹¹ RWM, *Conceptual Stage Letter of Compliance for Packaging MBGW through the Box Encapsulation Plant (BEP) at Sellafield – Issue 3*, LOC/24963110, June 2016 (RWM document reference LL/24963110).