Nuclear Decommissioning Authority

Radioactive Waste Management Directorate

# Packaging of DFR Breeder Fuel Removal Wastes (Conceptual stage)

## Summary of Assessment Report

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### *Background*

UKAEA has tendered a submission seeking Conceptual Stage endorsement for waste packages that would arise from the retrieval and processing of items currently remaining in the core of the Dounreay Fast Reactor (DFR). The proposals encompass the wastes collectively denoted the DFR Breeder Fuel Removal (BFR) wastes.

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

The Dounreay Fast Reactor (DFR) was an experimental liquid metal-cooled fast reactor operated by UKAEA between 1959 and 1977. The DFR core contained driver fuel elements, uranium breeder elements and nickel reflectors, as well as other furniture and equipment. Driver fuel elements and many of the breeder elements were removed during and subsequent to operations. However, 976 breeder elements remain in the core, together with other in-core items. This assessment considers the packaging of these wastes, which will be retrieved from the core and packaged under the Breeder Fuel Removal (BFR) Project.

The wastes to be packaged as Intermediate Level Waste (ILW) under the BFR project have been sub-divided into two categories:

- breeder waste – stainless steel cladding arising from the breeder elements, together with operational wastes and the tools used to extract the elements from the core (if contaminated and requiring packaging as ILW);
- in-core components – reflector elements, other in-core materials and operational wastes.

The breeder elements themselves are stainless steel clad uranium. These are to be de-clad to allow the uranium to be exported to Sellafield for reprocessing, with the cladding being retained for packaging as ILW. Consequently, the uranium breeder fuel itself does not form part of the waste considered under this assessment.

The proposals examined in this assessment have been developed by UKAEA as an alternative to the current baseline strategy, which is based on packaging intact breeder elements. As noted above, the proposals examined in this report are based on the packaging of the breeder element cladding only, with the breeder fuel itself being exported for reprocessing. The current baseline strategy has not been assessed by Nirex.

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[1] *The Nirex Process for Assessment of ILW Conditioning and Packaging Proposals*, Nirex Technical Note, March 2006 (Nirex document reference #497789).

The waste represents only a small fraction of the total volume of ILW predicted to arise in the United Kingdom (an estimated 19 of the proposed 500 litre drums) and contributes less than 0.1% to the total inventory of any of the significant longer-lived radionuclides. The only radionuclides present in moderate quantities are the activation products of stainless steel and nickel.

### *Packaging proposals*

Subsequent to retrieval and, in the case of the breeder elements, de-cladding, the waste would be washed to remove any residual reactor coolant, as the coolant (sodium-potassium) would react vigorously with water during packaging. Any small pieces of breeder fuel and fines generated during the de-cladding process would be collected and separately grouted into small containers.

It is proposed that all DFR BFR wastes would be loose-tipped into 500 litre drums of a double-skinned design, prior to interim storage for 5-10 years to await the construction of the final packaging plant. The double-skinned drum design has been proposed to give confidence in the continued integrity of the containment during interim storage. Ultimately, the waste would be immobilised by grouting in the final packaging plant, using the standard grout developed for that plant.

The submission indicates that the breeder waste and in-core components would be packaged under two separate campaigns, and hence the two waste categories would not be mixed. The breeder waste would be retrieved and packaged first.

### *Assessment of Disposability*

The acceptability of the proposed packages has been assessed against criteria established within the Nirex PGRC and associated Generic Waste Package Specification (GWPS).

The Assessment of Disposability is based upon the inventory data supplied by UKAEA, and is derived from modelling of the activation of fuel and reactor materials. The submission has noted that the information pertaining to the in-core components is preliminary and anticipates that further refinement prior to the Interim Stage. This position has been accepted as consistent with expectations at the Conceptual Stage.

Both the waste package types examined herein are consistent with the requirements of the Nirex GWPS and have been judged to follow established practice. Numerous analogues of the proposed wasteform are available and the associated development work assessed previously by Nirex provides confidence that an adequate wasteform could be produced for the DFR BFR wastes.

The assessments of transport safety show that it should be possible for 500 litre drums containing DFR BFR wastes to comply with all relevant transport safety criteria if transported in Type B transport container with 285mm thick walls, such as the RSTC-285.

Similarly, the assessments of operational safety show that it should be possible for 500 litre drums containing DFR BFR wastes to be handled and stored safely within a repository based on the PGRC. A conservative treatment of the potential risk arising from the release of the breeder debris and finely-divided material, if inadequately immobilised, highlighted the importance of developing a suitable process for the separate pre-treatment of this component of the waste. It is anticipated that such a process could be developed, but further evidence would be required at the Interim Stage to substantiate this expectation.

The post-closure safety assessment revealed no significant areas of concern that should prejudice disposal of packages containing DFR BFR wastes. This is due to the relatively small number of packages containing the materials, and the relatively small radionuclide inventory associated with them.

The bounding assessment inventory includes only a small quantity of fissile material that allows the conclusion that the proposed packages would not present a significant criticality hazard.

In summary, the Assessment of Disposability has concluded that a Disposability Safety Case ultimately could be made for packages containing DFR BFR wastes, and that the proposals for the packaging of these wastes can be endorsed at the Conceptual Stage. During the course of the assessment, areas requiring additional work to progress the proposals beyond the Conceptual Stage were identified, and are summarised below.

### *Requirements for further development work*

The following characteristics of the DFR BFR waste packages are especially significant from the point of view of the repository design and safety cases:

- the formulation of a cement grout suitable for the intimate infiltration of the stainless steel cladding and in-core components to provide a stable wasteform in which corrosion rates are low and controlled, thereby immobilising activity and any surface contamination;
- minimisation of the quantity of residual coolant to ensure compatibility with the proposed grouting of the waste;
- the successful development and application of a separate small-scale process to immobilise breeder debris and fines into a monolith before packaging, thereby minimising the source term of potentially mobile particulate activity;
- the design of 500 litre drum to ensure that the integrity of the containment boundary is maintained during and subsequent to the interim storage of the waste in an un-grouted form;
- management of the loading of any operational wastes (in particular aluminium alloy tools and PVC) to ensure that the longer-term stability of packages containing the actual breeder element wastes is not compromised, including segregation of the operational wastes.

The identification of these key characteristics provides a focus for development work. It is further noted that, where appropriate, such development would need to be based on a suitable simulant of the waste that took due account of any evolution that might occur during storage prior to final packaging.

### *Conclusions*

The assessment of the proposals has concluded that packages containing waste from both categories of DFR BFR wastes are potentially consistent with disposal under the PGRC and can be endorsed at the Conceptual Stage. The consistency of the proposed waste packages with the PGRC has been demonstrated through the provision of an Assessment of Disposability.