The Swedish Sea Transportation System
- for Safety Reasons

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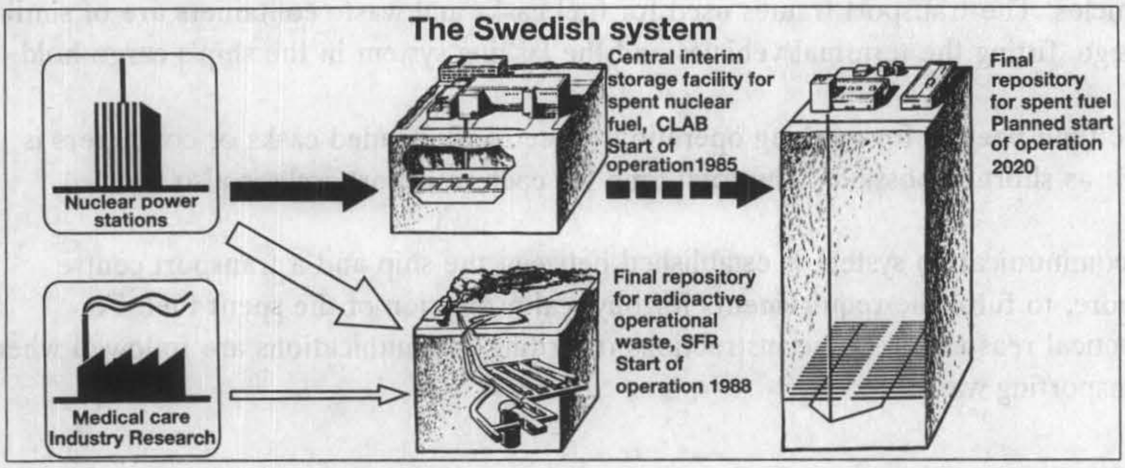
GENERAL

When planning and site selection were made for storage facilities for spent fuel and reactor waste in the 1970s, the transport aspects were very important to consider.

Studies were performed comparing road and sea transports. As a result it was decided to design and build a sea transportation system, where safety to the public and transporters had the highest priority.

The Swedish waste management system also includes the intermediate storage facility for spent fuel, CLAB, and the repository for radioactive waste, SFR. All nuclear power plants and the two storage facilities are situated at the coast of Sweden. CLAB was taken into operation in 1985 and SFR in 1988.



BASIC SAFETY PHILOSOPHY

The basic safety philosophy of the transportation system is as follows:

The transport packagings shall provide radiation shielding during normal operation and accident conditions. Other parts of the transport system shall provide additional radiation protection when necessary. The aim of the design is to minimize disturbances during transport, and should a disturbance occur, to prevent it from developing into a more serious accident.

The objective of the shielding design of the transport system has been to limit the exposure to the personnel involved to a maximum of 5 mSv per year.

In order to achieve a high level of operational safety and to keep the radiation doses low, the following factors are essential:

The transport operations are performed by SKB, the power plant staffs and the ship's crew, who have got special training regarding operation of the system and radiation protection. The ship's crew is employed by a wellknown Swedish shipping line, Rederi AB Gotland, and most of the officers and crew members have been the same during the last seven years. Thus the handling and transport personnel have achieved a wide experience of the work. The areas of responsibility for the various organizations are well defined.

Transport casks, containers and other equipment are designed and manufactured to withstand severe mechanical conditions and to facilitate fast and easy handling.

Road transports between plants and harbours are performed by special terminal vehicles. The transport frames used for fuel casks and waste containers are of similar design, fitting the terminal vehicles and the lashing system in the ship's cargo hold.

The time needed for working operations close to the loaded casks or containers is kept as short as possible. The total time for each transport cycle is also short.

A communication system is established between the ship and a transport centre ashore, to fulfil the requirements for physical protection of the spent fuel. For practical reasons the same instructions regarding communications are followed when transporting waste.

RULES AND REGULATIONS FOR TRANSPORT

The transportation system was designed to fulfil at least the international and national regulations and to make the system even safer than prescribed. This had the following impact on the main equipment and operation of the system.

The ship M/S Sigyn is specially designed for transports of radioactive waste. It has a double bottom and hull, and was designed in accordance with the most restrictive IMO rules concerning floatability after damage, for ships carrying dangerous chemicals in bulk. The ship conforms to the Swedish-Finnish Ice Class 1A, and can brake ice of at least 25 cm thickness, which often occurs during the winters in the Baltic sea. The cargo hold is separated from working and living areas by shielding walls.

The transport casks for spent fuel, TN 17/2, and for core components, TN17-CC, are designed as type B casks according to the IAEA Regulations. The cask for core components was designed for the Swedish system. It has the same dimensions and design as the TN17/2, except that the cooling fins are excluded, and the cask body has a smooth outer surface. The core components are loaded into canisters at the power plant. The canister is then transported and stored as a unit in the CLAB facility.

Transports of spent fuel and reactor waste are performed under "exclusive use". The major part of the reactor waste is classified as LSA-II (low specific activitity) material.

The shielded containers for transport of intermediate level waste are designed to meet at least the requirements for IP-2 packagings according to the new IAEA regulations. The waste containers in the transport system are much stronger than stipulated for IP-2. They are made of 70-130 mm thick steel and fulfil the dose rate requirements of the regulations. Despite these facts and the overall high safety built into the system, the quantity of LSA-material transported in a container is restricted by § 422 in the IAEA regulations, also included in the IMDG rules. For some of the standard waste units produced at the power plants, these activity limits are exceeded. Compliance with this paragraph would require a type B-packaging, an increased number of transport operations and perhaps more radiation doses to the transporters.

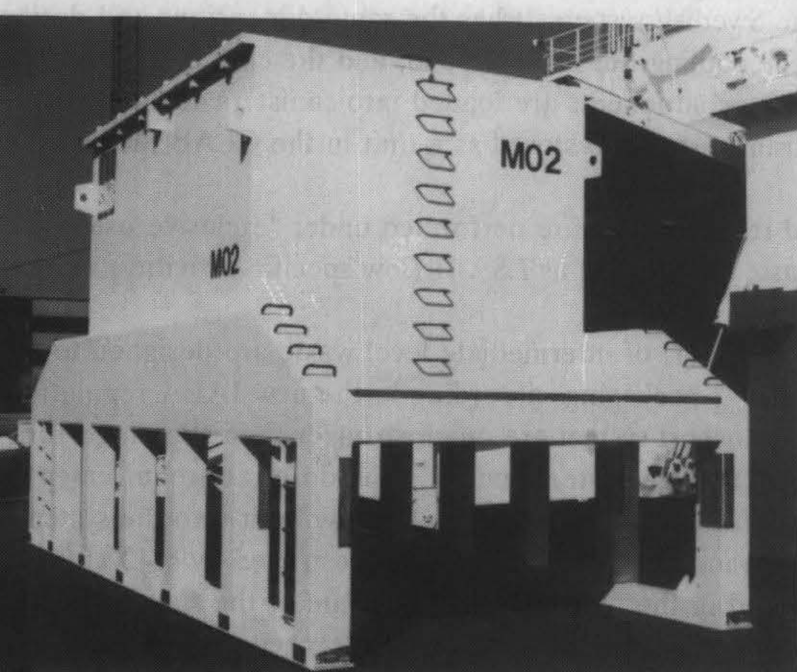
In order to fulfil the transport rules with the existing system, such transports have to be made under "special arrangement" according to IAEA § 211, which states that "A consignment which does not satisfy all the applicable requirements of these Regulations shall not be transported except under special arrangement. Provisions may be approved by a competent authority ---. These provisions shall be adequate to ensure that the overall level of safety in transport and in-transit storage is at least equivalent to that which would be provided if all the applicable requirements had been met. ---"

"Special arrangement" is obviously not intended for frequent transports on a routine basis. In fact, the rules of § 422 add nothing to the overall safety of the transports, neither to the personnel, nor to the public, when using ATB containers and a special transport system.

Low-level waste, i.e. products that do not need extra shielding, is transported in standard steel containers. This waste contains much less activity than the concrete/bitumen waste units, and this discussion does not apply to that waste category.

SHIELDED CONTAINERS FOR INTERMEDIATE-LEVEL WASTE, ATB

An ATB is a large steel container, welded to a transport frame. For sea transportation, SKB operates three types of ATB, designed for different shielding requirements and size of the waste units. (*Table 1.*)



ATB waste transport container

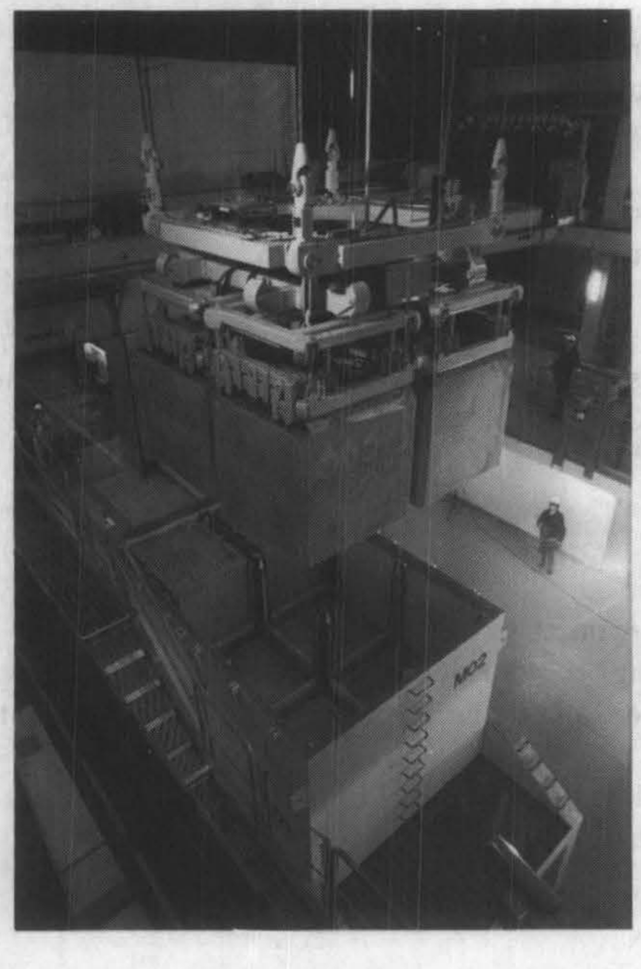
The maximum weight of a loaded ATB is 120 tonnes. It is about 4.5 m long, 2.5 m wide and 2.7 m high, not including the transport frame.

The ATB-containers can withstand all accidents that may occur during handling, land transport and loading. They are never lifted above ground, except about 10 cm when raised by the terminal vehicle.

Table 1. ATB-containers

Type	Wall thickness	Capacity, concrete moulds /drums	Max.dose rate level of waste	Number of ATB
ATB 12K	130 mm	12/48	60-70 mSv/h	10
ATB 16K	70 mm	16/96	5-6 mSv/h	10
ATB 3T	80 mm	3 tanks	7-8 mSv/h	5

The major difference compared to a type B-cask is that there is no requirement on an ATB-container to keep its leak-tightness after an accident. All waste units are solid objects made of concrete or steel and the waste is solidified in concrete or bitumen.



Remotely controlled unloading of concrete moulds from an ATB in the SFR facility

COORDINATION AND PLANNING

The transport planning and time schedule is made by SKB in close cooperation with the power plants and the receiving facilities, taking the availability of facilities, casks, ATB and the ship into account. This cooperation is essential for smooth and efficient operation and necessary in order to keep a high transport capacity.

There are four power plants (12 reactor units) generating spent fuel and operational waste. Waste is also transported from Studsvik, the national nuclear research centre.

Each transport, consisting of either about 5 spent fuel casks or 5-10 ATB, is governed by a "Transport Message" issued by SKB. This message contains specifications of fuel element or waste, of the time schedule for the transport and names of contact persons in charge. The transport message is sent to all parties involved and to the relevant authorities. It is issued about two weeks in advance.

Every transport cask or ATB is accompanied by its Transport Document, where major checks and measurements are signed by the responsible persons, and remarks of interest are entered.

The experience of SKB and its customers after several years of operation show that the equipment, organisation and coordination is satisfactory. When problems occur they are solved in close cooperation between the organizations involved.

The capacity of the transport system is sufficient. If necessary, the transported volumes could increase without any changes in the transport system.

The maintenance of the transport casks and other equipment is performed within the storing facilities and follows a standard schedule. For example, the maintenance of the TN17/2 follows the instructions of the "Green Book" which have been adopted to the CLAB facility.

FUTURE DEVELOPMENT

No major changes are foreseen in the organization of the transports. A continuous work is going on to improve, i.a. licensing procedures for waste transports, reporting and documentation systems and education, and in the development of new equipment.

The TN17/2 transport casks will be modified for spent fuel with higher burnup values (and higher initial enrichment) than today.

The existing ATB transport containers will not be sufficient for all waste categories in production. Thus at least one more type is planned, with thicker steel walls than the ATB 12K (compare *Table 1*), suitable for waste moulds and drums with higher dose-rates than 60-70 mSv/h. The SFR facility is designed for waste up to about 500 mSv/h.

Before a new ATB is manufactured, the problem with § 422 must be permanently solved, in agreement with the Swedish authorities.

In the far future, from the year 2020, there will also be transports of spent fuel from the CLAB facility to a final repository for spent fuel. Studies of the design and siting of such a facility is going on since several years at SKB.

SUMMARY

The aims of the Swedish Transport System can be summarized as follows:

The amounts of spent fuel transported shall be large enough to ensure continued power production of the nuclear power plants. All spent fuel in Sweden will be transferred to CLAB.

The local storages of waste at the power plants shall be emptied and the waste transported to SFR for final deposit.

The ship shall be operated with a high level of availability.

The equipment shall be maintained and renewed to keep the system operable for many years.

The safety level shall be kept high. The risks of accidents shall be minimized and a good working environment for the staffs and crew shall be maintained. The radiation dose levels shall be kept to a minimum.

The system shall be operated by qualified personnel. Frequent education shall help keeping the level of knowledge and minimizing the risk of incidents and mistakes.

Public acceptance is essential.

The Swedish transportation system has shown a very good record in obtaining low doses to the transporters. No accidents have occurred during this decade of transports. However, as the intention has been to follow at least the national and international transport regulations, it is obvious that the regulations do not cover all aspects of a transport system.