Development and qualification of waste packages for SFR silo

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1   Background

The Swedish repository for disposal of low and intermediate level radioactive waste SFR consists of four types of rock vaults. Intermediate level waste with the high activity concentrations will be placed in the Silo which is the vault designed for more than 90 percent of the total activity in the repository.

The Swedish nuclear industry has, based upon a common need, started a project to develop packages for scrap metal and other non burnable waste with activity up to 2 TBq per package and a surface dose rate of up to 500 mSv/h. NPP Ringhals has a special position since waste treatment of the PWR steam generators in Studsvik melting facility presently generates significant volumes of waste to be disposed in the SFR Silo.

A project team with participation of NPP Ringhals and Studsvik works with the design and qualification of a modern steel mould package with low weight and large inner volume that fulfils the requirements for disposal in the SFR Silo without requirements on composition or cementation of the waste.

A critical item is the request by Swedish Nuclear Fuel and Waste Management Co (SKB) to minimize the void (the free volume) in the packages. This must be done without negative impact on the pay-load. Intensive efforts are spend on finding materials with low density which not will have any negative impact on the long term safety or the waste material.

The presentation summarizes the main steps of the design and qualification of the new package.

2   Objective

The objective for the work in the project has been to develop and qualify a waste package for SFR Silo.

The driving force behind the project is to develop a package with maximised net volume, low tare weight and minimised void volume, in order to allow high waste weight in the package. The package shall also have compression strength resistance as well as resistance against major breakdown at free fall from 9 meters, without taking waste form and solidification of the waste into account.

3   Principles

The package should be in line with the for SFR established mould form and size i.e. cubic form 1,2x1,2x1,2 meters.

The maximum weight of the package must not exceed the maximum weight allowed in SFR Silo. The package must also fit into the SKB transport system and must have lifting points that fits with the lifting tools in each facility and in SFR.

The qualification report must be in line with the established practise for SFR and be in line with the SKB waste manual (Avfallshandboken).

4   Safety in focus

It is of great importance that both short term and long term safety is in focus. A poor package design can be both problematic and costly to solve if package-related problems are discovered when packages are conditioned with waste or, in the worst scenario, already have been disposed in the SFR Silo. For this reason, the principle of precaution has been ruling within the project. In case of any hesitation, further analyses/evaluations have been performed.

A high level of safety is, in addition to above, important in order to keep confidence in the nuclear industry.

5   Suitable Waste forms

- Metallic scrap
- Inorganic non metallic scrap
- Residues from cutting, mechanical decontamination and melting
- Ashes from incineration

6   Limiting factors

- Maximum gross weight   5000 kg
- Maximum dose rate   500 mSv/h
- Maximum activity   2 TBq of which 0,5 TBq gamma emitting nuclides
- Organic waste   < 1% of total waste mass

7   Verification of design

According to the requirements for SFR, the packages to be disposed in the repository must fulfil certain compression strength resistance and that a free fall from a certain height not will cause any unacceptable damage of the package.

The verifications can be achieved in two different ways. By simulation of the resistance or by a physical test. The simulation has the advantage that it can be a combination of optimisation and verification.

For this project the design has been optimised and verified by a finite element analysis.

8   Compression strength resistance

According to the requirements for SFR, the packages to be disposed in the Silo must resist the pressure from 42 packages with maximum weight. This can be achieved either by taking the waste matrix into account or not. For this project it was decided that the mould should be designed to resist the pressure without taking the waste matrix into account.

The simulation of the 42 packages with maximum weight shows that the design fulfils the compression criterias strength resistance with margin.

9   Free fall from 9 meters

According to the requirements for SFR, the packages to be disposed in the Silo must resist a fall from 9 meter without major damages on the package. This can be achieved either for a specified waste matrix or for an unspecified matrix. For this project it was decided that the package should be designed to resist the fall with the worst case load. The worst case load has been assumed as a few heavy metallic components loaded loose in the mould.

The simulation of the free fall from 9 meters shows that there will be no major breakdown of the package. The worst case drop is on a corner.

10   Minimisation of void

To prevent free flow paths in SFR Silo after closing the repository, void shall be minimised in the packages. In order to maximise the amount of waste in the packages, a number of filling materials with low density have been investigated. The project is currently focused on foam glass to fill up remaining volume in the package. This is a material that consists of recycled crushed glass with low density, chemical composition not violating the long term safety and high static resistance against mechanical compression combined with a reasonable price.

11   Summary

Project guidelines:
*   safety first - the principle of precaution is ruling
*   Maximum net volume and payload
*   Minimisation of void
*   The same mould should be qualified for several different disposal routes (SFR BMA, SFR Silo and SFL)