Radioactive Waste Management Directorate

Packaging of Dounreay PFR Effluent Treatment Plant (Conceptual stage)

Summary of Assessment Report

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Background

UKAEA has tendered a submission seeking Conceptual Stage endorsement of the proposed packaging process for the Ion Exchange (IEX) columns that would arise from the operation of the Effluent Treatment Plant (ETP) to be constructed at Dounreay to treat the effluents produced during the decommissioning of the Prototype Fast Reactor (PFR) (the PFR ETP IEX columns). The submission builds upon previous proposals for the packaging of other, similar IEX columns arising from other treatment plants to be constructed at Dounreay.

It is anticipated that up to 10 IEX columns would be produced by the PFR ETP, which would result in the production of 10 waste packages based on current packaging proposals. The radionuclide inventory is dominated by relatively short-lived soluble species such as Cs137, and the wastes do not make a significant contribution to the total inventory of any radionuclide considered in the Nirex Phased Geological Repository Concept (PGRC).

Nirex has previously considered proposals for the packaging of four other waste streams based on the IEX columns to be produced by treatment plants at Dounreay, as follows:

- PFR sodium destruction plant (SDP);
- PFR pond treatment plant;
- DFR NaK destruction plant (NDP);
- DFR pond treatment plant.

These wastes, and the associated packaging proposals, are sufficiently similar to each other and to those for PFR ETP IEX columns as to be covered by a single Assessment of Disposability covering all five waste streams. This recognises the commonality of the necessary development work and encourages efficiency.

These plants are anticipated to produce a further 37 IEX columns, which would result in the production of some 47 waste packages in total, when added to those resulting from PFR ETP operations. As with the above, these wastes do not make a significant contribution to the total inventory of any radionuclide considered in the PGRC.

Packaging Proposals

The waste comprises a variety of granular inorganic IEX materials contained within stainless steel columns. The PFR ETP is expected to employ a range of materials to absorb both Cs137 and a range of other radionuclides such as Co60. The other plants listed above would employ similar materials. The designs of the columns to be used in individual plants differ in detail, but all have a capacity of about 80 dm^3. It is currently intended that each column, or its contents, would be packaged separately.

It is understood that following removal from service, columns would be air-dried and stored for an interim period in retrievable fashion within dedicated storage containers. The duration of the interim storage period would be determined by the availability of the proposed new packaging plant at Dounreay.

UKAEA has put forward two options for the final packaging of the IEX materials, as follows:

- immobilisation of the IEX material in situ within the columns using a polymer, and subsequently grouting the infiltrated column into a stainless steel 500 litre drum using a cement grout (this option is denoted the infiltrated product);
- emptying of the IEX material from a column into a stainless steel 500 litre drum and mixing with cement powder (this option is denoted the in-drum mixed product).

Consistent with expectations at the Conceptual Stage, the details of both packaging processes remain to be fully developed and demonstrated.

Assessment of Disposability

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

The Assessment of Disposability is based upon the inventory data supplied by UKAEA, based on the assumed in service performance of the various IEX materials. In order to allow assessment of all Dounreay IEX columns, the average and maximum package inventories have been designed to bound those of all the various packages.

Both options are consistent with the requirements of the Nirex GWPS and have been judged to follow established practice. Nonetheless, it has been judged that the infiltrated product offers a number of significant advantages, in particular a high degree of protection of the waste and the immobilisation of mobile activity, and this option is to be preferred.

The assessment of Transport Safety showed that it should be possible for 500 litre drums containing Dounreay IEX materials to comply with all relevant transport safety criteria if transported in a Type B transport container with 285mm thick walls, such as the RSTC-285. The conservative treatment adopted in the assessments has highlighted tritium release during transport as a possible concern. Nevertheless, reasoned arguments regarding hold-up by the transport container and the packaging, especially the containment offered by the infiltrated product, and the belief that the bounding assessment inventory is conservative, allows the conclusion that this conservative treatment does not preclude endorsement.

Similarly, the assessments of Operational Safety show that it should be possible for 500 litre drums containing Dounreay IEX materials to be handled and stored safely within a repository based on the PGRC. The conservative treatment adopted in these assessments also highlighted tritium release as potentially dominating the expected risk. Nevertheless, reasoned arguments regarding hold-up by the packaging offered by the infiltrated product, and the expectation that the bounding assessment inventory is a conservative representation of the tritium inventory, show that this product would provide enhanced safety as compared to the in-drum mixed product. This preference is reinforced by the observation that the key accident scenarios are based on fire accidents, where the presence of an inactive grout annulus means that the performance of the infiltrated product is expected to be superior. Nonetheless, both proposed products are potentially acceptable.

The post-closure safety assessment revealed no significant areas of concern that should prejudice disposal of packages containing Dounreay IEX columns. This is due to the relatively small number of packages containing the materials, and the small and relatively short-lived inventory associated with them.

The polymers to be used encapsulation materials are typically relatively stable thermosetting polymers that are resistant to degradation and therefore are not expected to challenge the assumptions made in the PGRC. This position is judged to be sufficient to endorse the use of the material at the Conceptual Stage, particularly when weighed against the advantages of good infiltration and protection of the waste offered by the material.

The bounding assessment inventory includes a moderate quantity of fissile material that is within the screening level of 50g. Furthermore, the current maximum fissile loading is subject to conservative assumptions regarding the selectivity of the IEX materials, and may be revised downwards at a later stage. Consequently, it has been concluded that proposed package 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 Dounreay IEX columns, and that the proposals for the packaging of PFR ETP IEX columns 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 assessment demonstrated that the infiltrated product could be expected to be superior to that of the in-drum mixed produce, and the consideration of further work was based on the assumption that this option would be adopted as the primary focus of any further development work.

The following characteristics of packages based on the polymer-infiltration of IEX columns are especially significant from the point of view of the repository design and safety cases:

- the high degree of protection of the IEX material offered by the grout annulus surrounding the infiltrated column, in particular the essentially zero releases expected under impact conditions and the thermal barrier offered by the thick grout annulus;
- the capability of fluid polymer to infiltrate the fine voidage in the packed column containing IEX materials;
- the immobilisation of mobile species (Cs137 and tritium) by polymer, preventing migration of these species into the grout annulus;
- the minimisation of tritium releases from the waste package (based on the conservative assumption that tritium is present in significant quantities);
- the longevity of the wasteform, relative to the half-lives of the key radionuclides present (Cs137 and tritium);
- the low rates of gas generation from radiolysis and corrosion, even for relatively high loadings of Cs137.

The identification of these key characteristics provides a focus for development work, with the design, demonstration and justification of the polymer infiltration being the principal requirement. It is further noted that any such development would need to be based on a suitable simulant of the waste that took due account of any ageing effects that might occur during storage prior to final packaging.

Conclusions

The assessment of the proposals has concluded that both options for the packaging of PFR ETP IEX columns are potentially consistent with disposal under the Nirex Phased Geological Repository Concept (PGRC) and can be endorsed at the Conceptual Stage. Consideration of the relative merits of the two options indicates that the infiltrated product is to be preferred, on the basis that it would provide a high degree of protection of the waste and that mobile species (Cs137 and potentially tritium) would be fully immobilised. The in-drum mixed product should be considered to be a fall-back option in the event that the infiltrated product cannot be successfully developed.

The operation of the PFR ETP represents the best opportunity to capture many key data that eventually would be required to generate radionuclide inventory for the waste packages. Consequently, the data to be collected during plant operations must be agreed with Nirex before the plant operates.