

Encapsulation of RIPPLE X and Large Sources

(Final stage)

Summary of Assessment Report

Issue date of Assessment Report: 12 April 2013

Introduction

Research Sites Restoration Ltd (RSRL) has requested a Final stage Letter of Compliance for the grout encapsulation of 19 discrete sealed sources into three 3m³ boxes^[1]. This Assessment Report provides the basis and findings of the Final stage disposability assessment performed by NDA Radioactive Waste Management Directorate (RWMD). 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. 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 elsewhere ^[2].

Scope

Harwell stores a number of sealed sources (including the RIPPLE^[3] X generator as well as teletherapy and other radiotherapy units) which contain high activity levels of Cs-137, Sr-90 or Co-60. The waste to be packaged comprises 19 discrete sealed sources, contained within the original shielded transport packages.

The following wastes are encompassed by this assessment:

RIPPLE X



The RIPPLE X generator, which is slightly too large to fit in a 500 litre drum, is part of the 5C33 wastestream (Harwell Contact Handled ILW, 2010 UK Radioactive Waste Inventory). The RIPPLE generator project was established in 1963 by the Applied Physics Division of the UKAEA Atomic Energy Research Establishment (Harwell), to produce thermoelectric generators suitable for uses such as powering navigation buoy lights and radio-direction equipment.

RIPPLE X is of a completely unique design and represented the first of a second-generation of generators, which never progressed beyond the one

¹ B Williams and E Hunter, *Final stage Letter of Compliance Submission for RIPPLE X and Large sources*, May 2012 (NDA Document Reference LL16534641)

² NDA, *Guide to the Letter of Compliance Process*, NDA Document WPS/650, March 2008

³ RIPPLE is understood to be an acronym of Radioactive Isotope Powered Pulse Light Equipment.

unit. The generator has a mass of 1500kg and consists of twelve individual sealed sources of Sr90, in the form of strontium titanate pellets, encapsulated within high integrity, hermetically sealed containers.

Large Sources

The National Disposal Service (NDS) collected unwanted sources from UK minor waste producers for transfer to Harwell for management. Eighteen of these sources are included in the current packaging proposal, and are understood to be part of the 6C31 wastestream (NDS Contact Handled ILW, 2010 UK Radioactive Waste Inventory). The radioactive nature of the sources is believed to be Co60, Cs137 and Sr90, but the chemical nature of the source material itself is not known. The shielding around the sources may be steel, lead or depleted uranium (DU). For some sources, the shielding material is not recorded.

The sources themselves are stored within their transport packaging, although their certification is now “out of date”. Each source transport container is different in design. Due to the origin of these sources, detailed design drawings of the source containers are not available. Examples of some of the sources are shown below.



Available information is often limited to the source activity, and measurable physical quantities such as mass and dimensions. In one case, no information is available on the radionuclide inventory of the waste. The mass of each source within its individual transport packaging ranges between 88 and 1536kg. Source activities at 2011 are believed to range between 3MBq Co-60 and 520TBq Sr-90.

Waste packaging proposal

RSRL has obtained three side-lifting 3m³ boxes that were originally manufactured in 2004 for Berkeley power station. RSRL intends to package the RIPPLE X generator and the Large Sources into these boxes without the removal of shielding, by wrapping the sources in sacrificial harnesses and lifting them into a 3m³ box. The 3m³ box would then be filled with 3:1 Pulverised Fuel Ash/Ordinary Portland Cement (with a water to solids ratio of 0.42) using a mobile grouting plant. The completed package would be wrapped in protective non-chloride plastic sheeting to minimise surface contamination with chloride and transported to the Transfer Area for storage.

Parameters for Assessment of Disposability

Assessment Inventories

Assessment inventories for the proposed packages have been generated based on the information provided in the submission. There is some uncertainty regarding this information (e.g. the radionuclide inventory for large source ‘NDS find 3/4’ is unknown), see key issues section below.

Waste Package Properties and Performance

The 3m³ box design is considered likely to meet RWMD requirements, but there is some uncertainty regarding the details of the design, see key issues section below.

The long term performance of the wasteform could be affected by the corrosive expansion of uranium metal. This could affect the package dimensions and the performance in impact accident scenarios. Impact release fractions have been generated on the assumption that uranium metal within the waste would either be pre-treated e.g. by individual encapsulation in epoxy resin, or otherwise be shown to be robust e.g. by proving the thickness of the mild steel outer layer using non-destructive examination techniques.

Compatibility with Specifications

The current packaging proposal meets or could be shown to be compatible with many areas of the RWMD specifications. Further information is needed on Quality management, Waste package data and information recording, Criticality safety, Properties of Wasteform, Package Integrity and Stackability. These areas are discussed further in the key issues section below.

Assessment of Disposability

Transport Safety Assessment

The assessments of Transport Safety show that it should be possible for packages containing RIPPLE X and Large Sources to comply with all relevant criteria if transported in the SWTC-70, subject to the following restrictions:

- Items where the inventory is unknown (e.g. NDS find 3/4) should be excluded from the package.
- RSRL must ensure that the dose rate at 1 metre from the surface of an SWTC transport package is less than 0.1 mSv^h⁻¹ (If necessary, a transport container with greater shielding (e.g. SWTC-285) could be used to minimise dose rates.)

Operational Safety Assessment

The impact, fire and contamination re-suspension accident performance of this waste/container combination is acceptable, with the worst case doses (for fire accidents) being well below the most stringent BSLs. Radioactive gas generation is insignificant and there are no chemotoxicity issues associated with the waste.

Doses to operators during normal operations appear to be acceptable when considered in isolation, but will need to be considered in conjunction with other wastes and operations that may be required during the period of their emplacement in a GDF. Additional dose reduction measures could be considered for the waste package vault emplacement operations to demonstrate that routine worker doses will be ALARP.

Compliance gaps have been raised regarding waste containing uranium metal and waste where the inventory is unknown, see key issues section below.

Post-closure Safety Assessment

The potential significance of the proposed packages has been assessed by comparison with the baseline total inventory of waste to be disposed of as UILW. The assessment of GDF Post-closure Safety shows that, assuming there are no significant changes to the assessment inventory, packages containing RIPPLE X and Large Sources would have a negligible effect on the Environmental Safety Cases for the GDF.

Key issues

The key areas preventing final stage endorsement are summarised below:

Expansive corrosion of Large Sources containing depleted uranium

The shielding material used in some of the source transport packaging is uranium metal. Uranium metal is known to almost double in volume when it corrodes. If the outer mild steel shell of the source is damaged, the uranium metal shielding could undergo expansive corrosion. Expansive corrosion of the waste could cause the package to bulge.

Appropriate measures should be taken to ensure that expansive corrosion of the waste will not occur during interim storage, transport or GDF operations. There are various avenues that RSRL could pursue to mitigate the risk of wastefrom expansion:

- 1) Show that the outer steel shell of sources containing uranium metal is thick enough to prevent exposure of uranium metal to water vapour over a 150 year time period.
- 2) Pursue the use of 'non-encapsulation' for Large Sources containing uranium metal using inert void-fill material (e.g. sand).
- 3) Pre-treat Large Sources containing uranium metal by entombment in epoxy resin to prevent water ingress.
- 4) Design the package to allow for expansion of Large Sources containing uranium metal, e.g. leave suitable voidage around the waste item.

RSRL may come up with alternative solutions to this problem, and RWMD would be pleased to discuss their suitability.

Uncertainty about the nature and quantity of the Large Sources (NDS) waste

For the Large Sources waste, the radionuclide inventory information originated from NDS disposal records. The reliability of the NDS records is unknown. Questions exist regarding the purity of the source material prior to irradiation. Impure source material could lead to other radionuclides being present in the source. Based on our current understanding of the waste, it is deemed unlikely that impurities within the radioactive source material would have a significant impact on the transport, operations or post closure safety case. Further information would be helpful to support this assumption.



For one waste item, NDS Find 3/4, no history is available beyond the fact that it came to Harwell via NDS. Although NDS Find 3/4 is likely to be a source transport package containing a nuclide such as Co-60, Cs-137 or Sr-90, there is a risk that the container has fissile material inside. This risk affects the ability to show compliance with the criticality safety case. RWMD

recommends that this item is excluded from packaging proposals until further information is available on its radionuclide inventory.

Uncertainty about the 3m³ box design, materials of manufacture and cleanliness

No manufacturing drawings are included in the box quality records, although a reference is given to drawing number 20-03-09-002 Issue J. RSRL is understood to be attempting to obtain this drawing, which should confirm the box design and materials of manufacture.

The three boxes have been moved from Qualter Hall to Harwell, putting the boxes at risk of chloride contamination during transport. RSRL should perform a cleanliness check on the each box before use, including checking the base and the inside of the box. If chloride levels are above 10µgcm⁻², the box should be cleaned before use to reduce the risk of corrosion.

Management systems and package records

RSRL needs to state the data (and its provenance) that would be included in the Package Record set, and finalise the plans for long term management and storage. RSRL also needs to confirm how data generated during storage (e.g. transient environmental conditions, records of visual inspection) would be included in the Package Record.

RWMD requires the waste packager to establish, implement and maintain a formal and effective Quality Management System (QMS) with the objective of assuring the quality of both the waste package and the associated data records. RSRL needs to provide the following documents and information:

- A WPrS covering the three proposed boxes;
- a quality plan or similar for the packaging process, including any Work Instructions that could affect the package or the records. This should cover RIPPLE X terminal isolation, distribution of load, wasteform production, lidding, cleaning, package storage conditions and corrosion checking.

Conclusions

The proposed encapsulation of RIPPLE X and Large Sources waste to produce disposable packages has been assessed. It is concluded that packages containing RIPPLE X and Large Sources waste are currently not consistent with disposal under the geological disposal concept. Further evidence is required to support a final stage LoC. Ten Action Points have been raised, to be resolved at the Final assessment stage.