

Packaging of PFR Raffinate

(Interim stage)

Summary of Assessment Report

Issue date of Assessment Report: 18 April 2007

Background

UKAEA has sought Interim stage endorsement of the proposed packaging of the raffinate produced during the reprocessing of fuel from the Prototype Fast Reactor (PFR) at Dounreay. These proposals have previously been assessed and endorsed by Nirex at the Conceptual stage, as reported in Assessment Report NXA/482201.

This document summarises the results of the 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 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 elsewhere¹. The assessment reported herein builds upon that undertaken and reported at the Conceptual stage.

Scope of the Proposals

Reprocessing of PFR fuel required the dissolution of cropped fuel pins in concentrated nitric acid. Subsequently, the useful actinides were separated by solvent extraction from the clarified dissolver liquor. The acidic liquor remaining after extraction (the raffinate) was transferred to four subterranean storage tanks.

The resulting PFR raffinate is a highly acidic liquor based on nitric acid. The liquor contains a complex mixture of dissolved metals, principally sodium, copper, cadmium and iron, with the balance being various dissolved fission and activation products and actinides. A small quantity of solid particles is also present. The total volume of raffinate to be packaged is approximately 206m³.

In addition, UKAEA has also proposed that an existing stock of 0.46 m³ of plutonium nitrate solution be added to the one of the PFR raffinate tanks and the mixture processed as for standard PFR raffinate.

PFR raffinate is a highly active waste stream with a specific activity towards the upper end of the range normally encountered for ILW. It represents the most active waste stream stored on the Dounreay site. The proposals potentially encompass the production of up to about 750 packages containing homogeneous immobilised waste. The inventories of the proposed packages are amongst the highest expected for ILW and the bounding case is close to the limit for transport as ILW. Furthermore, the waste represents a major fraction of the total inventory of a number of radionuclides in ILW.

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

Packaging proposals

The raffinate would be homogenised and then retrieved in batches of approximately 1 m³ to a receipt and neutralisation tank. Each batch would be sampled and analysed to provide radionuclide and compositional data and to provide the basis for determining the necessary neutralisation conditions. A combination of calcium hydroxide and sodium hydroxide would be used for neutralisation, as this prevents excessive heat generation during reaction and provides optimum wasteform stability.

The neutralised PFR raffinate would be conditioned through use of the proposed new waste packaging plant at Dounreay using the liquids processing line. The container would be the liquids variant of the drum designed for use in this plant (a stainless steel 500 litre drum to be consistent with Nirex standards and specifications).

The neutralised raffinate would be dispensed to the drums and immobilised by an in-drum mixing process driven by a sacrificial paddle that subsequently would be retained within the wasteform. The immobilising material would be a 1:1 mixture of pulverised fuel ash and ordinary Portland cement (PFA/OPC) powders. Once cured, the wasteform would be capped with a standard 3:1 PFA/OPC grout.

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 for PFR raffinate and the added plutonium nitrate solution. This waste has been extensively characterised and this basis for the assessment inventory also will inform the radionuclide fingerprints to be used in deriving waste package inventory data.

The proposed waste packages examined herein are consistent with the requirements of the Nirex GWPS and the process has been judged to follow established practice by waste producers for the immobilisation and packaging of liquid wastes. Extensive development work has been undertaken by UKAEA, based on both simulants and samples of the actual waste. The process also has been demonstrated at full-scale using simulants of the raffinate stored in each of the different tanks. This development work has been assessed by Nirex and provides confidence that a good quality wasteform could be produced by the immobilisation of PFR raffinate in a cement matrix.

The assessment of transport safety shows that it will be possible for drums of PFR raffinate to comply with all relevant criteria if transported in 285 mm thick walled Type B transport containers such as the Nirex Standard Waste Transport Container (SWTC-285). In particular, the modelling of impact and fire behaviour for groups of four packages in an SWTC-285 shows that the criterion of activity released in a week following a transport accident would be met. The bounding inventory potentially challenges the activity limit for the loading of a transport container if four such packages are transported together. UKAEA has therefore undertaken to manage the loading of transport containers to ensure compliance with the limit.

Similarly, the assessment of operational safety shows that it should be possible for 500 litre drums containing PFR raffinate to be handled and stored safely within the repository. Although the current assessment indicates assessed doses that, in the worst cases, approach significant fractions of the limits applied by Nirex, consideration of the conservatism in the assessments and expected future revisions to methodologies and assumed parameters would be expected to reduce the assessed doses considerably. It is concluded that this provides robustness against any future revisions to risk or dose targets.

The potential long-term risk resulting from the disposal of the PFR raffinate has been assessed by modifying the existing post-closure assessment to include this waste. Although the inventory associated with individual packages is significant, the total inventory for disposal is such that overall assessed risk is not significantly increased. The bounding heat output is close to the limit applicable at the expected time of backfilling a repository. Nonetheless, any packages approaching this limit in practice could be accommodated by management measures. Overall, the post-closure assessment revealed no significant issues that should prejudice disposal of packages containing PFR raffinate.

A safe fissile mass for the proposed packages has been established, which would ensure that a criticality would be unlikely during transport or operations, or in the post-closure period. The assessment inventory complies with this safe fissile mass, showing that the packages would not present a criticality hazard.

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

Requirements for further development work

The design of the store will be undertaken prior to a Final stage submission for PFR raffinate. It is important that Nirex requirements for the control of environmental conditions and monitoring of the condition of packages are taken into account in the design process, to ensure package longevity. Early interactions with Nirex on this issue are therefore essential, and these issues should be resolved during the design process, prior to a Final stage submission.

At the Final stage, it is required that the necessary arrangements for the operation of the proposed packaging plant should be agreed and demonstrated through the following:

- demonstration of the satisfactory operation of the completed plant by providing the results of commissioning activities;
- development of the (Quality) Management System for the operation of the packaging plant, in particular the plant for packaging liquid wastes;
- documentation of the endorsed packaging process through issue of an approved Waste Product Specification (WPrS) for the immobilisation of PFR raffinate;
- provision of approved Criticality Compliance Assurance Documentation (CCAD);
- provision of detailed proposals for producing waste package records;
- specification of the arrangement for the storage of completed waste packages (noting the need for early interaction on the design of the store discussed above);
- continuing provision of evidence that activities such as plant commissioning and development work have been, and will be, performed under a suitable (Quality) Management System.

At this time, Nirex is not aware of any issues relating to the current endorsement that require specific development work.

Conclusions

The assessment of the proposals has concluded that packages containing PFR raffinate are potentially consistent with disposal under the PGRC and can be endorsed at the Interim stage. The consistency of the proposed waste packages with the PGRC has been demonstrated through the provision of an Assessment of Disposability.