Radioactive Waste Management

Omission of Capping Grout and Drum Modifications for packaging of PFR Raffinate (Advice Prior to Final Stage Submission)

Summary of Assessment Report

Issue date of Assessment Report: 21 December 2016

Background

Prior to the drafting of a Final Letter of Compliance (FLoC) submission, DSRL is seeking advice from Radioactive Waste Management Ltd (RWM) on modification of its plans to package Prototype Fast Reactor (PFR) raffinate. Specifically, DSRL proposes to omit a grout cap from the wasteform and to modify the design of the proposed 500 litre drum waste container.

PFR raffinate is one of several liquid waste streams stored on the Dounreay site that requires immobilisation as part of hazard reduction. In 2005, Dounreay 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 was provided in 2006. However, site strategies have evolved such that D3900 is no longer required, and Dounreay has therefore developed an alternative processing route for the PFR raffinate through the existing Dounreay Cementation Plant (DCP). The proposal to use DCP requires changes to the endorsed Interim stage proposals.

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 now proposes to modify DCP to allow the immobilisation of a third raffinate, namely PFR raffinate.

All three raffinates would be packaged using a similar process; the acid raffinate liquor is neutralised then mixed with cement powders within a lost paddle 500 litre drum (in-drum mixing). However, the packaging process for PFR raffinate differs from that for which DCP is currently configured. The packaging process for PFR raffinate would originally have utilised the Mark 2 500 litre drum, designed for the D3900 facility. Some modifications to the drum are required to allow it to correctly interface with the DCP. The modified waste container will be called the Mark 3 500 litre Liquids Drum.

Further, as part of the defining the modifications to the DCP to accommodate the processing of PFR raffinate, DSRL has presented a case to RWM for the omission of the inactive grout cap from the wasteforms. The drivers for omitting the cap are proposed to be associated with:

- The much higher activity of the PFR raffinate compared to the other raffinates, and the spread of contamination at the existing DCP capping station, would affect the ability to maintain equipment;
- The cost and timescales of activities to modify DCP to provide additional containment at the capping station are substantial.
- The additional time required for the PFR raffinate wasteform to cure, affecting packaging plant throughput rate if a capping grout process needs to be retained;

DSRL argues that the benefits of the capping grout for disposability are small compared to the changes to the plant that would be required. As such, DSRL has asked RWM to undertake an assessment of its proposals for the omission of the grout cap in order to inform the drafting of a Final Letter of Compliance (FLoC) submission.

RWM Reference Basis for Assessment and Endorsement

Disposability assessment considers the compatibility of the proposed packages with the requirements for safe long-term management, including storage, transport, emplacement and potentially extended storage underground, and disposal. The current reference basis for this assessment of disposability is the conceptual designs for a Geological Disposal Facility (GDF) derived from the recently-published generic Disposal System Safety Case (DSSC). Further information on the Disposability Assessment process is available elsewhere[1].
The general requirements placed on ILW packages for disposal in a GDF are embodied in the Generic Waste Package Specification (GWPS)[2].

Scope of the Assessment

This Assessment Report is based on the information provided in the submitted documentation. Consideration is given to the revised drum design and the compatibility of the proposed waste packages without capping grout against the requirements for safe long-term management, including transport, emplacement and extended storage underground, and disposal. This Assessment Report also addresses compatibility with the relevant Waste Package Specification (WPS), the WPS for the 500 litre drum waste package, and compatibility with guidance on the use of grout caps, WPS/915. RWM considers that the use of a capping grout layer should generally be seen as good practice, as it has the primary benefits of immobilising activity, protecting the wasteform and minimising voidage.

Packaging Proposals

DSRL will blend proportions of the PFR raffinate from all interim storage tanks prior to transfer to the DCP reception vessel. The PFR raffinate would then be processed through the DCP into 500 litre drum waste packages. The acid liquor raffinate would first be neutralised with sodium hydroxide, and then mixed with cement and lime powders within a 500 litre drum using a lost paddle in-drum mixing process.

The container has a double lidding arrangement, with an inner and outer lid. The inner lid comprises two parts, a top plate which is welded to the drum flange at its outer edge, and a central lid (called the inner lid) which is put in place following filling of the drum. The outer lid is a bolted design with a welded-on filter. Eight bolts secure the outer lid to the drum flange, rather than the 12 bolts more commonly used in 500 litre drum designs. There is no gasket sealing the outer lid with the drum flange.

The following minor changes between the two designs are proposed:

- The top plate and inner lid of the Mark 2 drum has been modified to align with the design of the original DCP 500 litre liquid waste drums. This is to ensure compatibility with the existing Mixing Station interface in DCP;
- The thickness of the inner lid has been increased from 2mm to 4mm;

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

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

- A rubber nitrile O-ring seal is now provided between the inner lid and the top plate;
- The inner lid features a single 2 mm diameter vent hole, which has been included to mitigate against the drums from becoming pressurised due to internally generated gasses during long-term storage;
- The weld joint at the connection between the top plate and the drum body flange has been optimised to improve both its strength and the manufacturability of the drum;
- The drum now features a simplified flat pressed base. The base indent notches and convexity feature of the earlier design have been removed to improve manufacturability of the drum;
- The design of the sacrificial paddle stirrer arrangement has been further optimised based on the results of the full scale in-drum mixing and immobilisation trials.

It is now proposed that 806 waste packages will now be produced, compared to 743 waste packages for the ILoC submission. This change is due to a combination of change in the estimated volume of PFR raffinate and a revised wasteform formulation. It is not proposed to modify the estimate of the total waste stream radionuclide inventory. This will result in the activity content of a drum being ~8% lower than calculated in the ILoC submission.
It is noted that the PFR raffinate is significantly more radioactive than MTR and DFR raffinates and is one of the most significant ILW waste streams in the UK. The PFR raffinate waste stream was a Bounding Waste Stream in the 2010 generic Disposal System Safety Case (gDSSC).

Assessment Findings

Drum modifications

RWM has assessed the proposed drum design modifications to the Mark 2 drum to move to the new Mark 3 Liquids drum. Advice has been provided regarding submission requirements at the FLoC stage, relating to the need for a manufacturing specification and procurement plan. It has also been noted that some of the standards quoted on submitted Mark 3 drum engineering drawings are superseded, withdrawn, or have been revised. It is recommended that the drawings are updated. Overall, the Mark 3 liquids drum is assessed as meeting transport and disposal requirements.
Further changes to drum design are recommended for use with PFR raffinate, associated with the proposal to omit capping grout (see below).

Omission of Capping Grout

Omission of the capping grout may leave loose active particulates at the surface of the wasteform or on the surfaces of the drum components under the inner lid. There is a potential release pathway for this particulate material via the 2 mm diameter hole in the inner lid to reach the interspace between the inner and outer lids. It is also noted that the outer lid sealing to the flange may be incomplete, due to the absence of a sealing gasket, the relatively few lid bolts applying sealing pressure and the small sealing face at the lid bolts. This may lead to potential releases under normal or accident conditions.
It may also be possible to generate a flammable mixture of gas in the ullage space below the inner lid, since hydrogen will be generated by radiolysis of the wasteform which may not be adequately vented by a 2 mm hole in the inner lid. Potential methods of providing improved gas venting through the inner lid and for improving

package sealing have been suggested, for example fitting of a large diameter filtered vent to the inner lid. That would also reduce the reliance on the outer lid to provide all aspects of package sealing performance.
DSRL has claimed various benefits and savings from omitting the capping grout. Set against this, RWM notes that the omission of capping grout will reduce waste package performance, by removing a waste package barrier. This potentially creates difficulty in showing that resultant doses are as low as reasonably practicable for an operating GDF.
The proposals to omit the capping grout also raises a geological disposal post-closure safety issue associated with voidage. If large volumes of void space are present in waste packages there is a potential for preferential pathways for groundwater flow and radionuclide transport to develop in the long term as the radionuclides are mobilised in groundwater. Resistance to any rock falls or rock creep after disposal will be reduced as stacks of waste packages degrade and weaken when there is significant voidage in the waste package stacks. Such mechanical effects could alter the hydrogeological properties of the host rock and, therefore, its containment safety function. However, the extent of such changes will depend strongly on the geomechanical characteristics of the host rock.

It is noted that voidage has not been minimised, as required by waste package specifications. RWM has recently undertaken work to evaluate the implications of voidage in a disposal facility on post-closure safety. This contractor report to RWM proposes that voidage comprising between 5% and 15% of the waste package volume may be acceptable, but must be justified either by showing that the voidage cannot be further minimised or that the benefits of allowing voidage (for example, in terms of cost and operational risk reduction) outweigh those of eliminating it (in terms of potential effects on post-closure safety). The submission states that the voidage in a PFR raffinate waste package will be around 13%.
An estimate of the cost of DCP modifications has been provided, linked to a need to install a glovebox at the capping station to control contamination and facilitate maintenance. The need for this change is claimed to be associated with the level of activity associated with PFR raffinate, and was not required for packaging of MTR or DFR raffinate. RWM notes that this assumes that capping cell maintenance workers would receive higher doses in the absence of that glovebox, although no underpinning of the claim of higher doses is provided. It is recommended that further underpinning of the need for the glovebox at the capping cell is provided. Arguments concerning DCP throughput associated with omission of the capping grout process are accepted, although it is noted that packages could be exported to store with wet capping grout.
Regardless of the justification for not minimising voidage in the GDF post-closure phase, in the long-term it may remain necessary to reduce the voidage retrospectively if dictated by developments in GDF siting, design or safety case. If necessary this could be achieved by an engineered penetration of the drum lids or similar. In terms of a future FLoC for packages of PFR raffinate, it may be necessary to apply a Qualification in the form of a caveat stating the potential need for retrospective incorporation of a capping grout. However, it is noted that this need arises from geological disposal post-closure safety, which is not applicable under current Scottish Policy.

Conclusions

Overall, the DSRL Mark 3 liquids drum is assessed as meeting transport and disposal requirements, although further changes to drum design are recommended for use with PFR raffinate associated with the proposal to omit capping grout.
RWM is also prepared to accept the omission of the capping grout. This is subject to satisfactory resolution of the issues raised concerning drum sealing, potential for

accumulation of flammable gases in the ullage space and provision of further information underpinning the need for the glovebox at the DCP capping cell.
In terms of a future FLoC for packages of PFR raffinate, it may be necessary to apply a Qualification in the form of a caveat stating the potential need for retrospective incorporation of a capping grout. However, it is noted that this need arises from geological disposal post-closure safety, which is not applicable under current Scottish Policy.