

Harwell LETP Waste Packages (Periodic Review)

Summary of Assessment Report

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Background

NDA Radioactive Waste Management Directorate (RWMD) has undertaken a Periodic Review of the existing Final stage endorsements for waste packages containing the liquors and sludge that arose from the operations of the Liquid Effluent Treatment Plant (LETP) at the Harwell site. For both the liquors and the sludge, the waste packages are based on the immobilisation of the wastes within a cemented wasteform in stainless steel 500 litre drums. It is understood that the packaging of these bulk wastes is now complete. It is understood that further operations may be required to package the small 'heels' remaining in the tanks.

The packaging of liquor and sludge from the Harwell LETP has been the subject of numerous interactions between RSRL (and its predecessor UKAEA) and both RWMD and its predecessor Nirex. These interactions culminated in endorsement through the issue of a number of Final stage Letters of Compliance (LoC) covering both types of wastes.

The Periodic Review of an existing Final stage LoC, both during and after packaging plant operation but prior to availability of geological disposal, is carried-out to maintain the currency of the endorsement in light of the continued evolution of RWMD safety cases and concepts. A Periodic Review also presents an opportunity for a detailed review of the status of waste package records and the ongoing management of completed waste packages. The reader is directed to published guidance for a more complete description of the Disposability Assessment process and Periodic Review^{1,2}.

Packaging of the Harwell LETP wastes has now been completed and the earliest of the Final stage LoCs is approximately ten years old. Furthermore, the earlier LoCs were provided prior to the adoption of the current requirement that all endorsements should be supported by a formal Assessment of Disposability to record the basis of the endorsement. Consequently, it has been determined that the existing endorsements should be subject to Periodic Review both to confirm the continued validity of those endorsements and to place on record a formal Assessment of Disposability.

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

² NDA, *Guidance on the Scope of Periodic Review of Final Stage Letters of Compliance*, NDA Document WPS/909, January 2009.

RWMD Reference Basis for Assessment and Endorsement

Periodic Review follows the process employed for Disposability Assessment, which considers the compatibility of the proposed packages with the requirements for safe long-term management, including storage, 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)¹.

The general requirements placed on ILW packages for disposal in a GDF are embodied in the Generic Waste Package Specification (GWPS)³. Further requirements for particular types of waste package are embodied in the relevant Waste Package Specification (WPS). In the case of the LETP waste packages, the relevant WPS is that for packages based on 500 litre drums.

Scope of the Assessment

This Periodic Review encompasses the existing packages containing immobilised liquor (waste stream 5C18/C) and sludge that require geological disposal. In both cases, these packages represent the fraction of the total that was not suitable for disposal at the LLW Repository (LLWR). In the case of sludge, it was originally intended that all packages would be consigned to LLWR and belatedly it was recognised that a small fraction would not be acceptable. RSRL has indicated that it will re-instate a Radioactive Waste Inventory waste stream to cover this fraction of the sludge packages now intended for geological disposal.

Recognising that packaging operations have now been completed, the scope of this Periodic Review may be summarised as follows:

- review and, as necessary revision or production, of the Assessment of Disposability for the wastes in light of the evolution of the GDF design, safety assessments and associated documents, and the evolving expectations of regulators;
- review of actual plant performance against the original proposals as endorsed at Final stage to confirm that the scope of the LoCs cover the packages actually produced;
- consideration of any necessary extensions to existing endorsements, including development of an extended Assessment of Disposability;
- review of any qualifications applying to the LoCs (conditions, restrictions and caveats);
- confirmation that waste package records have been completed satisfactorily and that arrangements for the preservation of such records are in place;
- review of the condition of stored waste packages, including continuing confirmation of ongoing arrangements for monitoring of the storage environment and the condition of the waste packages;
- review of the Management System applying to the continued maintenance of the waste packages and the associated records, including review of outstanding findings from previous Technical Audits.

³ NDA, *Generic Waste Package Specification*, NDA Report NDA/RWMD/067, March 2012.

The ultimate intention of a Periodic Review is the re-issue of the existing Letters of Compliance to confirm that the waste packages are consistent with current expectations. In the event that significant shortcomings are identified, this re-endorsement would remain under review and resolution of the outstanding issues (identified as Compliance Gaps in this report) would be sought through engagement.

Submitted Information

RSRL has submitted extensive documentation relating to the LETP waste packages, although this information has not been presented as a single coherent set of documents. Nevertheless, the submitted information is summarised as follows:

- compilation of relevant information and documents as an explicit submission (provided for liquors but not sludge);
- provision of example Package Data Record Sheets (PDSR) for manufactured packages;
- provision of additional information obtained during the packaging of the wastes;
- provision of specific additional data and spreadsheets on an *ad hoc* basis, typically at the request of RWMD in light of individual queries;
- identification and/or supply of historic documents, including previous submissions and interactions with Nirex/RWMD, and supporting research and development;
- evidence of audit and management of audit actions, including management system and records documents obtained and reviewed through audits;
- provision of Management System documents, including selected controlling documents for the packaging process and other ancillary systems and activities;
- other documents: Waste Product Specifications (WPrS), Criticality Compliance Assurance Documents (CCAD) and, for information, Radioactive Waste Management Cases (RWMC).

Where appropriate, the assessment has also used previously-submitted documents, for example the development work provided in support of the original assessments of the liquors and sludge packaging proposals.

Packaging Process

Nature of the Waste

The liquors arose from the treatment of effluents at the Harwell site and were held in four storage tanks (denoted Tanks 3.1-3.4) at the LETP. The liquors were collected since the early 1960s and mainly arose from early fuel reprocessing development, the fast reactor programme and a range of radiochemical studies. Most of the active component was due to the presence of natural or depleted uranium and thorium nitrates in a nitric acid solution, but there were also quantities of other actinides, uranium and thorium progeny, some fission products, Co-60 and tritium.

The sludge arose from the floc treatment of lower activity effluents that were too active for direct inclusion in the Harwell low-level effluent stream. Accumulation of the sludge commenced in 1982, when sea disposal of packaged waste ceased, and continued until 1990. The solids content of the sludge was dominated by calcium phosphate and iron hydroxide flocs, and it was not acidic. In common with the

liquors, the radiochemical composition of the sludge was dominated by uranium and other actinides, with Cs-137 also present.

Waste Processing and Packaging

The liquors have been pre-treated by neutralisation using calcium hydroxide in proportion to the measured acidity of the individual batches of liquor. The neutralised liquor was then immobilised in a 3:1 BFS/OPC cementitious matrix in 500 litre stainless steel drums using in-drum mixing. The encapsulated waste was capped with an inactive grout based on 3:1 PFA/OPC.

The sludge was directly immobilised by in-drum mixing without neutralisation, then capped in the same manner as the liquors.

The stainless steel 500 litre drums were either provided with additional internal shielding (a steel liner and cement annulus) or used in the original unshielded configuration. The former design provided the additional shielding required for on-site handling and operations involving the relatively higher activity wastes. Shielded containers were used for about half of the liquor packages, the remainder and all the sludge packages being based on unshielded containers.

After a period of temporary storage at the LETP, the completed waste packages are now stored in the Harwell Vault Store, the main store for ILW packages on the Harwell site. This store is temperature-controlled and ventilated, with store conditions being monitored.

Assessment Inventories and Number of Packages

Assessment inventories for the liquor and sludge waste packages have been defined based on the submitted waste package records. In both cases, the average package inventory is a simple average across all packages and the maximum inventory is based on selecting the highest individual package inventory. The inventories, being dominated by depleted uranium and thorium, with moderate quantities of fission products, are relatively small or moderate. The heat output and dose-rates are relatively small, and the fissile content is dominated by small amounts of U-235.

The analyses of the wastes during packaging has shown that the Ra-226 inventories of the packages is significantly greater than was anticipated when the existing endorsements were provided. The presence of this Ra-226 results in an increased rate of generation of radon (Rn-222). The significance of radon was considered in the safety assessments.

This Periodic Review covers only those liquors and sludge waste packages that have been sentenced for geological disposal. Further waste packages of both types were produced and consigned for disposal as LLW. The packages considered in this review comprise 41 packages containing liquors (corresponding to 6.7m³ of liquors from three tanks) and 13 packages containing sludge (corresponding to 3.4m³ of sludge from a single tank).

Assessment of Disposability

Waste Package Properties and Performance

The liquors and sludge wasteforms represent good examples of the homogeneous type of wasteform that would be expected to be produced by in-drum mixing with cement. Review of the process information and confirmatory trials has confirmed that expectations for the processing of the waste based on the existing endorsements have been fulfilled in practice.

The confirmation of the nature of the wasteforms has allowed the expected properties of the waste packages to be based on generic information available to RWMD, drawing upon experimental data and modelling relating to the homogeneous type of wasteform. These data indicate that radionuclide releases from the waste packages under accident conditions would be small.

The nature of the wastes and the inventories are such that bulk gas generation rates are small and do not have an adverse effect on the performance of the waste packages. Radon generation is identified as a significant issue and is discussed below.

Compliance with the Transport System Design and Safety Case

The LETP waste packages are generally compliant with the transport system design and safety case as currently foreseen. This is consistent with the relatively small inventories associated with the packages and the expected quality of the cemented wasteforms. It is anticipated that the dose-rates at 2040 would decay to the extent that all of the LETP packages could be transported in a Standard Waste Transport Container with 70mm of shielding (SWTC-70).

The packages are not considered to present a significant criticality hazard and the packages comply with suitable generic Safe Fissile Masses (SFM) for transport.

A Compliance Gap has been identified regarding the potential rate of radon generation from the sludge waste packages (and a sub-set of the liquors waste packages). Significant inventories of Ra-226, which decays to generate radon, were assigned during the packaging of the wastes. This is particularly the case for the sludge waste packages, where the previous analyses upon which Final stage endorsement had not reported this radionuclide. Based on the conservative treatment of the expected radon release from the cavity of the SWTC adopted in RWMD toolkits, the limit on radionuclide release under normal conditions of transport could be exceeded. Further evidence is required to reduce the initial conservatisms and confirm that releases would be consistent with the limits on activity under normal conditions of transport.

Compliance with Engineering Design and the Operational Safety Case

The LETP waste packages are considered to be compliant with the engineering design requirements of the GDF and the operational safety case as currently foreseen. All assessed doses are below the Basic Safety Objective for the public. All assessed doses to workers are significantly below the Basic Safety Level for initiating fault frequencies $>10^{-3}$ per annum and it is accepted that these would be further reduced as the GDF design is developed in future. These conclusions are consistent with the relatively small inventories associated with the packages and the expected quality of the cemented wasteforms. The packages are not considered to present a significant criticality hazard and the packages comply with suitable SFMs for operations.

Compliance with the Environmental Safety Case

The LETP waste packages are compliant with the generic Operational Environmental Safety Assessment (OESA) and the Post-closure Safety Assessment (PCSA). This is consistent with the relatively small inventories associated with the packages and the expected quality of the cemented wasteforms. The packages are not considered to present a significant criticality hazard and the packages comply with SFMs for post-closure.

Conclusions of Assessment of Disposability

The basis of the original endorsements that the waste packages should be disposable remains valid and robust. The packaging processes largely have been implemented as expected and it remains the case that the properties and performance of the waste packages should be consistent with the expectations expressed in the Waste Package Specification for packages based on 500 litre drums. A formal Assessment of Disposability has been recorded and it has been demonstrated that the packages are generally consistent with the assumptions of the generic Disposal System Safety Case.

A Compliance Gap has been identified, relating to the ability to demonstrate compliance with the need to minimise releases under normal conditions of transport, due to the presence of significant inventories of Ra-226

Comparison with the WPS for packages based on 500 litre drums has confirmed that the LETP waste packages are generally compliant with the quantitative requirements. Some deficiencies in the areas of waste package records and the interim storage of completed waste packages have been identified, as discussed below.

Waste Package Records and Ongoing Management Arrangements

Waste Package Records and Supporting Information

RWMD is satisfied that appropriate package-scale records have been produced for the LETP waste packages and that these are currently being managed under the wider arrangements governing such records for packages in the Harwell Vault Store.

Conversely, campaign-scale records and supporting information are not being managed in a manner consistent with the significance of the documents, as was evidenced by the difficulties in supplying some documents for the Periodic Review, and, as a result, there is a significant risk of information loss. RSRL has not clearly identified those documents to be managed nor have the arrangements to manage the documents been put into place.

The identification of supporting information is an important component of waste package records, particularly with respect to establishing and maintaining confidence in the waste packages over time. Consequently, a second Compliance Gap has been identified in this area, relating to a clear specification of all contents of waste package records.

Storage and Monitoring of Waste Packages

It is recognised that the Harwell Vault Store is a suitable location for the ongoing interim storage of completed waste packages. The requirements for monitoring of storage conditions and the inspection of waste packages have been accepted by RSRL but evidence that these requirements have been fully implemented is sparse. RWMD is currently not aware of any proposals to clearly link monitoring and inspection results to the package records for individual LETP waste packages.

It is concluded that, based on the available evidence, RSRL does not have in place the required arrangements to generate clear records of the ongoing storage conditions or routine inspections relating to LETP waste packages. Consequently, a third Compliance Gap has been identified in this area.

Management Systems

At the time of Periodic Review, RWMD seeks to establish that waste packages have been and, when appropriate, continue to be manufactured under a suitable Management System and that evidence to this effect is included in waste package records. This evidence represents a component of the campaign-scale records and supporting information discussed above.

It is also essential that the completed waste package records are managed and maintained appropriately. Only limited evidence has been made available relating to the arrangements for the ongoing management of package records and a fourth Compliance Gap has been identified.

Finally, reviews of the WPrS and the CCADs have highlighted a number of minor deficiencies that should have been managed as non-conformances. These areas should be addressed to ensure that records are correct and that inconsistencies do not undermine confidence in records. A fifth Compliance Gap has been noted to this effect.

Resolution of Compliance Gaps and Outstanding Qualifications

The assessment of the submitted information for LETP liquors and sludges waste packages has identified a number of issues that currently preclude the re-issue of the Final stage endorsements. These issues have been captured as five Compliance Gaps. The actions required to close these gaps have been considered by RWMD and seven Action Points have been identified to assist with the monitoring and timely resolution of the issues.

The original endorsements were subject to 11 explicit qualifications (conditions and exclusions). These qualifications have been reviewed and it is concluded that the identified conditions have been fulfilled or superseded. In most cases this is because the wastes have now been packaged and it is therefore unnecessary to maintain a condition relating to specific details of that packaging process. In some cases, it has also been necessary to confirm that the underlying issue has been addressed.

Recognising that the reported Assessment of Disposability covers the existing packages, it is concluded that the exclusion of any further package containing the remaining sludge tank 'heels' from the endorsement should be maintained. Separate engagement on any proposals to package the sludge tank heels would be required to remove this exclusion.

Conclusions

The Periodic Review of the existing Final stage endorsements for waste packages containing liquors and sludge originally stored at the LETP has concluded that the waste packages are disposable, subject to the resolution of five Compliance Gaps. The packaging processes largely have been implemented as expected and it remains the case that the properties and performance of the waste packages should be consistent with the expectations expressed in the Waste Package Specification for packages based on 500 litre drums.

The review of the arrangements covering the ongoing storage of the packages and the status of waste package records has concluded that these are currently not satisfactory. The identified shortcomings largely reflect issues raised previously through auditing by RWMD. These issues have been captured as the Compliance Gaps noted above.

Considering the actions necessary to resolve the Compliance Gaps, seven Action Points have been placed. For clarity, these Action Points are considered to supersede any existing actions arising from audits and the latter have been closed.

In light of the identified Compliance Gaps, and the need to resolve the related Action Points, RWMD will not re-issue the endorsements covering the LETP waste packages at this time.