Proceedings of the 17th International Symposium on the
Packaging and Transportation of Radioactive Materials
PATRAM 2013
August 18-23, 2013, San Francisco, CA, USA

TWICE AS SAFE AND TWICE AS EFFICIENT

Johan Rosenblad
Project manager Transports
Swedish Nuclear Fuel and Waste Management Co (SKB)

1 Abstract

The spent nuclear fuel in Sweden is continuously transported from the nuclear power plants to the national intermediate storage, Clab. Lack of a reliable transport system would shortly have a severe impact on the operation for all nuclear power plants since the fuel pools on the sites are quite small. The ability of transporting spent fuel is therefore essential to the operation of the nuclear power plants in Sweden.

Swedish Nuclear Fuel and Waste Management Co. (SKB) own ten casks for spent nuclear fuel which has been in use since 1985. Due to the double barrier requirement against water intrusion in accident condition the casks will not be relicensed in the future. Consequently they will not be validated for the use in Sweden. To secure the need for transport of spent fuel a new fleet of transport casks that fulfil today’s requirements by authorities and international regulations has to be provided.

The cask design challenge is to solve the right problem and still create reasonable flexibility for needs that may occur in the future. Typically cool down periods at the power plants for the fuel in the Swedish system is about 20 months before transport. This is a very short required cool down time for high burn-up fuel. It will be very challenging to design a high capacity cask, keeping the weight low and still fulfil requirements both regarding residual heat dissipation and radiation shielding.

An early feasibility study clearly showed that new casks well designed could lead to substantial improvements of the technical performance for the transport system, beneficial for both the nuclear power plants and the intermediate storage.

A safety upgrade has proven to be not only mandatory expense but an important opportunity to enhance system flexibility and to cut doses to staff.

2 Introduction

An increasing demand of the nuclear power was foreseen in the late sixties in Sweden. During the period 1965 to 1972 one commercial nuclear power reactor was ordered every year. Totally, twelve nuclear power plants were designed and ten of them are still in operation. SKB (Swedish Nuclear Fuel and Waste Management Co) was formed 1973 as a co operational organisation for common interests of the power plant owners.

In 1985 an interim central storage for spent nuclear fuel in Oskarshamn, the Clab facility was taken into operation. The fuel is stored wet underground in large pools for 30-40 years to reduce its residual heat and radioactivity before being encapsulated and deposited in the final repository, yet to be constructed. All Swedish nuclear power plants are located at the coast. To efficiently transport the fuel from the nuclear power plants to the Clab facility the transport system was created with its key components: ship, casks and vehicles. In fig 1 an overview of all existing and planned facilities in the Swedish system for waste management is described.

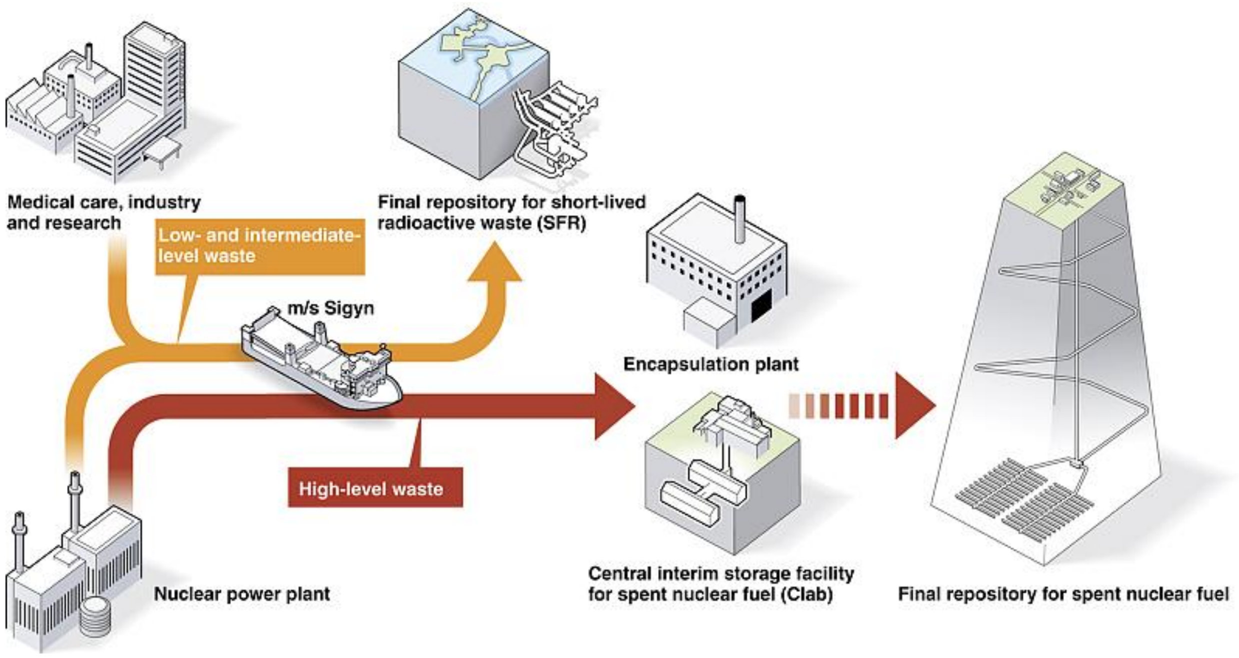

Figure 1 The Swedish system for management and disposal of radioactive operational waste and spent nuclear fuel. The encapsulation plant and the final repository for spent nuclear fuel are not yet constructed. The other plants are already in operation.

3 The replacement of casks for SNF

The spent nuclear fuel in Sweden is continuously transported from the nuclear power plants to the national intermediate storage, Clab since the fuel pools on the sites are quite small. The ability of transporting spent fuel is therefore essential to the operation of the nuclear power plants in Sweden.

SKB owns ten casks for spent nuclear fuel and two similar casks for transport of core components which has been in use since 1985. Due to the double barrier requirement against water intrusion in accident condition the casks have to be replaced. To secure the need for transport of spent fuel a new fleet of transport casks that fulfil today’s requirements by authorities and international regulations has to be provided.

SKB has to replace its current fleet of transport casks for spent fuel. The new fleet will, as the current, be part of SKB’s sea and land transport system. The new cask fleet will be used to transport the spent fuel and ideally also core components from the nuclear power plants in Sweden to the intermediate storage facility Clab for spent fuel in Oskarshamn, Sweden.

A feasibility study was performed to determine possibilities regarding modern technical solutions and also to determine the best alternative for SKB.

3.1 General requirements

In general there are some requirements that should be fulfilled in order to be an acceptable cask fleet replacement alternative for SKB. The new fleet of casks shall:

- fulfil the latest requirements and be a state of the art design according to IAEASSR-6 type B package,

- meet the weight and dimensional limitations defined by the nuclear power plants, Clab facility, ship and vehicles,

- be of a design such that the initial license can be amended in order to transport future contents such as fuel of new designs and other radioactive material,

- be fabricated of material chosen to provide long lifetime, high reliability of functions, smooth operation and easy maintenance.

3.2 The design challenge

A transport cask for spent fuel is a complex product. Given the right conditions the cask could be optimized in several different and linked areas such as:

- Criticality,
- Residual heat,
- Shielding,
- Mechanical resistance,
- Handling,
- Maintenance.

Apart from deciding a future content, a prediction how the system will be operated is just as important. A new cask design will lead to modifications of all existing facilities and replacement of handling equipment, primarily related to dimensions and handling weight of the new cask.

For SKB:s transport system the short cool down periods at the power plants may be the greatest technical challenge. It is very challenging to design a high capacity cask, keeping the weight low and still fulfil requirements both regarding residual heat dissipation and radiation shielding.

Modern cask designs could have a much better capacity and technical performance than the cask design that SKB currently is operating. Twice the capacity is anticipated for both BWR and PWR fuel assemblies. This is a remarkable improvement based upon decades of experience and development.

At the time of the design of the current casks high enrichment and high burn up was not foreseen. Current fleet was designed for much lower enrichment levels and much lower burn up. The change of content is significant, both the level of enrichment and the level of burn up have more than doubled since the commissioning of the fleet in 1985.

3.3 Future contents

To accurate predict what kind of spent fuel will be transported in the future is of course impossible. Nevertheless some detailed and realistic characteristics must be set for the fuel to make the spent fuel transport cask designers to work with. A penalising geometry with a high enrichment was chosen for the feasibility study.

Licensing is a very important and time consuming part of the administrative operation of the fuel cask fleet in Sweden. It is mandatory for the nuclear power plants to demonstrate to the authorities that the back end is taken care of when introducing new fuel types. During the operation of the fleet, relicensing of the cask is always critical for the introduction of new fuel. By choosing fuel characteristics conservatively for the new certificate it could be possible to eliminate some of the administrative work of introducing new fuel in the future.

However the strategy must not decrease the capacity of the cask too much. The current goal for SKB is to efficiently handle fuel with a burn up level between 60-70 MWD/kgU and an enrichment level of 5 % in the future.

3.4 Handling and maintenance

All though a doubled capacity contributes the most to cuts in operating costs and doses to staff it is still of great importance to enhance and facilitate all steps of a transport cycle. Both drying the content and decontamination of the cask are time consuming why it makes it important to design the cask in a way that speeds up and facilitates that work. Especially improved decontamination could further cut doses to the staff. Smooth surfaces, endurable paint, easy draining and avoiding water traps might be parts of a successful design.

All spare parts should be easily replaced and the periodic test should be simple to perform. The tools and surrounding equipment should be robust, simple and kept to a minimum both regarding types and numbers.

3.5 Environment

Sea transports are quite demanding regarding energy consumption. SKB:s ship is by far the single biggest pollutant considering operation performed by SKB. Much has been done in order to decrease the fuel consumption for the ship. Low speed, thorough transport planning, low sulphur fuel and catalytic refining have been in use since many years.

The spent fuel transports are the dominating transport category for SKB. Some 80% of the total number transports are fuel transports. Therefore a double capacity of the cask will lead to a significant decrease of SKB:s overall environmental impact, not only of the sea transports.

3.6 Safety

The fulfilment of the double barrier against water intrusion will of course make the fuel transports safer. The way SKB operates its system and perform its transport could make it hard to argue for very big improvement regarding safety for a single spent fuel transport.

However a double capacity will of course lead to half the number of transports and thus half of the risk exposure. Therefore the design could be considered as at least twice as safe.

3.7 Life cycle economy

To analyze cost efficiency for different cask alternatives the life time for the whole fleet was considered. For a number of scenarios all the investments and the operational costs were determined for the whole system for a life time. The analysis included investments, all major costs such as labour for handling and operational costs for the ship and vehicles. To verify the reliability of the result in the analysis a sensibility study was performed. In the sensibility study both technical and economical parameters was varied such as number of assemblies to be transported and interest rates for funding of the investment.

The alternatives with the best economy all have a high capacity design. The capacity of the solution impacts not only on the number of casks needed (investment) but also cask transported (operational costs) during a life time. New achievable designs of today will almost double the capacity compared of the design in current operation and make the system twice as efficient.

The system needs approximately 50 years of operation to reach pay off for the most economical alternatives. Pay off will most probably never be reached because such a long period of operation is not likely to happen. This would probably have been true even if a time shortly after 1996 were to be considered when the new requirements were introduced. Some 30 years of life time is more realistic which will return more than half of the investment in lower operating costs. The replacement will at some point in time be mandatory. Therefore there is no economical incentive to postpone the procurement due to the low risk funding of the investment. The funding with quite low interest rate can barely compete with yearly cost increase on material and labour. This makes every year with the new fleet a possibility to cut life time cost for the transport system.

Furthermore the Swedish aging NPP:s will most probably require more maintenance and renovation the older they get. During a number of years all the Swedish NPP:s prefer to transport spent fuel during two limited periods in the spring and in the autumn. These periods have become shorter over the years and it is harder every year to plan according to NPP:s preferences. A new cask fleet with a high capacity design would significantly improve the service to the NPP:s and enable the system to transport more fuel during these two limited periods. The capacity increase could be of even greater importance as soon as transports become critical for the operation of the NPP:s. In case a project at a NPP gets delayed or an event makes it important to evacuate fuel rapidly from the plant the economical significance of higher capacity changes dramatically. For such a situation the efficiency of the system is extremely valuable and handling time per fuel assembly could become most important.

3.8 Project execution

Since the system is quite complex and involves many parties, the work with taking the new fleet in operation will be very demanding. Operation adjustments needed for the transition to the new fleet will impact on several companies, 10 reactors of three generations, a number of areas and functions within each organisation such as handling, radiation protection, land- and sea transport.

It will not be a smooth transition and replacement without extensive cooperation from every part involved and engaged coordinators representing each site.

4 Conclusions

In spite of a significant increase in enrichment and burn up, the capacity of a modern cask design could be doubled compared to the current casks. A new fleet is anticipated to be twice as efficient as the current fleet.

Although a doubled capacity represents the major cut of doses to staff an improved decontamination of the cask is very important to cut doses further.

SKB:s ship is the single biggest pollutant in SKB:s system, a double capacity of the casks will lead to a significant decrease of SKB:s overall environmental impact.

Doubled capacity leads to half of the risk exposure due to the decreased number of transports. A new fleet could be considered as twice as safe, regardless of the double barrier.

Pay off will never be reached but the major part of the investment could be returned in lower operating cost.

A high capacity design would significantly improve the service to the NPP:s and enable the system to perform more transports according to NPP:s preferences.

A high capacity design could become extremely valuable if the NPP:s needs rapid fuel evacuation.

A successful replacement of a cask fleet is dependent of an extensive cooperation from every part involved and engaged coordinators representing each site.