Radioactive Waste Management Directorate

Packaging of Windscale Pile Reactors Concrete and Metal Wastes

(Conceptual stage)

Summary of Assessment Report

Issue date of Assessment Report: 20 September 2007

Background

UKAEA has sought Conceptual stage endorsement of the proposed packaging of the concrete and metal wastes which will be generated from the decommissioning of the Windscale Pile Reactors (Piles 1 and 2).

This document summarises the results of the assessment carried out by NDA Radioactive Waste Management Directorate in response to the submitted proposals. The assessment has been carried-out as part of the Letter of Compliance process, whereby NDA examines the disposability of the proposed waste packages by assessment against intermediate level waste (ILW) packaging standards and specifications and the Phased Geological Repository Concept (PGRC). Further information on the Letter of Compliance process is available elsewhere[1].

Scope of the Proposals

The two Windscale Pile reactors (also known as the British Production Piles) were operated by UKAEA at the Windscale site during the 1950s with the primary aim of producing nuclear materials for military purposes. The Piles were also used to produce a range of other radionuclides through the activation of selected precursor materials introduced into the reactors as 'isotope cartridges'. The reactors were fuelled with slightly-enriched metallic uranium fuel and operated with a relatively low neutron flux and short irradiation times. For the purposes of assessment the fuel burn-up has been assumed to be typically 300 MWd/t[2], with a maximum of the order of 600 MWd/t.

The reactors were graphite-moderated and air-cooled. The operating regime resulted in a relatively low temperature during normal operations and it was found that significant quantities of stored energy (Wigner energy) were built-up in the graphite moderator. This resulted in the requirement for a regime of periodic annealing of the moderator, achieved by allowing the core temperature to rise under controlled conditions to significantly increased temperatures. In 1957, unexpected problems during an anneal of Pile 1 resulted in a major fire in the reactor core, causing considerable damage to the core and a proportion of the fuel charge and isotope cartridges present. Subsequent to the extinction of the fire, Pile 1 was made safe and left in a passive state to await eventual decommissioning. Pile 2 was not damaged but was de-fuelled soon after the fire and also left, without being annealed, to await future decommissioning.

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1 *Guide to the Nirex Letter of Compliance Process*, Nirex Document WPS/650, June 2006.

2 Irradiation of fuel in reactors is measured in units MWd (megawatt days) per tonne (of fuel)

The waste addressed by these proposals comprises approximately 12,600 tonnes of concrete and metal wastes which will be generated from the decommissioning of the supporting structures of the two Pile graphite cores. In very broad terms, the wastes covered by the current submission could be divided into two types: the control and shut-down rods; and external structural components. The graphite and any fire damaged fuel and isotope cartridges remaining in pile 1 are not considered in this assessment. There are being addressed within the scope of separate Assessment Reports.

The wastes covered by the current submission comprise only parts of 2004 UK Radioactive Waste Inventory waste streams 5F304 and 5F313. Waste stream 5F313 (Windscale Pile 1 Miscellaneous ILW) does not include the Pile 1 decommissioning wastes that form the majority of this submission while waste stream 5F304 (Windscale Pile 2 ILW) includes some, but not all, of the decommissioning wastes from Pile 2.

Packaging Proposals

The components of the Piles would be dismantled in sequence and, as a result, wastes would arise in a series of 'campaigns':

1. Control and shut-off rods would be removed, size-reduced and packed into cassettes designed to stack within 4 metre Boxes.
2. The Burst Cartridge Detection Gear (BCDG) and other components from the discharge faces of the cores would be size-reduced and packed into purpose designed "project boxes" designed to stack within 4 metre Boxes with 200mm of internal shielding.
3. The bioshield roof would be removed and the resulting ILW concrete, thermal insulation boxes and thermal shield plates packed into project boxes; the thermal insulation boxes would be crushed prior to packing.
4. Structural components on the periphery of the cores (baffle plates, quadrant restraints, stringers, cast iron blocks *etc*.) would be removed and packed into project boxes.
5. Following removal of the graphite core (not considered in this report), the thermal insulation boxes and thermal shield plates on the bioshield walls would be removed and packed into project boxes; the thermal insulation boxes would be crushed prior to packing.
6. The aluminium cascade vanes would be removed, size-reduced and packed into project boxes.
7. The remainder of the bioshield would be demolished and the resulting ILW concrete packed into project boxes.

In some cases, furniture would be used in the project boxes in order to facilitate waste packing. Some wastes would, however, be loose-tipped into project boxes: size-reduced BCDG pipework, other size-reduced discharge face components, concrete, baffle plates, core structural components.

The project boxes would be loaded into 4 metre Boxes as they arise (i.e. there would be no buffer storage of project boxes), up to a maximum of eight project boxes per 4 metre Box. The 4 metre Boxes would then be in-filled with a fluid cementitious grout (3:1 PFA/OPC with a water/cement ratio of 0.42). The completed waste packages would be transferred to the Piles Project ILW store for interim surface storage.

Assessment of Disposability

The acceptability of the proposed packages has been assessed against criteria established within the Phased Geological Repository Concept and associated Generic Waste Package Specification (GWPS).

The Assessment of Disposability is based upon the inventory data supplied by UKAEA for the concrete and metal wastes, but these data have been reassessed to create a conservative, bounding case. It is believed that the bounding inventory is overly conservative, and further work is required to refine this inventory.

The proposed waste packages examined herein are consistent with the requirements of the GWPS and the process has been judged to follow established practice by waste producers for the immobilisation and packaging of solid wastes.

When filled with waste, the 4 metre Box is designed to meet the requirements for an Industrial Package Type 2 (IP-2) Freight Container as specified in the IAEA Transport Regulations and the radioactivity content is restricted to that classified as solid Low Specific Activity (LSA) material or Surface Contaminated Objects (SCO) at the time of transport through the public domain.

The assessments of transport safety show that although the material is considered likely to be compliant with the average specific activity limit for LSA-II material, there are doubts regarding the ability of all the waste packages to comply with external IP-2 dose rate limits for transport under non-exclusive use in 2040 (the date assumed for transport to the repository), even if the maximum 300mm of internal shielding were to be used. Additionally, it is not evident that these packages comply with the requirements of the IAEA Transport Regulations for fissile excepted transport packages. On these grounds, it has been concluded that the proposals cannot be endorsed at the Conceptual stage.

The assessment of operational safety has demonstrated that a worker in close proximity to the bounding package would soon exceed the basic safety objective of 1 mSv per year. This is inconsistent with our current concept which does not specify remote handling for shielded waste packages.

In addition the assessed consequences of impact accidents exceed the limits for workers from Design Basis Accident fault sequences. It is recognised that the inventories and the impact release fractions are pessimistic and it may be possible to reduce these pessimisms through additional work.

The post-closure safety assessment has revealed only one issue that could prejudice disposal of packages containing Windscale Pile Reactors Concrete and Metal Wastes and that relates to the potential for formation of C-14 labelled methane from corrosion of metals present in the inventory. This issue is not unique to Windscale Pile Reactors Concrete and Metal Wastes, and is likely to be a significant issue for many other ILW products.

In summary, the Assessment of Disposability has concluded that it may not be possible to make a Disposability Safety Case for these wastes in a 4 metre Box, and that it is therefore not possible to endorse these proposals at the Conceptual stage.

Due to the nature of the proposals, NDA Radioactive Waste Management Directorate (RWMD) has judged that this submission would be assigned category W when judged against the classification criteria given in the recent regulatory consultation document for the management of radioactive wastes at nuclear licensed sites[3]. This is on account of the volume of waste (4,663 m^3 raw waste) (Category W2A) and on account of the issues raised concerning the use of the 4 metre Box (Category W3C).

[3] Category W: “Projects or modifications that regulators will wish to be consider and assess in most cases.”

Requirements for further development work

It has been concluded that it is not possible to endorse at the Conceptual stage. Prior to such an endorsement, the following issues would need to be addressed satisfactorily:

- demonstration that the proposed packages could be transported as fissile excepted transport packages;
- demonstration that the external dose rates from the unshielded wasteform would be compliant with the IAEA Transport Regulations;
- demonstration that the external dose rates from the packages during transport and the operational phase would be acceptable and compliant with the IAEA Transport Regulations;
- demonstration that Design Basis Accident fault sequences do not give rise to unacceptable doses.

Conclusions

The assessment of the proposals has concluded that Windscale Pile Reactors Concrete and Metal wastes packaged in a 4 metre Box cannot yet be demonstrated to be consistent with disposal under the PGRC and therefore this packaging option cannot be endorsed at the Conceptual stage.