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PILOT STUDY ON THE RETURN OF REPROCESSED WASTES FROM GERMAN RESEARCH REACTOR FUEL ASSEMBLIES FROM THE REPROCESSING PLANT IN DOUNREAY, SCOTLAND

Marion Tholen
DBE TECHNOLOGY GmbH, Germany

Wilhelm Bollingerfehr
DBE TECHNOLOGY GmbH, Germany

ABSTRACT

The German Federal Ministry of Education and Research (BMBF) assigned DBE TECHNOLOGY GmbH with a project to review the prerequisites and contractual boundary conditions for the return of cemented residues from the reprocessing plant at Dounreay to Germany. For this purpose, the bilateral contracts between the German research facilities and the operator of the reprocessing plant at Dounreay, the UK Atomic Energy Authority (UKAEA), were examined. Possible interim storage sites in Germany were sought for, flasks suitable for transport and casks suitable for interim storage and final disposal were researched, and transportation options were explored. Based on the results of theses investigations, strategies for the return of the drums containing cemented residues were developed, including time and effort estimates.

The waste drums are 560-litre drums with NIREX specification. The drums containing the cemented residues may be provided at Dounreay starting in 2008. Their return to Germany has to be finished between 2018 and 2022 at the latest. The Federal Office for Radiation Protection (BfS) stated that the cemented waste is classified as intermediate radioactive waste which, according to the German nuclear energy act (AtG), is ‘other radioactive materials’.

Before the delivery of the drums to a final disposal, an interim storage in Germany may be necessary. Thus, possibilities for interim storage at German facilities were investigated. The Jülich Research Centre (FZJ) and the Central Decontamination Department (HDB) of the Karlsruhe Research Centre (FZK) are recommended as potential locations for the interim storage.

For the transport of the drums, a package with a type B(U)-license is necessary. For the final disposal, a category-II cask (accident resistant package) is required. As no suitable flasks and/or storage casks are available at present, concepts and proposals for the modification of existing casks were compiled. At this moment, various cask concepts are being considered.

Schedules and cost estimations for various return concepts were compared. It was shown that the return of the residues from Dounreay directly to a final disposal would be more favourable from a technical, licensing and economic point of view than the interim storage in Germany and final disposal afterwards.

INTRODUCTION

Spent fuel assemblies from German research reactors were reprocessed in the Scottish reprocessing plant in Dounreay between 1992 and 1996. There, the liquid radioactive residues have been stored in an underground tank. Cementation in 560-liter drums is planned as a conditioning procedure. The waste packages with the cemented reprocessed wastes can probably be made available by the UKAEA in Dounreay starting in 2008. The return delivery to Germany must be completed between 2018 and 2022.

Within the framework of a project commissioned by the Bundesministerium für Bildung und Forschung / BMBF (Federal Ministry of Education and Research), DBE TECHNOLOGY GmbH has examined the contractual boundary conditions and the requirements for the return of the cemented reprocessed wastes to Germany. For this purpose the bilateral contracts between the operator of the reprocessing plant in Dounreay, the UK Atomic Energy Authority (UKAEA), and the concerned research institutes were examined, the possibilities for interim storage in Germany were researched, suitable casks for transportation, for interim storage and final disposal were sought and transport possibilities were investigated. On the basis of potential storage possibilities as well as cask and transport concepts, return concepts were developed, and the time and cost expenditure was estimated. The results were summarized in a final report [1].

As this contribution was assigned to section D "Transport of Research Reactor Fuel and UF6", it focuses on the topics transport and storage containers as well as schedules for the return of the reprocessed waste to Germany.

STATUS QUO OF THE RETURN

The "Forschungszentrum Jülich, FZJ" (research center in Jülich), the "TU München" (Technical University in Munich), the Berlin "Hahn-Meitner-Institut", the "GKSS-Forschungszentrum Geesthacht" (research center in Geesthacht) and the "Physikalisch Technische Bundesanstalt Braunschweig, PTB" (National Metrology Institute in Brunswick) and the operator of the reprocessing plant in Dounreay, the UK Atomic Energy Authority (UKAEA), have stipulated in bilateral contracts the terms for the processing of fuel assemblies from German research reactors, and the return of radioactive residues thereby produced. The examination of these contracts and the research into the state of the conditioning of the liquid wastes at the UKAEA showed that from 2008 onwards, the 560-liter drums containing reprocessed wastes destined for the five research facilities will be available for collection from the UKAEA in Dounreay.

For the cemented fission product solutions UKAEA uses standard casks made of austenite (BS 1449 316 S13, corresponds to material no. 1.4404) conforming to a NIREX-specification. Figure 1 shows such a NIREX-cask with the corresponding technical data.

Gross volume:	560 liters
Outer diameter:	800 mm
Height:	1,196 mm
Thickness of the wall:	2.3 mm
Thickness of the bottom:	2.9 mm
Mass of the empty cask with mixer:	135 kg
Maximum mass of the filled cask:	1.400 kg

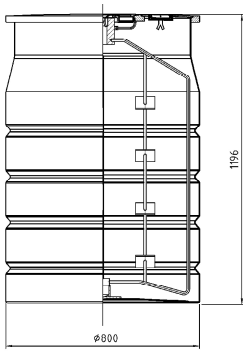

Figure 1. Standard cask with NIREX-specification

The lid is fastened by means of bayonet connectors. Polymer seals are used; gas-tightness is not planned. A sintered metal plate is built into the lid for pressure relief. This serves as a filter with a filter-efficiency of at least 99.97 % for particles of 0.3 µm size.
The liquid reprocessed wastes stored in the High Active Level Storage-tank 18 (HALS-tank 18) are conditioned using the cementation plant shown in figure 2 on the UKAEA site in Dounreay. In a first step, a concentrated sodium hydroxide solution is added to the highly acidic waste solution up to a small surplus. A mixture of Portland cement, blast furnace slag, and lime is used for the cementation. The cementation is done in the waste package with a 'lost mixer'. An inactive protective covering made of Portland cement, fly ash, and water is finally poured onto the product layer.

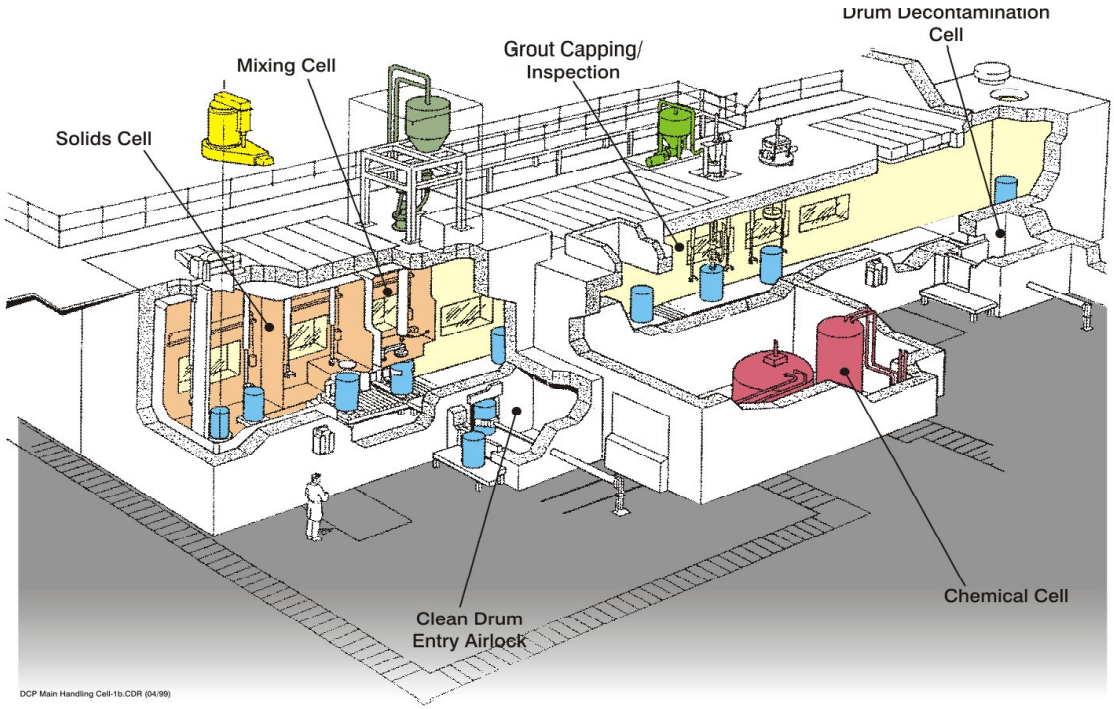

Figure 2. Cementation plant (DCP - Dounreay Cementation Plant)

The number of waste packages to be taken back by the German research institutes indicated by the UKAEA is 153 pieces. Until their return delivery the waste packages are temporarily stored in a drum interim storage warehouse or extension warehouse on the UKAEA site in Dounreay. The appropriation of the waste packages is carried out by an export facility.
The Federal Office for Radiation Protection (BfS) as the competent authority classified the waste packages as “medium-level radioactive waste” and “other radioactive substances” in accordance with § 2, section 3, of the Nuclear Energy Act (AtG). With respect to their return this means:

- Transport of the waste packages from Scotland to Germany as a type B(U)-transport unit according to the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)
- Transport within Germany in accordance with § 16 of the Radiation Protection Ordinance (StrlSchV)
- Interim storage of the waste packages in Germany according to § 7 StrlSchV

At the moment no operational final repository is available in Germany for the reprocessed wastes from German research institutes and no obligatory final disposal regulations exist. Only requirements for radioactive wastes to be stored at the Konrad mine and the product control of these wastes [2], [3] exist. If the waste packages are transported from Dounreay before the

initiation of the final repository Konrad they will have to be placed into interim storage before their final disposal.
The "TÜV Hannover/Sachsen-Anhalt e.V." (technical inspection agency Hanover/Saxony-Anhalt, today: TÜV NORD EnSys Hannover GmbH & Co KG) was commissioned by the BfS with the product control of the waste packages for the final repository Konrad. The TÜV generally concurs with the cementation of the reprocessed waste in Dounreay. Due to their dose rate the NIREX containers are to be shielded and placed in containers approved for interim storage and final disposal. For the final disposal of the waste packages, “accident-resistant packaging with class-II certification” is to be used.

TRANSPORT AND STORAGE CONTAINERS

Requirements of Transport and Storage Containers

For the waste packages from Dounreay, containers for the transport from the UK to Germany as well as for the interim storage and final disposal are required.
For the transport, a shipping unit with a type B(U)-certification according to ADR [4] is required. Requirements for the container arising from the storage license or from the technical delivery conditions, utilization arrangements, or similar, of the interim storage facility may have to be met during interim storage. As a final decision on the interim storage site is still pending and thus the interim storage facility is not yet known, the requirements for the interim storage containers are derived from the RSK-recommendations for the long-term interim storage of radioactive wastes [5]. For final disposal in Shaft Konrad, accident-resistant packaging with class-II certification is necessary.
A shipping unit with type B(U)-certification has to undergo tests to prove its integrity under normal transport conditions and under transport-accident conditions according to ADR. The containers for waste products to be stored in Shaft Konrad must fulfill general basic requirements as well as specific requirements, which are based on analyses of safety studies on the accidental release of radionuclides and on the allowed radionuclide release during normal operations. The most stringent tests of the transportation and storage containers include:

- Drop test: 5 m-drop without shock absorbers (according to the acceptance criteria at Shaft Konrad)
  9 m-drop with shock absorber (according to ADR)
- Heating test: Damaging fire of 800°C for more than 1 hour (according to the acceptance criteria at Shaft Konrad)

Container Concepts

Manufacturers of containers for radioactive wastes and transport companies that carry class 7 hazardous goods (radioactive substances) were interviewed with regard to transport or storage containers for the Dounreay waste packages. Initially, the enquiry was directed towards containers already approved for the transport or the interim storage and final disposal of waste packages. The research showed that, at present, none of the providers questioned has suitable transport or storage containers available for these waste packages.
Thus, in a second step, container concepts were developed that range from shipping units with B(U)-certification that need only insignificant modification up to container redesign. Table 1 gives an overview of the container concepts indicating whether the container is intended for transport (T) or interim storage (IS), or final disposal (FD).

Table 1. Container concepts for waste packages from Dounreay

Manufacturer	Container concept	Transport, Interim storage, Final disposal
COGEMA LOGISTICS (F)	ATB 8K	T
Eisenwerk Bassum mbH (G)	Konrad container type VI	(IS), T, FD
Gamma-Service Recycling GmbH (G)	UKT 10, UKT 4	T, (IS)
GNS Gesellschaft für Nuklear-Service mbH (G)	MOSAIK	T, IS, FD
NIREX Ltd (UK)	SWTC-285	T
RWE NUKEM Ltd (UK) AEA Technology plc (UK)	TA-10 TA-20	T T
TRANSNUBEL n.v./s.a.(B)	TNB 181 B	T

These container concepts were evaluated from a technical and licensing point of view as to their suitability as transport and storage containers for the waste packages from Dounreay. The TRANSNUBEL transport container is considered to be unsuitable since the TNB 181 B is currently only licensed as an industrial packaging and would have to be completely refitted as a B(U)-shipping unit and would then have to be recertified. On the other hand, the container concepts from GNS (MOSAIK), Gamma-Service Recycling (UKT 10, UKT 4), RWE NUKEM (TA-10), AEA Technology (TA-20) and former NIREX, now Nuclear Decommissioning Authority NDA (SWTC-285) are considered to be suitable for the transport of the waste packages from the UK to Germany. The interim storage of the waste packages could take place in MOSAIK containers (as certified interim storage containers). As final repository containers, the Konrad-container Type VI can be used. If GNS offered the MOSAIK container with final disposal certification it could also be used as a final repository container.

An evaluation not only containing the technical and licensing issues but also considering economical aspects was made during the preparation of time schedules and cost estimates for the return of all waste packages to Germany [1]. It was concluded that as transport containers both the Transactive (TA-10 / TA-20) and MOSAIK containers can be regarded as superior to the other container concepts. MOSAIK containers are additionally favored as combined transport and final disposal containers.

The Transactive-20, figure 3, has the design of a standardized ISO freight container. It is made of 4-mm-thick sheet steel and can be transported with a conventional trailer. The door of the container offers protection against external mechanical and thermal influences. It is hydraulically operated and opens upwards. The waste packages (primary packages) are packed in secondary packages, lifted onto a pedestal, hydraulically turned through 90° and fixed in the container. The 2-Mg-heavy door is lowered and bolted. The container interior is a high-grade steel pressure vessel and is subjected to a pressure test after the secondary packages are loaded. If the pressure test is successfully finished, the door is shut and the container is ready for transportation.

Figure 3. Loading the Transactive (left, middle), TA-20 (right), source: AEA Technology

The secondary packages developed and approved so far have to be modified for the transport of the waste packages from Dounreay: they are to be equipped with shielding and then can take one waste package each. Two secondary packages, each with one waste package, can be put into the TA-20. The TA-20 can be available within 1 year from date of order.
The TA-10 has not yet been built and approved. It is a 10'-container. Construction, fittings, design properties and loading sequence are similar to the TA-20. The secondary packages of the TA-10 need to be modified: they are to be equipped with shielding and then can each incorporate three waste packages. A secondary package with three waste packages can be put into the TA-10. The TA-10 can be made available within 2 years from date of order.
In the MOSAIK container family the MOSAIK II, figure 4, is a container that is primarily designed for ion exchanger resins, evaporator concentrates or also for activated components from the core region of nuclear reactors. GNS offers a modified MOSAIK container for the transport of waste packages from Dounreay. A standard MOSAIK container cannot be used for the 560-liter drums due to its size. GNS offers the modified MOSAIK container with the certification as a type B(U)-shipping unit. It can be made available within 2 to 3 years from date of order at the earliest.

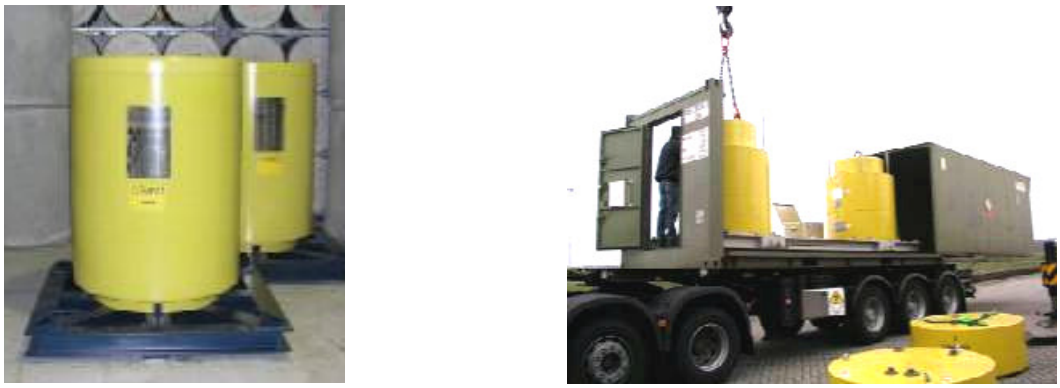

Figure 4. Standard MOSAIK container as interim storage container and in transport configuration with shock absorber in the 20'-Open-All-Container, source: Gesellschaft für Nuklear-Service

SCHEDULES

Schedules for the return of the waste packages from Scotland to Germany were compiled in [1] and updated in [6]. Two basic return concepts are being discussed: Final disposal of the waste packages in the final repository Konrad with prior interim storage in Germany (return concept 1) and final disposal of the waste packages in the final repository Konrad without prior interim storage in Germany (return concept 2). The schedules for the return of the waste packages to Germany are based on several assumptions concerning:

- Availability of the waste packages at UKAEA in Dounreay
- Availability of the transport and storage containers
- Transport from Dounreay to the interim storage facility in Germany
- Interim storage in Germany (in an already existing and licensed interim storage facility with and alternatively without approved interim storage container)
- Transport from the interim storage facility in Germany to the final repository Konrad
- Delivery schedule of the waste packages to the final repository Konrad

Schedules for the return of the waste packages to Germany for various container and transport concepts were compiled based on the assumption that the return process is initiated at the beginning of 2008 with the order to develop and manufacture the transport and storage

containers for the transport of the waste packages and that the delivery of the waste packages to the Konrad repository can start in mid 2013. As the interim storage of the waste packages incurs annual storage fees as well as operating costs both at UKAEA in Dounreay as well as at a German interim storage facility the schedules were compiled for the earliest possible return of the waste packages.

Return concept 1:
Depending on the container and transport concept, the delivery of the waste packages to an interim storage facility would be possible by the end of 2010 or mid of 2013 (without approved interim storage container), figure 5, or by end 2011 or mid 2014 (with approved interim storage container). In the latter case, delivery of the waste packages to the interim storage facility would only be possible if the interim storage containers (e.g. MOSAIK containers) with transport and final disposal approval were already available on-site. Furthermore, the return schedule depends on when the transport containers can be made available to UKAEA in Dournreay. The duration of the return process is then subject to the transport time which in turn depends on the number of waste packages per return cycle and the time period between return cycles.

Type B(U)-transport unit: 12 MOSAIK containers transport via charter ship, 1 sea tranport per quarter, interim storage without approved interim storage container	**2006**		**2007**		**2008**		**2009**		**2010**		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**	
	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy
UKAEA in Dounreay																										
Interim storage (storage fees starting mid 2008)											3/3		2/3		1/3		Proportionate storage fees: 4 years									
Licensing and manufacturing of transport containers																										
MOSAIK containers (12 pcs.)									2 years																	
Transport from UK to German interim storage facility																										
Transport licenses, import/export etc.									1/2 year																	
Transport by road/sea															3.5 Years											
Interim storage in Germany																										
Licensing and modifications (if necessary)									1 year																	
Interim storage and conditioning for Konrad repository (if necessary)																	Storage fees: 4 years									
Licensing and manufacturing of containers for final disposal																										
MOSAIK containers (150 pcs.)																	4 years									
Transport from interim storage facility to Konrad repository																										
Transport by road																	1/2 year									

Figure 5. Return concept 1 (example): Final disposal of the waste packages in the final repository Konrad with prior interim storage in Germany – without approved interim storage container

Return concept 2:
Depending on the transport concept, the delivery of the waste packages to the Konrad repository in MOSAIK containers would be finished by mid 2014 or mid 2016 (figure 6).

Type B(U)-transport unit: 150 MOSAIK containers transport via charter ship, 1 sea tranport per quarter	**2006**		**2007**		**2008**		**2009**		**2010**		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**	
	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy	1hy	2hy
UKAEA in Dounreay																										
Interim Storage (storage fees starting mid 2008)																	3/3		2/3		1/3		Proportionate storage fees: 7 years			
Licensing and manufacturing of transport and final disposal containers																										
MOSAIK containers (150 pcs.)																	4 years									
Transport from UK to Konrad repository																										
Transport licenses, import/export etc.															1/2 year											
Chartered ship																					3.5 years					

Figure 6. Return concept 2 (example): Final disposal of the waste packages in the final repository Konrad without prior interim storage in Germany

A comparison of the two return concepts based on the MOSAIK container shows that the costs for the return of the waste packages without interim storage in Germany are about the same as the costs for the return with interim storage in Germany. Based on the results in [1] and [6] it is recommended to take both the return of the waste packages to a German interim storage facility and subsequent final disposal at the Konrad repository and the return of the waste package to the Konrad repository without prior interim storage into consideration.

CONCLUSIONS

The preliminary study shows that the return of waste packages with cemented reprocessed wastes from Dounreay in Scotland is basically possible from the technical and licensing point of view.

Considering that UKAEA announced the availability of the waste packages starting in 2008 and that time is necessary for the development and manufacturing of containers as well as for obtaining the corresponding licenses, it is recommended to make the necessary decisions regarding the interim storage site for the waste packages until their delivery to the Konrad final repository as quickly as possible. The conditions for obtaining the necessary permits for transport and storage need to be clarified. In a next step, the technical planning (concept and draft planning) for transport and final disposal containers needs to be started. Furthermore, specific technical and logistic transport options have to be compiled and the most economical transport route needs to be identified.

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