The drip-dry waste job

In order to minimise handling times GNS FAFNIR and NEWA facilities were placed very close to each other in the Sizewell B radwaste building

German radioactive waste management specialist, GNS, used two different techniques to dry out liquid waste at the Sizewell B and Bradwell sites in the UK. By Jörg Viermann

It's Tuesday 20th May, 2014, 19:30 local time, and the Dolphin Inn in the picturesque village of Thorpeness in Suffolk is unusually crowded. The pub is not just full of tourists who have been visiting the Neverland-themed village inspired by Peter Pan author J.M. Barrie. Many of the people gathered are celebrating the culmination of a six-year project to empty the intermediate level waste (ILW) resin tanks at the Sizewell B nuclear power station, just a few miles down the road.

At Sizewell, like other nuclear plants, ion exchange resins are used in the primary coolant purification system to eliminate corrosion products from the reactor cooling water. When the resins are exhausted they are replaced, and the spent resins are transferred into a tank.

As the radioactivity of the spent resins was low during the first few years of operation of the Sizewell B pressurised water reactor, they could be treated as low-level waste. However, when the activity levels rose it was found that process applied to treat LLW was no longer suitable. Instead, tanks were built (total capacity 25m^3) to store the spent resins.

In 2008/2009 when the first 10m^3 tank was completed filled, and the second 10m^3 tank was nearing capacity, British Energy (today EDF Energy) performed a Best Practicable Environmental Option study of different technologies to treat spent ion exchange resins.

Both of the preferred options of the BPEO study have been developed and used in Germany. The first is hot supercompaction as carried out in Philippsburg. The second involves draining the resins, packaging them into high-integrity MOSAIK type containers and removing their free water content, as operated by GNS (Gesellschaft für Nuklear-Service GmbH) at all other German plants.

Five years ago, GNS was carrying out a resin treatment campaign using its FAFNIR and NEWA plants at Biblis in Germany and a group of British Energy employees flew in to see the technology in action. Liking what it saw, British Energy opted for the second solution: draining resins in MOSAIK casks. A contract between British Energy and GNS for the work was concluded in June 2010.

Preparation work

In May 2013, on-site work to modify the pipework of the resin transfer system (RTS) started at Sizewell. This system, which connects the station ion exchange resin filters with the storage tanks and the LLW resin treatment plant, did not have any couplings to connect a mobile facility. So, approximately 100 m of new pipework and a booster pump had to be installed. The booster pump was needed because calculations showed that with the existing water injection pump the necessary flow velocity could not be guaranteed.

Three years of planning, safety case submissions, comprehensive checks that the new pipework could avoid any blockages and interim approval that waste packages would be accepted in a final repository were all required before the first wall breakthrough could be made and the first pipe could be installed.

The iLoc (interim stage Letter of Compliance) granted by RWM, the authority in charge of the Geological Disposal Facility, in March 2012 marked an important milestone of the project, being the first iLoC in more than 20 years in England and Wales. The iLoC confirms that (except for some minor action points which have to be addressed in the final stage) there are no reasons to assume that a package will not be acceptable for storage in the future GDF. This process included preparation of documents showing that containers used will withstand the assumed accidents and conditions, confirming the stability of the waste product, and documentation that the combination of container and waste product will not lead to undesirable effects.

Other preparatory work included changes to the radwaste building

Lifting the lid before connecting a MOSAIK cask to the GNS FAFNIR facility

The GNS FAVORIT plant ready to process ILW sludge at Bradwell

where the FAFNIR and NEWA plants would be operated, such as the installation of a new crane with a capacity of 25 tonnes to handle the heavy parts of the machines and the MOSAIK casks, as well as delivery of a forklift and a cross beam to handle the casks.

A room in the basement of the building that was intended for storage of the filled MOSAIK casks also had to be emptied. The room contained solid ILW packed in mesh box pallets, which had to be sorted and to be packed into shielded drums using a remotely controlled manipulator due to the dose rate.

EDF's first preference for the remote manipulator was a model manufactured by a US company, but unfortunately this manipulator failed to have a CE certificate. After some discussion with the technical team at Sizewell a custom-made manipulator was ordered from a Swiss supplier instead. GNS supplied 100 drums for packaging of the ILW in the basement, which was carried out by its subcontractors.

GNS also delivered 55 empty MOSAIK casks to Sizewell to take the resins, each with a capacity of 460 l.

Treatment

At the end of 2013 all the preparations had been completed. FAFNIR and NEWA, which had been delivered to Sizewell in five 20-foot ISO containers, were in place in the basement of the radwaste building and the treatment of the resins from the tanks could begin.

As this was the first time that the GNS kits would be operated in the United Kingdom, the Office for Nuclear Regulation and EDF Energy agreed that the whole processing of filling the casks using the FAFNIR kit and subsequently de-watering the resins using the NEWA would be tested on a limited batch of four MOSAIK casks. This would allow confirmation that all of the processing steps were working reliably before bulk loading of the other 51 casks started.

The treatment process works as follows. First, the resin is retrieved from the storage tanks and transferred into FAFNIR's dosing tank through the RTS (old and new pipework) by means of the station's pumps.

In the dosing tank of the FAFNIR facility, the excess water is separated from the resins by a screen and recirculated into the station's system. After this initial pre-dewatering step, the water content will be around 50 weight % water (slightly less than in the storage tanks). Next, FAFNIR evacuates the MOSAIK cask connected to it, and resin is extracted from the dosing tank into the cask. These three steps are repeated until the cask is filled to at least 90%.

After this, the casks are disconnected from the FAFNIR and put aside for a week for the remaining free water to settle to the cask bottom.

The casks are then connected to the mobile dewatering kit, NEWA. This facility evacuates a buffer cask, and then opens a valve connecting this buffer cask with one of the four resin casks connected to the NEWA. Thus, by means of the vacuum in the buffer cask any water that has settled is removed from the resin cask through a sieve at the bottom. This process is repeated until no significant amount of water can be extracted.

Another week after dewatering the "Guarantee Measurement" can

Sellafield skip challenge

In the northwest of England on the so-called 'Energy Coast' in Cumbria, GNS is helping with one of the biggest challenges of the UK's nuclear heritage: emptying of the different storage pools at Sellafield.

Most of the waste, including spent fuel from the Magnox reactors and zeolite filters that removed caesium from the coolant gas, is stored in so-called skips. These are small containers that can be remotely handled. When taken from the pools they still require significant shielding and, again, their water content would make it necessary to take measures against gas generation.

After being made aware of this challenge Eisenwerk Bassum GmbH and GNS together started developing a container that would be able to take these 3'3" wide and 3'10" long skips as a whole without any need for size reduction. The cavity of a GNS Yellow Box® would be big enough in principle. The small round lid opening, however, would have made it necessary to cut the skips into relatively small parts.

The new container, SBoX®, has the same outer dimensions and ISO corners as the GNS Yellow Box and can therefore be handled with the same handling equipment. It also contains a revolutionary new internal heating system which accelerates the drying process significantly and, at the same time, reduces the energy consumption.

The heating requires electrical connections which penetrate through a leak tight breakthrough in the container wall. The container is heated as long as there is still water in it in order to replace the evaporation enthalpy, otherwise there would be a risk of the temperature falling under the melting point of water freezing, decreasing the evaporation rate significantly.

The application for a conceptual stage LoC covering all container related requirements has been submitted and the corresponding container cLoC is expected before the end of this year (2014).

But development does not end here. Handling requirements of the different areas on the Sellafield sites, container venting options in order to manage a gas generation that cannot be avoided by drying and other special features have to be incorporated into the design. This leads to a number of different variants of the SBoX which are available today.

While GNS has received no firm commitments for the technology it believes that it will be able to sell several hundred SBoX containers to customers in the UK and elsewhere.

be performed, confirming that the objective of less than 1 % of free water in the package has been achieved.

At the end of May with all 55 casks filled, and the final batch of four casks connected to the NEWA plant, the team celebrated the project success with a barbecue at the Dolphin Inn. In the meantime, the treatment of the final four MOSAIK casks has been completed, FAFNIR and NEWA have been mobilised and removed from the station.

In all, once it got started the ILW Spent Ion Exchange Resin Long Term Solution Project to treat the resins at Sizewell B it took approximately two and a half months. Failing to deliver could have caused an unplanned longer term outage at the Sizewell B site, where resin tanks were nearing capacity, only months later.

Vacuum drying at Bradwell

Forty-five miles south of Sizewell at the old Magnox site at Bradwell-on-Sea, GNS is using a different technique to treat sludge and ion exchange material from two tanks to bring them into a condition that allows continued storage for decades and final disposal once the GDF opens. Like at Sizewell, the waste's moisture content is too high and could lead to undesirable effects, especially gas generation.

Vacuum drying technology that has been in use in Germany for more than two decades will be used to treat the waste from the two tanks at Bradwell. The waste, which is difficult to characterize, contains a mixture of activation and fission products, including a significant Am-241 content.

The GNS FAVORIT plant that will be used is a vacuum drying/vacuum evaporator facility which is able to convey liquid waste, sludge and slurry into containers and dry them under vacuum at simultaneously elevated temperature. The evaporating water leaves voids in the containers which can be refilled with slurry and then dried again. This fill-dry-fill-dry circuit is continued until the container is 90 to 95% filled.

Before the FAVORIT plant could start drying radioactive waste at Bradwell the suitability of the process for treating the waste has to be proved. Bradwell decided to do this by drying simulant material.

In autumn 2013, after successful conclusion of the tests, the drying of radioactive material finally began. As there was no space near the tanks to erect the FAVORIT plant, the sludge from the tanks first had to be mobilised. This work was carried out by EnergySolutions EU Ltd (the prime contractor for the project) using specialized equipment developed by the Scottish company STEM Drive Ltd.

The sludge was pumped into ductile cast iron containers. These DCICs were used as mules to transport the contents of the tanks to the dosing tank of the FAVORIT, which was located in the Circulator Hall (used for circulating CO_2 coolant during plant operation). In total 12 of these mules are containing approximately 30m³ of waste was emptied into FAVORIT and dried into six MOSAIK casks. This represented a volume reduction by a factor of more than ten.

In parallel to drying the MOSAIK casks, drums holding sludge samples were connected to the FAVORIT plant to ensure that they were always exposed to the same pressure and relative humidity as the bulk sludge being dried in the MOSAIK casks. As a result Magnox is able to prove that their proposed drying criterion of 5% water in the package, which has been accepted by RWM Ltd, are not just met but exceeded. The remaining moisture content of the final waste product is proved to be less than 1%.

Encouraged by these results, the drying of ion exchange material from a second tank is now underway. ■

About the author

Jörg Viermann, head of the sales department for Waste Management, GNS Gesellschaft für Nuklear-Service mbH, Essen, Germany