

Packaging of PFR Decommissioning ILW

(Conceptual stage)

Summary of Assessment Report

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Background

UKAEA has sought Conceptual stage endorsement of the proposed packaging of the intermediate level waste (ILW) that would arise from the decommissioning of the Prototype Fast Reactor (PFR) at Dounreay. The proposals are currently at an early stage of development and UKAEA has sought guidance from NDA Radioactive Waste Management Directorate (RWMD) to help establish the most appropriate approach. In particular, UKAEA has sought guidance on the most appropriate type of waste container, taking due account of the nature of the waste.

This document summarises the results of the assessment carried out by NDA RWMD in response to the submitted proposals. The assessment has been carried-out as part of the Letter of Compliance process, whereby NDA RWMD 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 elsewhere¹.

The Scottish Government has announced a policy for the long-term management of radioactive wastes currently held on sites in Scotland that is based on near-site, near-surface storage, rather than geological disposal. This assessment has not considered the compatibility of the proposals with near-site, near-surface storage option.

Scope of the Proposals

The decommissioning of the entire PFR reactor vessel is expected to result in a relatively large volume of waste, much of which will be low level waste (LLW). The volume and nature of the ILW is not known with certainty and would be established in detail only when decommissioning is undertaken. Consequently, this assessment is based on an assumed quantity of ILW based on modelling of the activation of the reactor core structure and its radiation shielding. The waste is expected to comprise a range of activated steel components and graphite reflector rods. Due to the high neutron flux in PFR, the inventories of activation products are substantial but potentially quite short-lived.

The decommissioning operations for the reactor would be undertaken using a facility to be constructed over the containment vessel, denoted the Reactor Decommissioning Facility (RDF). To allow the construction and operation of the RDF, various shielded storage areas need to be cleared and some upper parts of the reactor need to be removed. Consequently, a separate packaging facility would be constructed to handle these wastes, denoted the Size Reduction Facility (SRF). Consequently, the PFR decommissioning ILW considered comprises two fractions, as follows:

- the principal decommissioning wastes to be excised from the primary vessel itself (the RDF wastes);

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

- the operational wastes currently stored within mortuary holes and caves in the reactor hall and those upper reactor components that must be removed to facilitate the construction of the RDF (the SRF wastes).

The total volume of ILW considered in the assessment is 425 m³. The volume of waste would give rise to between 39 and 159 ILW waste packages (depending on the waste package type) containing, on average, a moderate radionuclide inventory dominated by short-lived radionuclides such as Co-60.

Regulators have recently issued a draft revision to the guidance on the regulatory arrangements for the conditioning of ILW². This introduces a categorisation scheme for conditioning proposals, based on the perceived significance of the waste and the packaging process. It is proposed that the current proposals would fall under Category X (projects or modifications that regulators wish to be given advance notice of and may wish to consider for assessment).

Packaging Proposals

The proposed methods of processing and packaging of the waste in the SRF and RDF is essentially the same and, at the Conceptual stage, it is not necessary to consider detailed differences in the processes. Consequently, the proposed process may be summarised as follows:

- retrieval of the waste, accompanied by size reduction as necessary (retrieved items would be size-reduced in the SRF, whereas RDF wastes would be size-reduced *in situ* during retrieval);
- pre-treatment of the waste to remove residual sodium coolant by steam-cleaning;
- loading into containers using suitable furniture;
- immobilisation of the waste by infiltration with 3:1 PFA/OPC grout;
- capping and lidding of the containers prior to storage.

The packaging of any debris arising from retrieval operations is not explicitly considered in the current submission, although ultimately it would be necessary to develop suitable processes for such wastes.

UKAEA has sought guidance as to the most appropriate container(s) for the waste. In the case of the RDF wastes, UKAEA has suggested that either the 3m³ box or the 2m box should be considered. This recognises that the waste may be relatively bulky and might be most effectively completed using containers larger than 500 litre drums. The possible use of the larger 4m box was not considered in the submission. Nevertheless, to include the full range of possible options, the current assessment also considers the 4m box for RDF wastes.

The SRF wastes give a lesser volume of smaller items of waste. It has therefore been proposed that these wastes could be packaged in 500 litre drums, using a drum design developed previously for the packaging of solid ILW at Dounreay. Alternatively, the SRF waste would be packaged using the same container as adopted for the RDF wastes.

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).

² *The Management of Radioactive Waste on Nuclear Licensed Sites – Guidance from HSE, EA and SEPA to Licensees. Part 1: The Regulatory Process*, draft document for consultation, February 2007 (NDA document reference #527516)

The Assessment of Disposability is based upon inventory data obtained from the modelling of the irradiation of reactor components in PFR, as supplied by UKAEA. These data have been used to develop average and bounding assessment inventories constrained by the limits on the mass of packages.

For the purposes of assessment, the bounding inventories have been based on the co-packaging of the most highly activated components within a single package. This conservative approach gives inventories of short-lived radionuclides such as Co-60 that initially are relatively large and is influential on the conclusions of the assessment.

Separate data for the SRF wastes has been used to define the assessment inventory for the 500 litre drums, although this inventory is relatively small compared to that of the RDF wastes (less than 25% of the volume). Therefore for the other packages it has been assumed that any variations due to the co-packaging of RDF and SRF wastes would be covered by the bounding inventory for the RDF wastes alone.

The proposed waste packages have been examined in two groups:

- packages based on the 500 litre drums and 3m³ boxes – unshielded waste packages that would have to be remote-handled due to the high dose-rates and which would be transported in a separate, shielded container such as the Standard Waste Transport Container (SWTC) (Type B arrangements under IAEA Transport Regulations);
- packages based on the 2m and 4m boxes – self-shielded waste packages (where shielding is built into the container) that would be intended to be contact-handled. Such packages would not be transported in a separate transport container and would be classed as Industrial Packages under IAEA Transport Regulations.

The requirements for the transport of packages and their handling and emplacement at a repository are significantly different for these two types of package. This is recognised in the GWPS and the various proposed packages have been judged against the relevant criteria.

Overall, the general process has been judged to follow established practice by waste producers for the immobilisation and packaging of solid wastes. Existing development work and general information has been assessed by NDA RWMD and provides confidence that a wasteform of sufficient quality could be produced for all container options.

The proposed 500 litre drums and 3m³ boxes would be compliant with the requirements of the GWPS, provided that the current bounding inventories could be reduced by a moderate factor. It has been judged that such a reduction readily could be achieved through measures such as the management of the loading of waste to control the final dose-rate, a short period of decay storage beyond the assumed transport date of 2040 and more accurate modelling of dose-rates and irradiation.

In contrast, the proposed 2m and 4m boxes are judged not to be compliant with the relevant requirements. The necessary reductions in the bounding inventories would be large and, in the absence of detailed proposals for any mitigating measures, it is judged inappropriate to conclude that such reductions are plausible. Furthermore, wastes to be transported in Industrial Packages must comply with the requirements for Low Specific Activity (LSA) material. The expected dose-rates for the waste itself and the potentially inhomogeneous distribution of activity challenge the requirements for LSA material.

The conclusions of the assessment of transport safety reflect those of the review against the GWPS discussed above. The proposed 500 litre drums and 3m³ boxes, if transported in thick-walled Type B transport container such as the SWTC-285, would be consistent with the regulations if transported in 2040. The modelling of impact and fire behaviour for packages consigned in an SWTC-285 shows that the criterion of activity released in a week following a transport accident would be met. The bounding assessment inventory would exceed the dose-rate and heat output criteria in 2040, but it has been accepted that moderate measures such as those outlined above would resolve these apparent inconsistencies.

In the case of the proposed 2m and 4m boxes, it has been concluded that the waste packages would not be consistent with requirements for transport as Industrial Packages. In particular, the necessary reductions in external dose-rates and heat output to comply with the more stringent criteria applied to Industrial Packages are not judged to be plausible. Furthermore, as noted above it is not clear that the waste would be consistent with the requirements of LSA material.

The assessment of operational safety shows that it should be possible for the packages based on 500 litre drums and 3m³ boxes to be handled and stored safely within the repository. The dose-rates arising from packages containing the bounding assessment inventory would challenge the constraints on dose to workers in normal operations, but the measures necessary to meet the transport requirements would also mitigate these risks. Conversely, the 2m and 4m boxes containing the bounding inventory would give rise to significant doses during normal operations, particularly as these packages are considered to be contact-handled in the repository. The resulting risks are sufficient to preclude endorsement of these packages at this time.

It is noted that 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. Nonetheless, although this provides robustness against any future revisions to risk or dose targets, it is not possible to allow for such changes in the current assessments.

The potential long-term risk resulting from the disposal of the PFR decommissioning ILW has been assessed. The inventory associated with individual packages is generally not significant, with the exception of the quantity of carbon-14, which could exceed the annual risk target of 10⁻⁶ if it were to be released at the rate suggested by the modelling of release through corrosion of the waste. This conclusion reflects the general, conservative position that the inventory of carbon-14 associated with decommissioning wastes is challenging. This is considered a generic issue and research is continuing to define the true level of risk. Consequently, the potential risk from carbon-14 does not preclude the endorsement of the packaging of PFR decommissioning ILW.

The fissile material associated with the PFR decommissioning ILW is assumed to arise from the activation of naturally-occurring thorium and uranium impurities in the wastes. It is currently assumed that the level of fuel contamination of these wastes would be negligible. The resulting quantities of fissile material are less than 15g per package and are consistent with a screening level of 50g per package. It is therefore concluded that the risk of a criticality due to these wastes is not significant.

In order that wastes could be transported in the current designs of Industrial Package, it would be necessary to demonstrate that the waste was fissile-excepted. This would be possible based on the currently assumed fissile loadings but could be challenged by the requirement to demonstrate that the quantity of beryllium would be negligible. This issue introduces further constraints on the endorsement of the 2m and 4m boxes.

In summary, the Assessment of Disposability has concluded that packages containing PFR decommissioning ILW packaged into 500 litre drums and/or 3m³ boxes are potentially acceptable and can be endorsed at the Conceptual stage. In contrast, a number of significant issues have been identified for the packages based on 2m and 4m boxes and, at present, it is not possible to endorse these packages 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 these are summarised below.

Requirements for further development work

The proposed packaging of PFR decommissioning ILW using 500 litre drums or 3m³ boxes can be endorsed at the Conceptual stage. On this basis, the principal requirements for further development, to be reported at the Interim stage, would be as follows:

- provision of improved and less conservative assessment inventory;
- development of proposals for the management of the loading of waste into packages;
- confirmation that the effects of radiolysis would be tolerable for the maximum inventory packages, including consideration of the period of on-site storage;
- development and demonstration of a process for the removal of Na contamination;
- development of processes for the separate immobilisation of operational wastes;
- finalisation of the container designs, including furniture;
- further development of proposals for producing waste package records;
- specification of the conditions for the storage of completed waste packages (subsequent to interactions with NDA on store design);
- provision of evidence that activities such as development work have been, and will be, performed under a suitable (Quality) Management System.

The potential effects of the release of mobile, gaseous species containing C-14 are recognised as a generic issue and would be addressed separately.

It has been concluded that the packaging of the wastes using the 2m or 4m box containers cannot be endorsed at this time. Prior to such an endorsement, the following issues would need to be addressed satisfactorily:

- demonstration that the waste was consistent with the requirements for LSA material, as defined in the IAEA Transport Regulations;
- demonstration that the maximum external dose-rates and heat output would be consistent with requirements for safe transport, and for safe handling and continued storage of the packages at a repository;
- demonstration that the 4m box packages could be transported by road.

It is recognised that some of these challenges have arisen from the conservative approach to the definition of bounding radionuclide inventories. A number of opportunities to significantly reduce the bounding inventories have been identified but their acceptance would require explicit substantiation of the actual reductions that could be achieved. It is further noted that, should the issues specific to the 2m and/or 4m boxes be resolved satisfactorily, the list of issues to be resolved at the Interim stage given above also would apply to these packages.

Conclusions

The assessment of the proposals has concluded that packages based on the use of 500 litre drums and/or 3m³ boxes can be shown to be consistent with disposal under the PGRC and therefore these packaging options can be endorsed at the Conceptual stage.

The assessment of the proposals has concluded that packages based on the use of 2m and/or 4m boxes cannot yet be demonstrated to be consistent with disposal under the PGRC and therefore these packaging options cannot be endorsed at the Conceptual stage.

The consistency of the proposed waste packages with the PGRC has been considered through the provision of an Assessment of Disposability.