Nuclear Decommissioning Authority

Radioactive Waste Management Directorate

Assessment of Piles Fuel Cladding Silo Waste Treatment Options

Summary of Assessment Report

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Background

The Pile Fuel Cladding Silo (PFCS) was built at the Windscale site in the early 1950s to store waste cladding and graphite components generated during the reprocessing of irradiated uranium cartridges from the Windscale plutonium production piles. The PFCS was subsequently used also to store cladding from Magnox fuel elements reprocessed at Windscale together with a relatively small amount of miscellaneous wastes of other types and origins, including miscellaneous beta-gamma waste (MBGW) and plutonium contaminated material (PCM). Waste was added to the Silo over the period 1952 to 1964, since when the Silo has been maintained as a store for the accumulated waste.

The advanced age of the PFCS means that Sellafield Ltd (SL), regulators and the Nuclear Decommissioning Authority would like to see the accumulated waste retrieved from the silo and put into a more safe and secure state as soon as possible, pending future disposal in the planned deep Geological Disposal Facility (GDF). In line with this intention SL is currently planning to take a step-wise approach to preparing the PFCS wastes for disposal. Firstly, SL is planning to retrieve the waste from the PFCS as soon as possible and to pack the waste into custom-designed containers that outwardly are based on the standard $3m^3$ Box design but that incorporate many special features appropriate to their intended role. The containers would then be placed into a modern store at the Sellafield site for a period of time. At some point in the future, the containers would be retrieved from the store and the waste would be converted into a form suitable for final disposal to the GDF.

In SL's view this step-wise approach has some important advantages. It allows the waste to be retrieved from the aged PFCS and put into modern, safe and secure storage as quickly as possible, without spending time deliberating and deciding what is the best form in which to ultimately dispose of the waste and how best to get the waste into that form. Once the storage conditions of the waste have been improved, these decisions can be taken at greater leisure and with the benefit of the improved knowledge about the condition and characteristics of the waste that will be gained during packing. Like any other approach, however, this one also has its disadvantages and risks.

In order to help to get the waste into improved storage as quickly as possible, the plan is to pack the waste into stainless steel $3m^3$ boxes with minimum intervention. Thus, while the plan is to weigh batches of retrieved waste and to record as much about their composition as can be gleaned from visual inspection, there are no detailed plans to characterise the waste further. Neither are there any plans to sort, segregate or treat the waste in any way during packing, other than to soak up free liquids using absorber cartridges, which then will be added to the waste containers. One risk of this approach is that the packing step will be seen as a missed opportunity to gather information about the waste that would help when making decisions about the best form in which to dispose of the waste and how to get the waste into that form. Another missed opportunity could be to have included activities during the planning, development and implementation of the packing step that might help conversion of the waste into a form suitable for final disposal in an easier or quicker manner.

Assessment Objectives

SL has recognised these risks and is seeking to reduce them. In order to do so, SL has identified a number of options that it sees as being representative of the forms in which the PFCS wastes might conceivably be disposed of and how they might be converted into those forms. The baseline planning assumption is to retrieve the wastes from their $3m^3$ storage containers, package and encapsulate the wastes in new containers for geological disposal. Other options are:

1. Leave the wastes in their $3m^3$ storage containers and dispose of them in a non-encapsulated form.
2. Leave the wastes in their $3m^3$ storage containers, infill the containers with an inorganic cement and dispose of the infilled containers.
3. Leave the wastes in their $3m^3$ storage containers, infill the containers with an organic polymer and dispose of the infilled containers.

The baseline option would allow any additional waste treatment, sorting, segregation, characterisation etc. to be done when the wastes are retrieved from the storage containers and repackaged in the future. The other three options represent different ways of realising the opportunity to dispose of the wastes without the need for a second round of waste retrieval and repackaging. SL is considering what activities would be worthwhile in the short to medium term to keep alive the opportunities embodied in these other three options and to improve the chances of them eventually being brought to fruition. SL has asked for NDA Radioactive Waste Management Directorate's (RWMD) advice on worthwhile activities associated with the three alternative options.

This report provides the basis and findings of the review of the presented treatment options for PFCS by RWMD. The assessment has been carried out through the Letter of Compliance Disposability Assessment process. Further information on this process is available elsewhere[1].

Outcome of assessment

<u>Characterisation</u>

The PFCS waste is a heterogeneous mix of materials derived from a range of on-site and external waste producers. The absence of contemporary tipping records, the general level of record keeping at the time and the difficulty in undertaking representative sampling and assay have unavoidably hindered the development of a precise, accurate and fully justified inventory prior to waste retrieval, and will continue to do so. Notwithstanding these difficulties, SL has clearly undertaken a considerable amount of work to further develop knowledge of the PFCS waste properties and characteristics, and has provided a fairly detailed and comprehensive inventory of the waste.

There are various other short to medium term activities that might improve the chances of realising the opportunities offered by one or more of the three alternative options. Given the likely interest in the total irradiated uranium inventory of the PFCS under any of the three options, it would be worthwhile investing some time and effort in trying to corroborate the lower inventory that has been estimated recently from the results of radiation surveys of the silos.

Characterisation on retrieval can assist the overall waste characterisation process. The waste characterisation process during retrieval described in the submission mainly relies on a visual assessment of the physical composition of each grab-full of waste as it is spread for viewing. The waste components of relevance for data recording would be those that could

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

have a significant effect on the properties, performance and evolution of the waste packages. This report suggests which waste components may be of most relevance.

Any future LoC submission for the PFCS wastes should provide a fully developed data recording strategy that details how the estimates of waste volumes per grab would be converted into per package waste inventories. An assessment of uncertainty should also be included. According to the submission, radioactive characteristics of the waste would be established using an algorithm which aggregates fingerprints for each identified waste type. This report identifies that additional work would need to be undertaken by SL to support the proposals. A waste product specification or some similar generic document should be prepared that covers the waste retrieval, characterisation and loading parts of the process, together with generic aspects of the containerisation process like the generic container information.

It would be worthwhile considering how practicable it might be to control the amounts and locations of some waste components retrieved and packed into containers. These would include particulates, free liquids and corrosive chloride-bearing materials (e.g. PVC) in the case of all three alternative options; heavy items and organics in the case of the non-encapsulation option; and uranium in the case of the cement and polymer encapsulation option.

Graphite

Graphite boats and dowels that were irradiated in the Windscale Piles make up a considerable proportion of the wastes accumulated in the PFCS. It is estimated that about half of the packages to be created by the retrieval and packing operation will contain irradiated graphite. During irradiation at the relatively low temperatures in the Piles, stored (Wigner) energy will have built up in the graphite as neutron bombardment displaced atoms in the lattice structure of the graphite. Some of this energy could be released during the future management of the PFCS wastes, particularly should the temperature of the waste be raised. The presence of Wigner energy is a known issue that has previously been considered by RWMD and SL. Complex modelling, previously developed, can be utilised but this may not support simple safety arguments. The issue would need to be addressed by SL when any more detailed proposals for the PFCS wastes are presented in the future.

Compliance

For any of the three alternative options, waste package criticality safety assessment and criticality compliance could be a threat to the chances of realising the opportunities offered by the options. In order to keep alive any of the three alternative options, it would be prudent to begin work as soon as possible on developing a criticality safety case and a methodology for demonstrating criticality compliance at the time of waste retrieval and packing.

It could also be argued that some other materials may need to be limited in the packages to show compliance with R&D, for example that which supports product quality. However, in the absence of wasteform definition and supporting R&D it will not be possible to demonstrate compliance at the time of waste packing. Indeed, without control of package composition it is possible that some packages will prove non-compliant with limits defined by future R&D and would thus need to be re-packaged. An example could be packages with high particulate loading.

It should be noted that waste packages would be transported from Sellafield as part of a Type B Transport Package. The Transport Package will have a Contents Specification placing constraints on contents. The waste consignor will need to demonstrate compliance with this. It may be possible to show compliance through analysis of waste records, use of R&D, measurements on packages and generation of appropriate arguments but there could be some challenges relating to specific items of waste and uncertainties about their location or presence in the waste.

Non-encapsulation

Many of the most important findings of this assessment represent threats to the potential for realising the alternative option of disposing of the PFCS wastes in a non-encapsulated form. In any proposal that involves non-encapsulated waste, substantial reliance is placed upon the benign behaviour of the waste and the container to provide the necessary overall waste package properties and performance. Even accepting that the proposed container for the PFCS wastes is at a very early stage in its design and development, in its current form it appears to be unlikely to be able to meet all necessary performance requirements if it were to be used for the transport and disposal of non-encapsulated PFCS wastes.

Encapsulation

Many of the uncertainties and demands concerning non-encapsulated waste would be alleviated under the alternative options that involve encapsulation of the PFCS wastes in polymer or cement. With an encapsulated waste, the onus placed upon the container is generally less significant. In the case of the PFCS wastes, while there may be some shortcomings and doubts about the performance and properties of the wasteforms that could be produced by cement or polymer encapsulation, a suitably robust container could make up for many shortfalls in overall waste package performance. It is expected that polymers would be capable of achieving more effective encapsulation of waste at this scale than cement grout, but use of polymer at this scale would be unprecedented and may raise issues, for example relating to heat generation during curing.

Container Design

In order to improve the prospect of any of the alternative options being brought to fruition, a considerable amount of work would be needed to resolve the many uncertainties created by the novel container design and its performance in impact accidents. In particular, the behaviour of the proposed casting for the top flange and its effect on the behaviour of the package as a whole is a major uncertainty and would need to be thoroughly investigated.

The submission does not provide details of the planned container emptying process, since it is the baseline process, but there are various possible options for emptying a $3m^3$ box of loose waste that would need to be incorporated into the box design. Suggestions have been incorporated into this report.

Overall view

Demonstration of the acceptability of non-encapsulation is going to be onerous, and RWMD judges this option unlikely to be acceptable without radical changes in box design and control of content. In principle, there do not seem to be any insurmountable obstacles standing in the way of any of the encapsulation options. Proposals for characterisation during the waste retrieval process need to be developed. Consideration needs to be given to how this contributes to the overall waste package records and how compliance with any package limits is to be demonstrated. It will also be necessary to resolve the uncertainties surrounding the significance or otherwise of the graphite with stored energy for management of these waste specific package designs.