

Packaging of Prototype Fast Reactor (PFR) Raffinate at Dounreay (Final Stage)

Summary of Assessment Report

Issue date of Assessment Report: 22nd May 2018

EXECUTIVE SUMMARY

Background

Radioactive Waste Management Limited (hereafter RWM) has undertaken a Final stage Disposability Assessment for the proposals by Dounreay Site Restoration Limited (DSRL) for the packaging of Prototype Fast Reactor (PFR) raffinate at the Dounreay site.

The objectives of this Final stage assessment of proposals for packages of PFR raffinate are to provide DSRL with:

- an assessment of disposability in accordance with the Joint Regulators' Guidance to Industry
- supporting advice on disposability of PFR raffinate to DSRL in the form of an Assessment Report
- where appropriate, endorsement of the proposals via issue of a Letter of Compliance (LoC).

Further information on the Disposability Assessment process is available elsewhere¹.

PFR raffinate is one of several liquid waste streams stored on the Dounreay site that requires immobilisation as part of hazard reduction. In 2005, DSRL made an Interim Stage Letter of Compliance (ILoC) submission to RWM for the immobilisation of PFR raffinate within a new facility to be known as D3900. Endorsement of those Interim stage proposals were provided in 2006. However, site strategies have evolved such that D3900 is no longer required, and DSRL has therefore developed an alternative processing route for the PFR raffinate through the existing Dounreay Cementation Plant (DCP).

The DCP was originally designed to immobilise first cycle raffinate from reprocessing of Materials Test Reactor (MTR) fuel as ILW within 500 litre drums. It has since been used for the packaging of all MTR raffinate and all Dounreay Fast Reactor (DFR) raffinate. DSRL has now modified the DCP to allow the immobilisation of PFR raffinate.

RWM Reference Basis for Assessment and Endorsement

The Disposability Assessment process considers the compatibility of the proposed packages with the requirements for safe long-term management, including interim storage at the site of arising, transport, emplacement and

¹ *An Overview of the RWM Disposability Assessment Process*, WPS/650/03, April 2014.

potentially extended storage underground, and disposal. The current reference basis for such an assessment is the documented disposal system concept and safety case for a Geological Disposal Facility (GDF) derived from the generic 2010 Disposal System Safety Case (DSSC).

Scottish Government policy specifies long-term near surface, near site storage and disposal facilities, so that the waste can be monitored and is retrievable. Foreclosure of options should be minimised, consistent with the requirement for passive safety during storage. The regulators' view is that packages conditioned in anticipation of geological disposal, and assessed under the Letter of Compliance process, will also be suitable for long-term storage in accordance with Government policy in Scotland.

The general requirements placed on waste packages for disposal in a GDF are embodied in the Generic Waste Package Specification (GWPS)². Further requirements for particular types of waste package are embodied in the relevant Waste Package Specification (WPS). In this case the relevant WPS is WPS/300/03³.

Scope of the Assessment

PFR raffinate arose from the reprocessing of irradiated and un-irradiated PFR fuel and is currently stored in four purpose-built High Active Liquor Storage (HALS) tanks on the Dounreay site. It is also proposed to add 490 litres of plutonium nitrate solution residual from the reprocessing operations at Dounreay, of a similar isotopic/chemical composition to the raffinate, to the raffinate, prior to packaging. The heels that will be retained in the HALS tanks after processing of PFR raffinate are excluded from the submission and the RWM assessment. The PFR raffinate is included in the UK Radioactive Waste Inventory (UKRWI) as waste stream 5B01 - PFR raffinate.

Packaging Process

Nature of the Waste

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 PFR raffinate waste stream was a Bounding Waste Stream in the 2010 generic Disposal System Safety Case (gDSSC).

PFR raffinate is a highly acidic liquor (nitric acid digest) containing a complex mixture of dissolved metals, principally sodium, copper, cadmium and iron, with various dissolved fission and activation products and actinides. Small quantities of solid particles are also present in the liquor. The total volume of raffinate to be packaged is approximately 212 m³.

Waste Processing and Packaging

Batches of raffinate (from Tanks 13-16) would be pumped into an empty tank (Tank 17 or 18) to blend them. These would typically be a quarter of each tanks' initial raffinate volume, so that four ~50 m³ blended batches would be

² NDA, *Generic Waste Package Specification*, NDA Report NDA/RWMD/067, March 2012.

³ NDA, *Geological Disposal: Waste package specification for 500 litre drum waste packages*, WPS/300/03, January 2013

produced. The blended raffinate in the tank would then be sampled and analysed to confirm its radiological and non-radiological characteristics.

Batches of raffinate (each 3m³) would then be transferred to the DCP Reception Vessel (DCP-RV), where they would be sampled and analysed. Based on the analyses the required volumes of sodium hydroxide (17.6M) to neutralise the PFR raffinate would be calculated. The blended raffinate would then be transferred to the DCP Mixing Vessel (DCP-MV) where it would be neutralised with NaOH to a pH>10.5. The actual volume of NaOH added to the raffinate would be recorded and the neutralised raffinate would be sampled and analysed.

Dry cement powders, containing a mix of Ordinary Portland Cement (OPC), Pulverised Fuel Ash (PFA) and lime would be metered into a hopper above the DCP mixing cell. Aliquots of the cooled, neutralised raffinate would be transferred into a 500 litre Mk3 drum (lost paddle design of 500 litre drum), via a 328 litre transfer pot. The cement powders would then be added at a controlled rate, and the contents mixed for a further 20 minutes from final powder addition. These product drums would then be left to cure before being lidded, monitored for surface contamination and then stored.

Assessment Inventory and Number of Packages

For assessment purposes, DSRL provided an estimated average PFR raffinate waste package radionuclide inventory based on historical sampling and analysis of the raffinate in the tanks and accounting for plutonium nitrate addition, and on the volume of raffinate to be packaged. RWM used the average waste package inventory provided by DSRL, decaying the inventory to 2040, the earliest date for transport assumed in the gDSSC, and 2150, the planned date for GDF closure in the 2010 gDSSC.

RWM produced a conservative maximum package radionuclide inventory by selecting the highest specific activity of raffinate in the HALS tanks for each radionuclide and multiplying by an uncertainty factor (of between 1.1 and 2.0) that reflects the analytical uncertainty in the derivation of the activity of each radionuclide. The maximum waste package radionuclide inventory was decayed to 2040. It is estimated that 887 waste packages will be produced.

Assessment of Disposability

Waste Package Properties and Performance

DSRL has undertaken extensive wasteform development work. The development work included small, medium and full-scale inactive trials, active trials, working envelope trials and neutralisation trials. It resulted in a proposed reference formulation and working envelope suitable for use in DCP and provided information to demonstrate the properties and stability of a wasteform produced from PFR raffinate.

The wasteforms produced during the trials were shown to be robust, homogenous and monolithic. With the absence of any predictable degradation mechanism and the reported dimensional stability measurements, it is concluded that the wasteform would remain essentially monolithic under interim storage, transport and GDF operational conditions. PFR raffinate waste packages are not expected to be a significant source of radioactive

gases, although they are expected to produce some hydrogen from radiolysis of water.

The fire and impact accident performance of these waste packages is assessed to be predictable and releases are a low fraction of the package inventory. The estimated release fractions for the PFR raffinate wasteform provide conservative prediction of the performance of these waste packages under credible accident scenarios.

Compatibility with Specification

This assessment confirms that the packages would be expected to comply with the requirements of the Waste Package Specification for the 500 litre drum (WPS/300/03).

Compliance with the Transport System Design and Safety Case

The waste packaging proposal has been checked against the IAEA Transport Regulations in terms of limits placed upon the radionuclide content, dose rates, pressurisation under normal conditions of transport, containment under normal conditions of transport, containment under accident conditions of transport, criticality and other dangerous properties. The waste packaging proposal was found to be compliant with each of the limits.

Compliance with Engineering Design and the Operational Safety Case

The package is a standard 500 litre drum, and is compliant with the engineering design for a GDF. It is noted that the drums would need to be loaded to a transport and disposal stillage on export from Dounreay to be compliant with plans for a GDF.

The PFR waste packages are expected to be capable of complying with a fully developed Operational Safety Case (OSC) for a GDF. At this stage of OSC development, this assessment estimates the Design Basis Accident doses for impact faults for the PFR raffinate waste packages to be high and just above the maximum DBA worker doses in the 2010 gOSC. RWM recognises that there are a number of significant conservatisms involved in the derivation of the impact fault Release Fraction. Furthermore, the OSC is only at the preliminary stage of development and additional measures to reduce doses further will also be considered by RWM as the disposal concept develops.

The generic criticality safety assessment for High Enriched Uranium is applicable to this waste package, and the package is expected to be compliant. Overall, it is concluded that the waste packaging proposal would be compliant with each of the limits.

Compliance with the Environmental Safety Case

This waste package is not expected to be a significant source of radioactive gases. The assessment concluded that the potential off-site doses from gases discharged from this waste stream during GDF operations would not challenge requirements.

The GDF post-closure safety assessment screening stage identified 24 radionuclides as being present in the PFR raffinate waste stream in amounts greater than 1% of the total Unshielded ILW activity planned for a GDF. Of these, I-129 is the most significant for the post-closure groundwater pathway, comprising around 4% of the total I-129 inventory in total UILW. For the post-

closure gas pathway, there are no significant quantities of radioactive species in PFR Raffinate in a form that would be transported in a gas phase. The generic criticality safety assessment for High Enriched Uranium is applicable to this waste package and the package is expected to be compliant. The package is also compliant with the probabilistic low-likelihood package envelope for long-term criticality safety.

RWM is currently undertaking ongoing work on chemo-toxics in the context of the Water Framework Directive and the Groundwater Daughter Directive. RWM identifies a risk against any Letter of Compliance as the future acceptability in a GDF is dependent on a successful outcome to the ongoing development work and the engagement of RWM with the relevant regulators.

DSRL made a case for the omission of a capping grout, which had been present in previous proposals. The addition of a capping grout at a later stage should not be precluded in case it is deemed necessary to reduce voidage for the optimised disposal concept for the selected host rock.

Overall, RWM considers that the PFR raffinate cemented in 500 litre waste packages would be compliant with the disposal system safety requirements as currently foreseen.

Status of Management System and Data Recording

RWM has reviewed the updated key management system documents, the Data Recording Methodology and the Package Record Specification. The data recording system for producing waste package records is now assessed to be acceptable. It is noted that DSRL is currently making decisions on how waste package records from site-wide packaging operations will be managed in the long term. DSRL will be developing its long term strategy during 2018.

DSRL has supplied approved versions of Management System documents, including Quality Plans, operating instructions, evidence of internal assurance activities and a Standard for management of non-conforming waste packages. These provide RWM with confidence that the PFR Raffinate cemented in 500 litre waste packages would be manufactured and stored in compliance with the Waste Product Specification and Criticality Compliance Assurance Documentation.

Conclusions of Assessment of Disposability

RWM has concluded that there are a small number of potential future requirements that do not preclude endorsement, and which can be addressed as qualifications to the endorsement. The proposed PFR raffinate waste packages have been found to be consistent with RWM requirements as currently foreseen and therefore are considered disposable.

Conclusions

The Final stage Disposability Assessment undertaken for the proposals to package PFR raffinate at the Dounreay Cementation Plant has considered the consistency of the proposed packages with RWM requirements for safe long-term management, including interim storage at the site of arising, transport, emplacement and extended storage underground, and geological disposal. It is concluded that the proposed waste packages are consistent with RWM requirements as currently foreseen and therefore the packages are endorsed

at the Final stage. Six qualifications have been raised against this endorsement.