

# Packaging of Plutonium Contaminated Material at the Waste Treatment Complex

## (Extension to Final stage and Periodic Review)

### Summary of Assessment Report

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#### **Introduction**

Sellafield Ltd (SL) has provided evidence and made requests in support of an extended Final stage Letter of Compliance and Periodic Review for the packaging of Plutonium Contaminated Material (PCM) in the Waste Treatment Complex (WTC) at Sellafield. These wastes consist of materials derived from operations, maintenance, and decommissioning which have become contaminated, mainly by plutonium. The wastes are contained within 200 litre drums ('Feed Drums') which are subject to high force compaction to reduce the volume of the waste material creating pucks. These pucks are then placed into 500 litre drums ('Product Drums') and grouted in place to form waste packages. The waste packages are being stored at Sellafield awaiting final disposal in the Geological Disposal Facility (GDF).

This Assessment Report provides the basis and findings of the Periodic Review and updated Final stage disposability assessment by NDA Radioactive Waste Management Directorate (RWMD) for packages of PCM at WTC. The assessment has been carried out using the Disposability Assessment process, where we examine 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<sup>1</sup>.

#### **Background**

The WTC was designed and constructed to package PCM for interim storage and future disposal, with operations starting in 1998. The current process transfers 200 litre Feed Drums suitable for processing from storage to WTC and positions them in the 'supercompactor' within a glove box. The drum is then subject to high force compaction to reduce the volume of the waste material. These supercompacted drums are called pucks. Absorbed liquids are squeezed out and collected pending further treatment. Next, the pucks are placed into a 500 litre Product Drum, grouted (a blend of cement and fly ash), and left to cure. A lid is fitted, the Product Drum is monitored for contamination, and transferred to an engineered drum storage facility pending transport to the GDF.

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

RWMD provided Final stage endorsement in 1996 through a Letter of Comfort, now a Letter of Compliance (LoC), for packages of supercompacted PCM manufactured at WTC. Subsequent interactions have included an endorsement to package PCM from the Sellafield MOX Plant in 2001, an endorsement to package a specific decommissioning waste in 2008, a quality management system audit, and numerous pieces of advice on other waste streams, product quality documents, assay systems, and outstanding issues.

### ***Scope of the Periodic Review for the Current Endorsement***

The Final stage endorsement from 1996 was just the initial step in the long-term management of packaged PCM. The Periodic Review provides the means to ensure continued validity of the Final stage endorsement and consistency with potentially evolving safety and environmental assessments supporting the GDF. The Periodic Review focuses on compliance with the evolving GDF disposability assessments, preservation of waste package records, the storage arrangements for the packages, and on-going quality management.

The current endorsement covers PCM from fuel reprocessing and similar waste which is expected to arise in the future. These materials are contaminated by plutonium and typically consist of small items such as tools, equipment, filters, rubber, metal, and wood. The entire volume of a Feed Drum could be filled with any combination of PCM waste materials. An extension to this endorsement to include a specific decommissioning waste was later provided. All of these materials are included in the current endorsement.

As of the end of December 2011, almost 3,000 Product Drums have been produced. Based on the current and future inventory of PCM, Sellafield Ltd predict that a total of approximately 24,000 Product Drums will be produced.

### ***Outcome of the Periodic Review for the Current Endorsement***

RWMD has established waste packaging standards and defined package specifications to enable the treatment of radioactive wastes in a form that will be compatible with future transport and disposal at a GDF. As part of the process for the implementation of the geological disposal option RWMD has developed the generic Disposal System Safety Case (DSSC). The prime purpose of the DSSC is to allow RWMD to assess the risks associated with geological disposal and to demonstrate that a GDF can be implemented in a safe manner and in such a way that would meet all applicable regulatory requirements. This periodic review was made against the current Level 3 Waste Package Specification for a 500 litre drum and the generic DSSC, to ensure the 1996 Final stage endorsement is compliant with evolving GDF safety cases. The key elements of this assessment are summarised below:

- *Wasteform:* The Product Drums contain grouted pucks with potentially high quantities of metal, mainly steels, from decommissioning wastes. Some corrosion of these materials is expected during storage, but it is expected that the grouted 500 litre Product Drums will retain their integrity for the required period.
- *Heat Output:* The maximum package inventory produces 4 Watts of radiogenic heat per Product Drum at 2040. This is below the 50 Watt package limit at the time of transport specified by RWMD.
- *Gas production:* Gases will be produced from microbial degradation of organic materials and corrosion of some metals, but the estimated rate does not challenge the integrity of the wasteform. A small quantity of the gaseous radionuclide Rn-222 would be generated, but dose rates from this gas are estimated to be minimal. Other gases will be generated due to waste degradation, consisting primarily of hydrogen and some methane and carbon

dioxide. In regards to flammable gases, the target limit for transport could be exceeded, so purging of the transport container with nitrogen prior to despatch to the GDF may be necessary.

- *Impact accident performance:* For an impact accident during GDF operations, the worst-case worker dose is above the Basic Safety Objective (BSO) and just above the most restrictive Basic Safety Level (BSL). However, the impact Release Fraction utilised in the analysis includes particles larger than the respirable fraction, allowing for this should reduce worker consequences from a single package impact to BSO level. It is also recognised that design of the GDF is at an early stage of development, which is reflected in the conservative assessment methodology. Public consequences from an impact accident are below the BSO.
- *Fire accident performance:* Activity releases from exposure of a waste package to a fire accident have been derived to represent waste packages with high metal content from decommissioning waste streams (highest thermal conductivity). Worker protected doses are marginally above the BSO but well below the most restrictive BSL. No toxic substances are expected to be released from the waste packages if the waste package were exposed to a fire. Public consequences from a fire accident are below the BSO.
- *Container Design:* The 500 litre Drum is an unshielded, vented waste package manufactured from thin stainless steel. The mass, size and handling features are compliant with the RWMD waste package specifications.
- *Criticality Safety:* The maximum package radionuclide inventory is covered under a transport criticality safety case for a Standard Waste Transport Container conditional on beryllium and graphite not being present in the waste.
- *Safeguards:* 'Nuclear safeguards' give assurance that nuclear materials are controlled and not diverted to undeclared use. All WTC PCM is considered as Safeguarded material. It is however noted that the submission does not indicate whether the relevant authorities (i.e. the local safeguards office or Euratom) are aware of the waste packaging arrangements, from the point of view of the Nuclear Material (NM) it contains.
- *Physical Protection:* The Office for Nuclear Regulation requirements are met if the PCM supercompaction process satisfies the requirement for wastes to be immobilised in a grout. On the assumption that this requirement is satisfied, standards of physical protection no higher than Category III would be required. The current Security Plan for the GDF proposes that all wastes be protected to no higher than Category III standards.

As part of the Periodic Review, the Product Drum storage arrangements, the preservation of records, and quality management were assessed. The conclusion can be summarised as follows:

- *Waste Product Storage:* Product Drums are sent to the Engineered Drum Store (EDS). There are three EDS facilities constructed, commissioned and operating for WTC drums. These all contain atmosphere controlled storage vaults and bays. EDS 1 has a 50 year design life and EDS 2 and 3 have a 100 year design life. SL expects EDS 1 to have its design life extended. SL has committed to monitor and inspect the waste packages during interim storage at EDS prior to disposal at the GDF to maintain package integrity. RWMD inspected EDS 2 and 3 in 2009 and recommended that EDS adopt a code of practice for handling both Feed Drums and Product Drums. This position is satisfactory.

- *Package Records:* RWMD requires the waste packager to provide assurance of the quality of both the waste packages and the associated waste package records. Records for PCM waste packages are derived from a data recording methodology and defined in updated controlled documents. The Information Management strategy for intermediate level waste at Sellafield indicates roles and responsibilities, records storage, and management. Sellafield Ltd currently transfers original paper documents to another storage facility and intends to have a dedicated records management system, although there is no indication of when and how this system will be put into practice. This issue prevents re-issue of the Letter of Compliance.
- *Quality Management:* RWMD requires the waste packager to establish, implement and maintain a formal and effective Quality Management System (QMS) to ensure the quality of the waste packages and the associated package records. These arrangements should be reviewed periodically and adequate records maintained. WTC controls quality assurance documents through the following:
  - A Strategy for the Determination of Radionuclide Inventory,
  - Criticality Compliance Assurance Document,
  - The Waste Product Specification (A full review of the WTC Waste Product Specification against RWMD guidance was completed and found no deficiencies),
  - WTC Conditions for Acceptance, and the
  - WTC Product Quality Review Committee Terms of Reference.

RWMD conducts customer audits to confirm that processes are established and implemented to incorporate the full life cycle of the waste package. RWMD conducted an audit in 2006 which identified one item requiring correction. This item was to consider the adequacy of media on which records are stored, the storage systems and materials, and the storage environment. Another audit will need to be arranged in order to confirm that activities influencing product quality continue to be conducted within a suitable QMS. As noted above, the long-term records management system is currently not adequate and it will not be possible to close the finding from 2006.

### ***Conclusion of the Periodic Review***

The objective of the Periodic Review was to ensure that previously endorsed supercompacted and encapsulated PCM into 500 litre drums is still valid against evolved safety and environmental assessments, and to ensure the waste packages would be disposable at a GDF against the evolving requirements for transport, operations, and post closure safety. No safety significant issues have been identified, although two issues relating to records and one relating to a need for audit have been identified. RWMD anticipates that one of these actions, relating to long-term management of records, may take significant resource and time to resolve.

RWMD is aware that Sellafield Ltd has developed a records strategy, to manage and preserve records for the long-term. However, this has not been implemented in practice. This issue is relevant to all higher activity waste packaging plants at Sellafield, and is not unique to WTC, however RWMD considers that is not appropriate to continue to re-issue Letters of Compliance in response to periodic reviews whilst this issue remains outstanding. There is an outstanding WTC audit finding from 2006 on this issue. RWMD therefore requests SL to implement the strategy for long-term records management at WTC for new records and supporting information, and to set out a programme for converting historical product drum information files to final form consistent with the strategy.

### ***Proposal and scope of assessment for the extended waste envelope***

The waste material included in the current endorsement is limited to operational and decommissioning PCM waste from reprocessing and plutonium handling operations at Sellafield. It is recognised that future decommissioning activities to manage legacy liabilities at Sellafield and around the UK will produce additional PCM stocks. In an effort to expand the waste envelope to include some of these materials and process more waste, additional waste streams and conditions have been proposed for packaging at WTC. These materials would also be supercompacted and grouted producing Product Drums in the same packaging process currently operating for the endorsed wastes. The proposals to extend the waste envelope include the following requests from SL:

- 1) *As a minimum, retain the existing Product Drum fissile mass limit:* a safe fissile mass limit (expressed as a mass of total Pu and U-235), derived in the 1990's, is applied to WTC Product Drums.
- 2) *Addition of unlimited U-235 for uranium at up to 1.6wt% enrichment:* the WTC assay suite detects uranium isotopes but there is insufficient confidence in the U-235 measurement for criticality control. Nevertheless, it is proposed that the U-235 contribution to reactivity of PCM can be discounted if it is ensured to be below 1.6% enrichment. For the purposes of disposal inventory recording, uranium would be estimated utilising the uranium to plutonium ratio estimated from donor plant information multiplied by assay suite fissile mass data. The uranium inventory would be recorded on a new form and placed in the Product Drum Information File.
- 3) *Increase in the Product Drum safe fissile mass limit:* a specific increase in the safe fissile mass, considered safe by SL for Sellafield site operations, was presented as an option in the scope of this disposability assessment but was not selected by Sellafield Ltd for full evaluation.
- 4) *Addition of waste material derived from crates:* Materials derived from crates include large items such as glove boxes with or without equipment, and broadly the same materials as endorsed waste.
- 5) *Addition of large cylindrical **High-Efficiency Particulate Air (HEPA)** filters:* The filters would be supercompacted within a Feed Drum to immobilise the associated radioactivity.
- 6) *Addition of bottles of grouted aqueous liquid "squeezeate":* Absorbed liquids in the waste are collected from the supercompaction process and accumulated in bottles. Solvents and oils are separated, leaving aqueous squeezeate. The aqueous liquids would be neutralised, grouted, and left to cure. Twelve bottles would be placed in a Feed Drum and supercompacted.
- 7) *Permit unlimited aluminium:* Aluminium has been present in HEPA filters, and will be in specific items like scaffold tower tubes, tools, sheeting, and brackets. Wastes containing aluminium would be double-wrapped in polyvinylchloride to reduce the available surface area for reaction.
- 8) *Retain the current endorsement limit of 260kg cellulose per Product Drum:* The cellulose content is limited to control gas production. SL requested confirmation or removal of this limit.
- 9) *Addition of cellulose and glass fibre square filters:* The legacy square filters contain cellulose, steel, galvanised steel, aluminium, glass fibres, and polyurethane. The filters are much smaller than the cylindrical HEPA filters.

- 10) *Addition of galvanised feed drums:* Raw waste feeds may be packaged in galvanised 200-litre drums which have a protective oxidised layer of zinc.
- 11) *Agree in principle to the installation of the Radiometric Drum Monitoring System at EDS to improve the assay capability for enriched uranium (at any enrichment) and other gamma emitting radionuclides:* This assay system would be operational in 2016 with the main function of having the capability to handle future waste stream endorsements consisting of uranium and other gamma emitting radionuclides. The current Non-Intrusive Interrogation suite, at WTC, consisting of Real-Time Radiography, High-Resolution Gamma-Ray Spectrometry, and a Passive Neutron Coincidence Counter would continue to be used.
- 12) *Increase the safe fissile mass by considering a selective management process for transport of packages:* Feed Drums consist of a range of fissile masses with the majority of these drums containing lower fissile masses. It is planned to transport up to four waste packages in a stillage per transport package. On the basis that the transport scenario is the most restrictive phase of waste management, setting the lowest package safe fissile mass, it is proposed that a selective management process could enable the transport of high fissile content waste packages with some low fissile content waste packages.
- 13) *Utilise the Sellafield Ltd impact accident finite element modelling and the comparison with impact test results:* Two sets of impact tests and a finite element analysis have been completed for PCM waste products to provide impact accident performance data. The tests demonstrated that there is no significant reliance on the nature of the puck to prevent release of particulates. With these results and given that all Feed Drums would be supercompacted and the resulting pucks solid, it is proposed to have no limits on specific materials within a drum as long as a material is able to be supercompacted.
- 14) *Comment on whether a reduction in the supercompaction force would be acceptable:* Compaction trials have been undertaken to investigate the performance of certain wastes under varying compaction loads. Simulated feed drums containing various materials including, wood/paper, filters, concrete, steel, rubber, glass, and other materials were manufactured and compacted under a range of forces. This demonstrated that reducing the compaction force in the range tested has not resulted in increased voids in the puck and will minimise the amount of stored energy in the puck. A reduction or variable supercompaction forces would apply to the endorsed materials and extended waste envelope materials packaged in the same overall process as the endorsed wastes.
- 15) *Endorse of all material considered suitable for supercompaction:* Drums would continue to be assessed and checked prior to supercompaction. The drum would not be compacted if it is considered that an adequate puck would not be formed or damage to the plant may occur.
- 16) *Endorse inclusion of containerised liquids in raw waste:* Bottles of liquid are currently excluded from feed drums. SL argues that such liquids would be expelled from the puck after the bottle ruptures during compaction, and that the resultant puck containing the bottle(s) would have minimal voids if intermixed with mostly soft waste.

### ***Conclusion of assessment of extended waste envelope***

We have assessed each of the individual requests to broaden the scope of the Final stage endorsement. Assessment was made against the same waste packaging standards and defined package specifications and against the generic DSSC, as for the current endorsement. The assessment concludes that the following can be endorsed:

- Retention of the existing Product Drum safe fissile mass (1);
- Material derived from crates (4);
- Large HEPA filters, to a maximum of 5 per Product Drum (5);
- Grouted bottles of aqueous liquid “squeeze” (6);
- Retention of the current cellulose limit per Product Drum (8);
- Cellulose and glass fibre square filters (9);
- Galvanised feed drums (10);
- Slags (15);
- Brick, rubble, and soil, no more than 20% of drum height (15);
- Wood, no more than 20% of drum height placed horizontally (15);
- Four small cartridge style glove box filters, distributed between Feed Drums (15);
- Decommissioning wastes, compactable (15);
- Perspex, no more than one piece per Feed Drum (15).

RWMD also agrees in principle to the installation of the Radiometric Drum Monitoring System (11), considers the impact tests and finite element modelling completed on simulated WTC packages adequate (13), and agrees that reduced or variable compaction forces in the range tested produce acceptable products (14). The requests to extend the envelope to include PCM stocks and arisings are assumed to include the items listed above.

Full transport and post closure safety evaluations were not completed for the request to increase the fissile mass (3). Work is in hand to update the criticality safety assessment as part of the Design Safety Report for the SWTC (12). Depending on the outcome of this work, a revised safe fissile mass can be considered, but at this stage it cannot be assumed that a significant increase can be justified.

For the addition of unlimited U-235 for uranium at up to 1.6wt% enrichment (2) it has been shown that uranium of less than 1.6% U235 enrichment can be exempted from accountancy against the Drum fissile limits. Uranium isotopes are to be recorded for the disposal inventory using realistic uranium to plutonium ratio fingerprints and assay system fissile inventory data. Metallic uranium is excluded. However, criticality safety assessments for transport, GDF operations, and post closure conditions do not yet account for uranium addition to separated plutonium waste. A special criticality safety case for WTC waste packages needs to be produced to account for addition of uranium at up to 1.6% enrichment. Furthermore, there is a need to further develop the fingerprint approach for uranium recording, specifying which isotopes are to be recorded.

The key technical area preventing endorsement of unlimited aluminium (7) and materials containing dust and sludge (15) is lack of evidence to support a compliant waste product. The proposal to add bottled liquids (16) is not supported, due to lack of evidence to support product quality and the need to build a case for this process considering management of the waste packages over the full lifecycle. To facilitate further work towards potential endorsement of these materials, Action Points have been provided in the main assessment report.