MANAGEMENT OF FUEL WASTE FROM FUEL TESTING PROGRAMS AND POSTIRRADIATION EXAMINATION IN SWEDEN

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ABSTRACT

Fuel waste has been generated since 1960 at the STUDSVIK research facility in Sweden. Fuel testing programs in the materials testing reactor, R2, and postirradiation examination in the hot-cell laboratory had produced about 2200 kg of fuel waste up to 1986.

The accumulated older waste as well as the waste currently generated at STUDSVIK is now being treated and encapsulated to fit the central interim storage facility for spent fuel, CLAB, and later disposal in the planned repository for long--lived waste, SFL. CLAB and SFL are essential parts of the Swedish nuclear waste management system.

This paper describes the treatment and the storage technology used, and the experience after five transfer operations of fuel residues from STUDSVIK to CLAB.

INTRODUCTION

In Sweden the primary responsibility to guarantee safe and efficient management of the radioactive waste generated from nuclear energy production or research programs lies with the owners of the reactors or a nuclear research facility. This responsibility also includes the financing of the total waste management costs. For the financing a fee is levied on nuclear electricity production.

There is also a prerequisite that Sweden should be independent of other countries for the execution of its nuclear waste management program. Direct disposal is being favored for the spent nuclear fuel.

To fulfil this obligation Swedish Nuclear Fuel and Waste Management Company, SKB, which is a company jointly owned by the nuclear utilities, has developed a comprehensive system for the handling, transport, storage and final disposal of reactor operation waste, spent fuel and decommissioning waste. Essential parts of this system are already in operation.

- The Swedish nuclear power plants and the STUDSVIK research facility are situated on the coast with their own harbors, Fig. 1. Therefore an integrated sea transportation system, ISTS, for the transport of spent fuel and reactor waste, was commissioned in 1982.
- A facility for central interim storage of spent fuel, CLAB, located close to the power plant at Oskarshamn, started operation in 1985.
- The repository for low- and intermediate-level wastes from reactor operation, SFR, located near the Forsmark nuclear plant, was commissioned in 1988.
- After interim storage in CLAB for around 40 years, the spent fuel and long-lived radioactive residues will be transported to a final repository, SFL. There, the fuel assemblies will be encapsulated in sealed copper

Fig. 1. Location of Swedish Nuclear Power Plants and STUDSVIK Research Facility.

canisters, which will be deposited 500 meters underground in the bedrock surrounded by highly compacted bentonite. SFL will be commissioned around the year 2020.

During the development of nuclear power in Sweden STUDSVIK has operated several research reactors and laboratories. As a result of the operation and decommissioning of these facilities a considerable amount of nuclear waste has been stored at STUDSVIK. The older waste as well as the waste currently generated at STUDSVIK are also contracted for disposal in the SFR and SFL repositories and must therefore be conditioned and packed to fit into the SKB-system [1].

A separate project, AMOS, for the modernization of the waste facilities at STUDSVIK was carried out during the period 1982 to 1988. An overview of the AMOS project is given in [2].

AMOS also includes installation of special equipment for the conditioning of fuel waste from fuel testing programs and postirradiation examination. The aim of this presentation is to describe the encapsulation technique adopted for the fuel waste, the overall handling in STUDSVIK and the transport to and handling at CLAB for interim storage.

DESIGN OF CANISTERS AND TRANSPORT BOXES FOR FUEL WASTE

The choice of canister type for enclosure of the fuel waste, and the design of a suitable transport and storage unit for a number of canisters, have been made with regard to the following demands:

- Possible use of the steel capsule OD 78 mm, length 1038 mm used for the present storage of fuel residues at STUDSVIK as an inner container for the canister.
- A canister type with due regard to the anticipated 40 years wet storage in CLAB and the subsequent treatment before final disposal in SFL.
- A transport module as well as a storage unit that makes it possible to be handled and stored like a fuel assembly at CLAB.
- The transport box with fuel waste should fit a 29-tone transport cask for the transportation from STUDSVIK to CLAB.

Different materials and designs of canisters were investigated in order to arrive at an appropriate solution after conducting a special test program.

Figure 2 shows the design of the stainless steel canister. The canister has an outer diameter of 89 mm, a wall thickness of 4 mm and a length of 1110 mm. The material is stainless steel, austenitic type, SS2353 (AISI 316L).

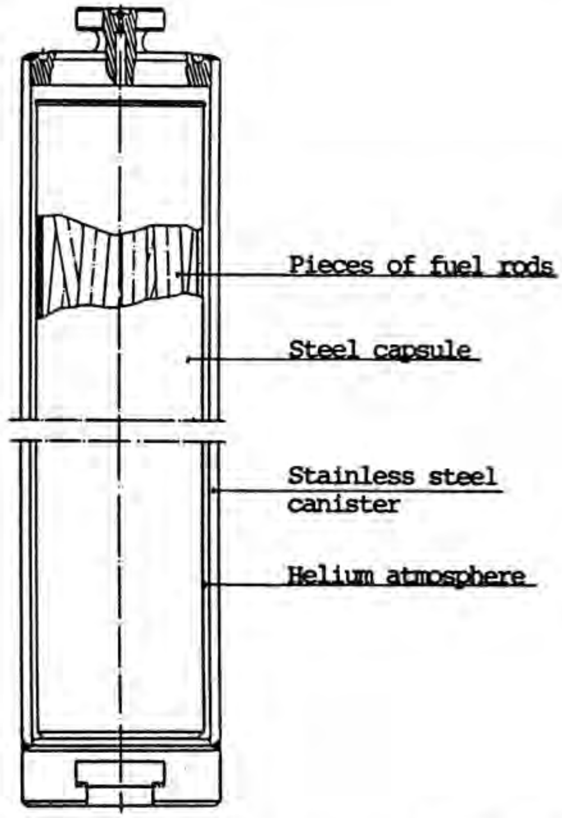

Fig. 2. Stainless Steel Canister for Encapsulation of Fuel Residues.

The bottom lid is welded to the tube with filler material in a single-V butt joint. It is done in the premanufacturing performed in a work-shop. After loading the canister with fuel waste in a hot-- cell, the top lid is TIG-welded to the tube with a single-V butt joint without filler material.

The external key grip in the top end fits into the internal key hole in the bottom end. This makes it possible to dismount the canisters from the transport boxes and handle them as a unit at the time for the treatment before final disposal.

The top lid has a center hole for evacuation and refilling of helium gas. After He-filling of the canister the center hole is sealed by TIG-welding.

Twelve fuel canisters are loaded into a transport box according to Fig. 3. It was found suitable to design the box to fit into the storage racks at CLAB which normally are used for PWR fuel assemblies. The cross section of the box is 212 mm square and the total length is 4069 mm. The material is stainless steel SS2343 and SS2353 (AISI 316 and AISI 316L). Four parallel tubes are joined together by a sheet construction and a bottom piece. In each tube three canisters can be loaded. The top end consists of a handle

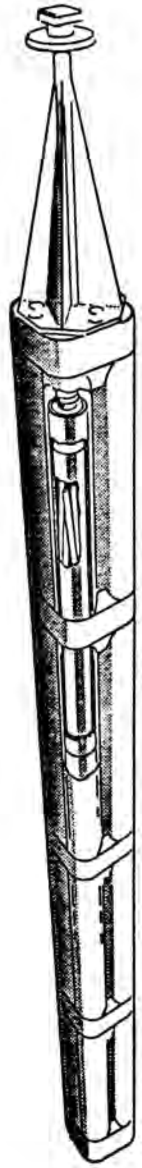

Fig. 3. Transport Box Containing Twelve Canisters.

for the enclosure of the box and for the handling with an available tool at the loading machine in CLAB.

The manufacture of all canisters and transport boxes is subject to QA/QC procedures. The remaining quality control of the encapsulation process is performed in the hot-cells.

SCHEME FOR THE HANDLING OF FUEL WASTE

The handling of the fuel waste is shown in the flow chart, Fig. 4. Pieces of fuel rods and fuel residues placed in steel capsules are currently stored in a concrete shielded facility at STUDSVIK. These capsules are transferred to the hot-

Concrete shielded facility (STUDSVIK) Dry storage of radioactive waste
Retrieval from storage positions Cask loading

Transport

Hot-cell Laboratory (STUDSVIK) Encapsulation
Cask reception Unloading to hot cell Verification of material Evacuation hole, inner capsule Loading into canisters (12 pcs) Test welding, metallurgical examination Welding top lid Visual inspection, tube-to-lid weld Removal high temperature oxide Evacuation, canister inside He-refilling Welding centre hole Visual inspection, centre weld Leak tightness check Loading canisters into transport box Transport box enclosure Cask loading

Transport (by road)

CLAB facility (Oskarshamn site) Interim storage
Cask reception Unloading in pool Transfer to storage rack Predetermined position in storage pool

Fig. 4. Scheme for the Handling of Fuel Waste.

cell laboratory for encapsulation and then transported to CLAB for interim storage.

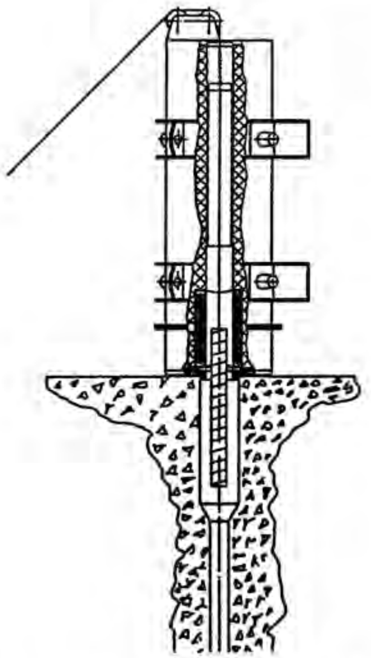

Fig. 5. Retrieval of Fuel Waste Packaging From Storage Postition to a 10-Ton Cask.

RETRIEVAL FROM STORAGE FACILITY TO THE HOT CELLS

The waste storage facility at STUDSVIK was built in 1960 and the shielding consists of a concrete foundation containing holes with diameters depending on the size of packaging used for different types of waste. No retrieval of material was planned from the building at the time of its construction.

The transfer of fuel waste packaging from the storage positions to a 10-tone cask is performed in a secure fashion by a special technique illustrated in Fig. 5. By December 1989 seventy fuel waste capsules had been transferred to the hot-cell laboratory for encapsulation.

ENCAPSULATION OF FUEL WASTE IN HOT CELLS

The following step by step procedure describes the method used and the equipment developed for encapsulation of fuel waste in stainless steel canisters in the hot cells.

1. Enough fuel waste to fill twelve canisters is needed in preparation for one transport unit for transfer to interim storage. After careful verification of waste material against documents and acceptance criteria a 4 mm hole is drilled in each inner capsule for evacuation purposes. The capsules are loaded into the canisters and temporarily stored in a rack.
2. The equipment for all phases in the encapsulation process is mounted on a bench. Figure 6 shows the set-up for welding the top lid of the prefabricated canisters with the welding unit to the right and a rotating device to the left.
3. A test welding is performed on an extra canister for each transport box. Both the tube-to-lid weld and the center seal weld are performed with the same parameters as are used by the real fabrication.
4. A section is cut from each weld for metallurgical examination and acceptance. Microscopy is performed on the samples at a magnification of 100x.
5. The top lids are welded to the prefabricated canisters, Fig. 6. The current during the welding sequence is registered on a chart recorder and compared with conditions from the test welds.
6. The uniformity of the weld is checked by visual inspection at a magnification of 10x.
7. The high temperature oxide formed during the welding process is removed by a rotating steel brush.
8. A chamber with an O-ring seal is attached to the top end of the canister according to Fig. 7. Evacuation of the canister inside free volume is performed to a vacuum better than 0.1 mbar. Helium is refilled in the canister to an overpressure of 0.2 bar.
9. The center hole in the top lid is then sealed by a TIG--welding procedure.
10. The center sealing is also checked by visual inspection.
11. A helium leak testing instrument is connected to the chamber, Fig. 7. The leak tightness of the top lid welds can be tested due to the helium atmosphere inside the canister.

LOADING OF TRANSPORT BOX AND CASK PREPARATION

Studsvik hot cells are designed for horizontal loading and unloading of transport objects. A compressed air piston pushes the canisters into the transport box, which is placed inside a 29-tone cask attached to the cell as shown in Fig. 8. The key grip holds three canisters together, in each of the four tubes, in the transport box.

The handle is attached to the transport box, and the box weighing approximately 450 kg, is pushed into the cask by means of a roller conveyor installed in the cask.

The encapsulation work, loading of transport boxes and cask preparation before transportation to CLAB are some-

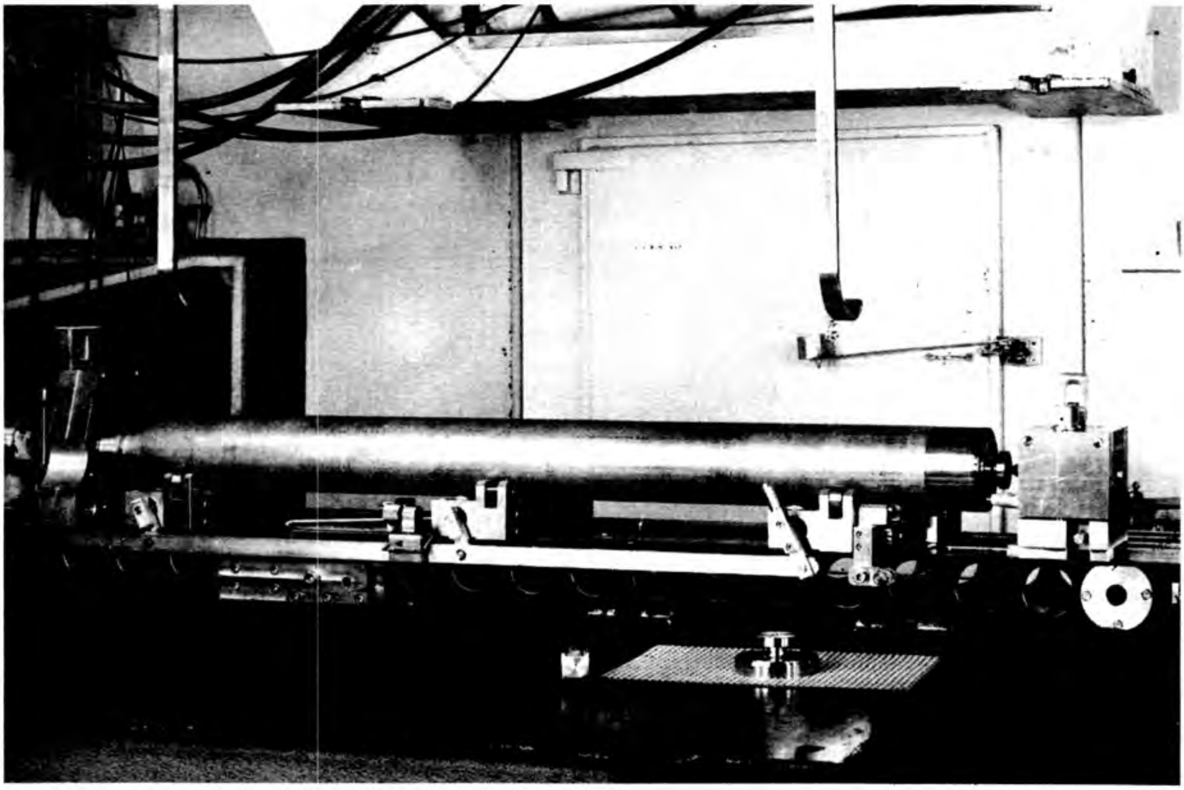

Fig. 6. The Set-Up for Welding the Top Lid of the Canisters.

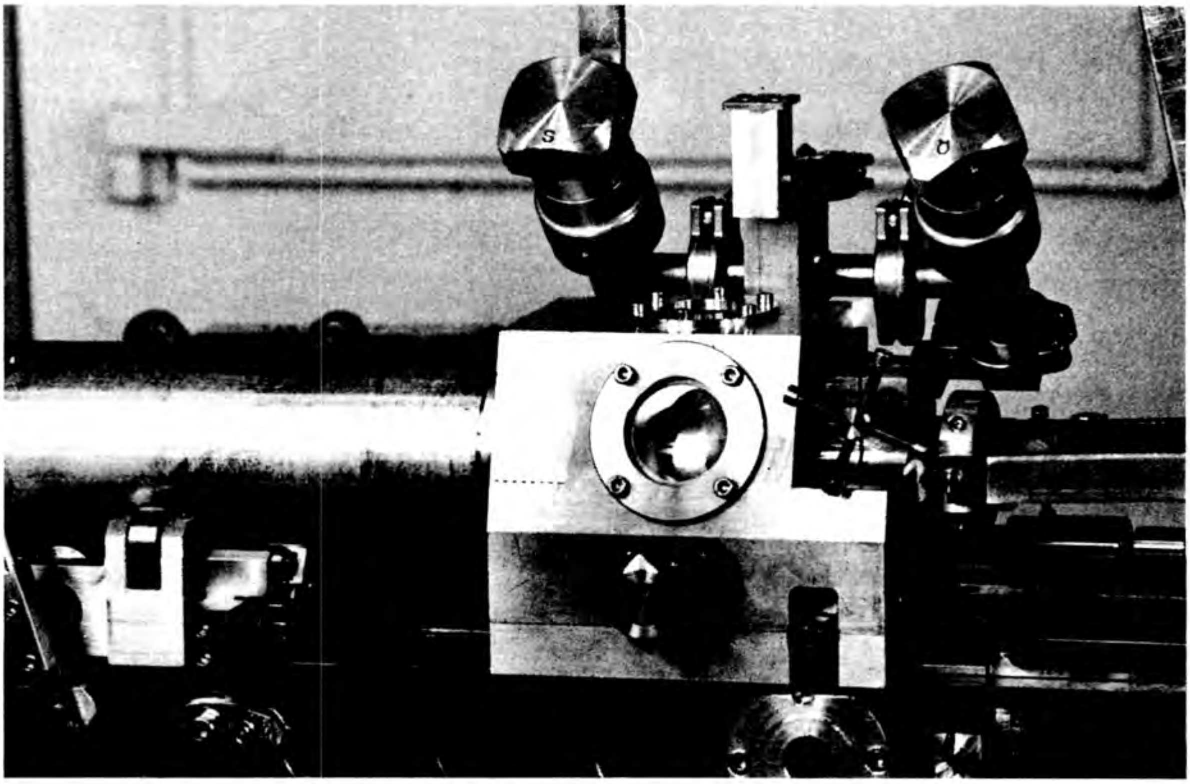

Fig. 7. Chamber for Evacuation, He-refilling, Welding and Leak Testing.

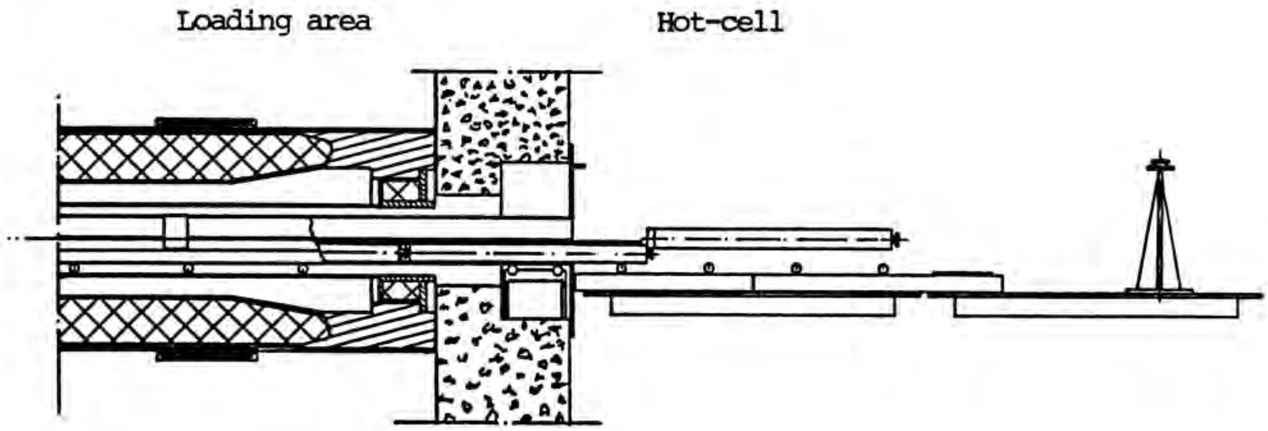

Fig. 8. Loading of canisters

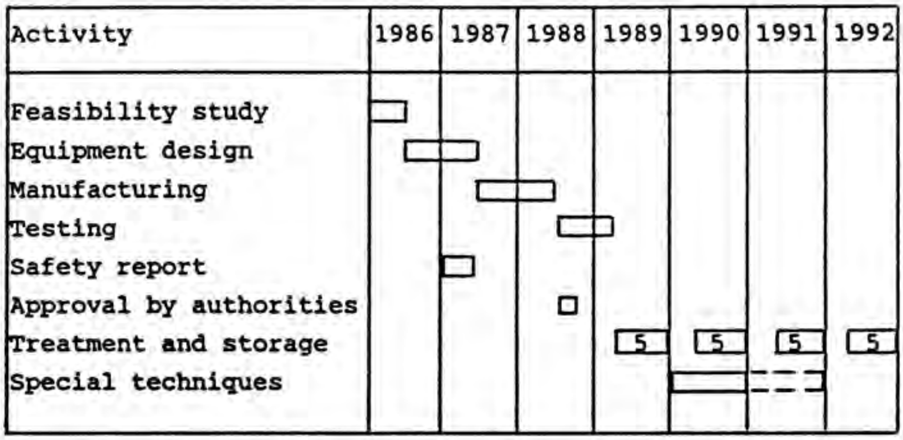

Fig. 9. Time Schedule of the Fuel Waste Treatment Project.

times performed under the supervision of the IAEA and the Swedish Nuclear Power Inspectorate.

TRANSPORT STUDSVIK-CLAB

The STUDSVIK 29-ton cask is licensed as a type B(U) container. A truck and trailer are used for the transportation by road of one transport box containing fuel waste at a time. The distance between STUDSVIK and CLAB is 250 kilometers.

STUDSVIK had performed 30 shipments to CLAB with the cask by December 1989. The first 25 shipments contained spent fuel from the 65 MW Ågesta HPWR. This fuel has temporarily been stored at STUDSVIK. The cask is capable of holding seven assemblies of that fuel design at a time.

HANDLING AND STORAGE IN CLAB

General

The central interim storage facility for spent nuclear fuel, CLAB, was taken into operation in the middle of 1985. CLAB is situated at the Oskarshamn nuclear power plant site, where three nuclear reactors are in operation.

CLAB is designed in two main complexes. The aboveground complex consists of a number of interconnected buildings, i.e. the fuel reception building, the auxiliary system building, the electrical building and the office building. The underground complex contains mainly the storage pools, situated 30 meters below the surface.

The fuel reception building and the storage pools are connected through an elevator shaft where the fuel elements are transported down for interim storage for about 40 years.

CLAB is designed for a storage capacity of 3000 tones(U) of spent fuel. So far about 1000 tones(U) have been received and stored at CLAB. Planning for an extension of the storage capacity up to 5000 tones is now going on.

Reception and handling at CLAB

The 29-ton cask i transported into the facility through the transport sluice in the reception building. After checking of the cask it is lifted into the reception hall by an over-head crane, and placed in a preparation position. At reception of standard fuel, the cask is placed for cooling in one of the three preparation cells at CLAB. As the decay power of the fuel residues is very low there is no need for this operation and the 29-ton cask is therefore transported directly from the preparation position to the unloading pool.

Before lowering the cask into the pool it is water filled and connected to the ventilation system. An adapter for handling of the lid is connected.

When the cask has been lifted down to the bottom of the pool the lid is removed with the fuel handling machine and the transport box with the fuel residues is lifted by the handling machine and placed in a storage rack of standard PWR design.

The storage rack contains 5 positions. When all positions have been filled up the storage rack is lifted down to the storage pool by the fuel elevator.

The time needed for reception, handling and unloading of the 29-- ton cask at CLAB is about 8 hours.

SUMMARY

The project for the treatment, interim storage and final disposal of fuel waste from fuel testing programs and PIE in Sweden was started in 1986. The activities performed so far, and the future planning, are shown in Fig. 9.

The approval of the handling and storage of fuel waste was granted to STUDSVIK and SKB by the Swedish authorities in October 1988. The first transfer operation was performed in May 1989, followed by another four during that year.

In total 684 kg of encapsulated fuel waste has been transported to CLAB for interim storage. During the next three years (1990-92) five transfer operations per year are planned.

The waste treated has so far been very well defined material containing UO_2-fuel and zircaloy cladding. Special techniques must be developed for some of the fuel waste stored at STUDSVIK to meet the acceptance criteria for interim storage in CLAB and final disposal in SFL. For example cut pieces of fuel rods embedded in epoxy resin must be removed from the epoxy before encapsulation.

The aim of the project is to encapsulate and transfer all the accumulated older waste, about 2200 kg, by the end of 1992. After this time the fuel waste subsequently generated in the hot-cell laboratory will be treated without short-term storage at STUDSVIK and transferred to CLAB.

To date, the fuel waste shipments from STUDSVIK to CLAB have been carried out safely, reliably and on schedule.

The dose to the personnel involved in the fuel waste treatment project has not reached measurable values i.e. less than 0.1 mSv per person and month.

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