ES7800242

INIS-mf--4490

A CENTRAL SPENT FUEL STORAGE IN SWEDEN

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This paper describes a planned central spent fuel storage facility in Sweden. The nuclear power program and quantities of spent fuel generated in Sweden is discussed. A general description of the facility is given with emphasis on the lay-out of the buildings, transport casks and fuel handling. Finally a possible design of a Swedish transportation system is discussed.

1. INTRODUCTION

The available reprocessing capacity is at the moment limited. Furthermore it is at present not quite clear in which way the spent fuel will be handled in the future. For this reason, and as a general precaution to secure the operation of the nuclear power units, it is planned to extend the storage capacity which is now available at the Swedish nuclear power stations. For several reasons and also economical, a central spent fuel storage facility (CLAB) is planned to be established in Sweden serving all the Swedish nuclear power stations.

Swedish Nuclear Fuel Supply Company (SKBF) is actually conducting a pre-project for the erection of such a facility. The site application was submitted to the authorities in November 1977 as well as the permission according to the Nuclear Energy Act. Permission has been sought for three sites adjacent to nuclear facilities on the Baltic coast, namely Forsmark, Simpevarp, and Studsvik. At present all the three local communities have answered positively to locate the storage facility within their communities. The final choice of the site will be made during this summer.

The pre-project management has been entrusted to AB Kärnkraft, AKK, an organisation owned by Oskarshamnsverkets Kraftgrupp AB, one of the private nuclear utilities group. The following organisations are at present engaged as consultants:

Asea-Atom (AA)
Société Générale Pour Les Techniques Nouvelles (SGN)
Swedish State Power Board (SSPB)
Vattenbyggnadsbyrån (VBB)

2. NUCLEAR POWER PROGRAM AND QUANTITIES OF SPENT FUEL IN SWEDEN

The expected generating capacity in GW(e) of light-water reactors scheduled for construction up to 1985 in Sweden, is given in table 1.

Table I

Expected generating capacity (GW(e)) of LWR up to 1985

1976	1980	1985
3.2	7.4	9.4

Table II gives the expected accumulated quantity of spent fuel obtained from operation of the 13 reactor blocks specified by the 1975 Swedish Parliament for Sweden's nuclear power plant program up to 1985. The table also shows the accumulated quantity from the 6 reactor blocks in operation in 1978. The dates assumed for the start-up of the uncommissioned blocks are:

- Ringhals 3 1978
- Forsmark 1 1978
- Ringhals 4 1979
- Forsmark 2 1980
- Forsmark 3 1984
- Oskarshamn 3 1985
- Unit 13 1986

Fig 1 gives the location of the Swedish nuclear power plants and proposed sites for the central fuel storage facility.

Table II

Accumulated quantities of spent fuel in tons of uranium from the operation of 6 to 13 reactors in Sweden.

End of year	Reactors in operation	
	1 - 6	1 - 13
1977	28	28
1978	120	120
1979	270	280
1980	380	420
1981	470	600
1982	570	790
1983	670	980
1984	770	1,200
1985	870	1,400
1990	1,400	2,700
1995	1,900	4,000

The average yearly discharge from 13 reactor blocks in operation (10.3 GW(e)) will amount to 280 tons of uranium.

3. DESCRIPTION OF THE FACILITY

3.1 General description

The CLAB design is based on a storage facility of 3,000 tons of uranium with possiblities to extend its capacity up to 9,000 tons. The facility will also have the possibility to store reactor core components. Some of these components will have to be subjected to mechanical processing (cutting, compaction) prior to storage. In terms of function the CLAB facility can basically be divided into three main parts, namely fuel reception, storage, and auxiliaries.

Fuel reception

This area is designed to receive the fuel shipping casks where the cask is cooled down, moved to the unloading area, unloaded, internally and externally decontaminated and is finally moved back to the transport vehicle. This part also houses a cask maintenance area.

Storage

In the storage building, the fuel is stored in special canisters in 4 water filled pools, each one having a capacity of 750 tons of uranium.

Auxiliaries

The auxiliaries consist of the equipment necessary for handling, cooling, cleaning, ventilation, waste treatment, control and monitoring, power supply and for transport.

3.2 Lay-out

The water filled storage pools will be situated underground in a cavern with a rock cover of approximately 20 - 30 meters. Such a rock cover provides good protection against damage caused by acts of war, sabotage, accidents, and extreme natural phenomena. The cost

LOCATION OF THE SWEDISH NUCLEAR POWER PLANTS AND PROPOSED SITES FOR A CENTRAL FUEL STORAGE FACILITY

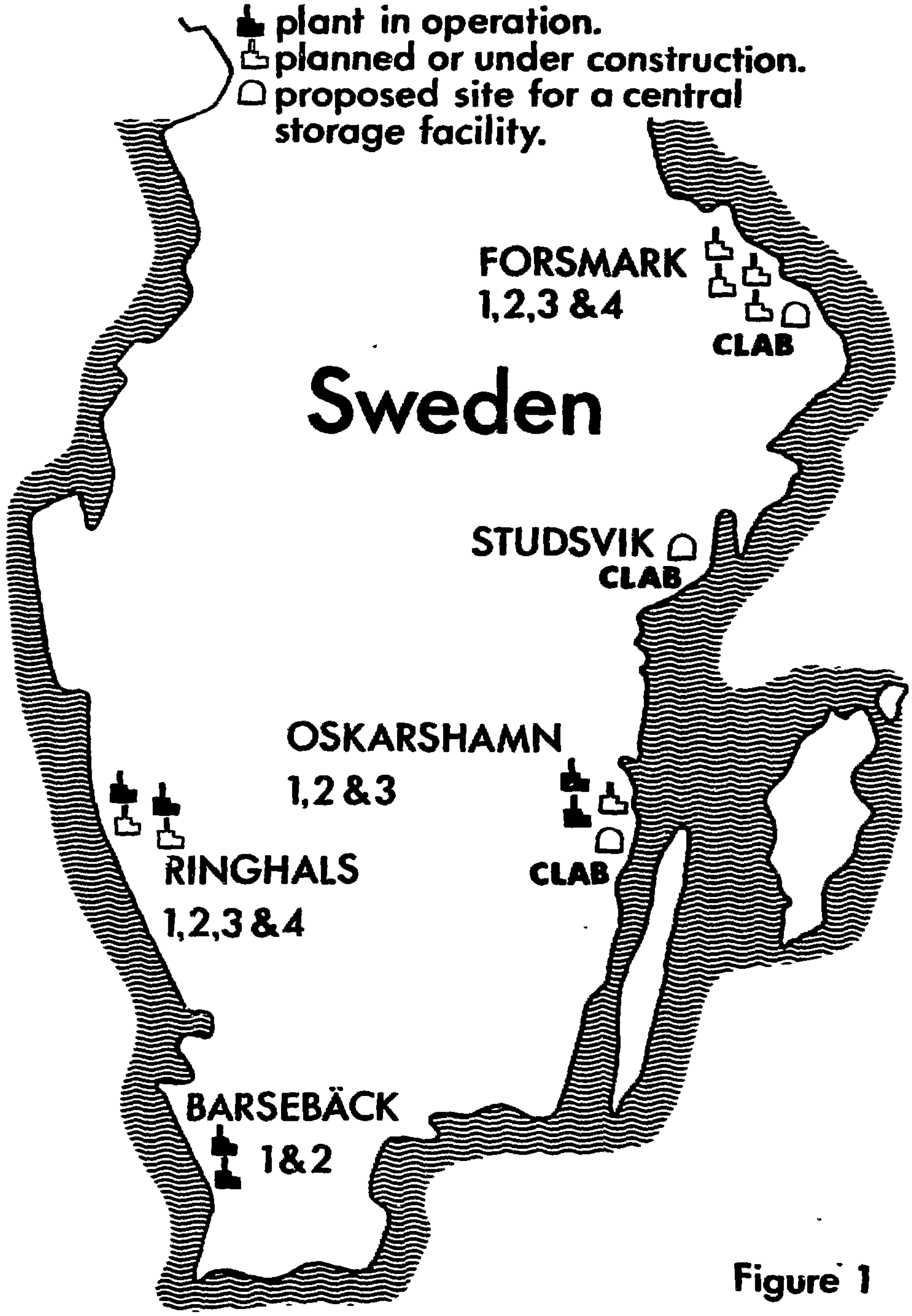


Figure 1

difference between a rock-enclosed storage facility and a surface facility with a corresponding arrangement for protection is small, since Swedish bedrock by experience is known to be tight and stable. At present lots of experience exists in Sweden from construction of different facilities in rock caverns e.g, research nuclear power stations, military facilities, oil storage etc.

The dimensions of the CLAB cavern housing the storage pools will approximately be 120 x 20 x 27 m.

The fuel reception and auxiliary buildings will be located above ground level.

Fig 2 gives a simplified perspective view of the CLAB facility.

3.3 Design specification

Overall dimensions of the buildings:

Fuel reception	length	100 m
	width	26 m
	height	32 m
Auxiliary	length	80 m
	width	30 m
	height	33 m
Storage	length	120 m
	width	20 m
	height	27 m

Total storage capacity	3,000 MTU
Storage capacity for BWR elements	12,000
Storage capacity for PWR elements	1,800
Storage canisters of 16 BWR fuel elements each	750
Storage canisters of 4 BWR fuel elements each	450
Number of storage pools	4
Water volume per pool	3,500 m^3
Storage capacity per storage pool	750 MTU
Power density of BWR fuel elements	28 MW/MTU
Power density of PWR fuel elements	34 MW/MTU
Average fuel exposure BWR/PWR	28,000/33,000 MWd/tU
Minimum cooling time before transport to CLAB	1 year
Total maximum cooling demand	6.5 MW
Average throughput of the facility per year	300 MTU
Normal pool temperature	32 °C
Max pool temperature during normal operation	45 °C
Pool structure designed for	100 °C
Reception capacity	1-2 casks/day
Total volume of rock blasted out	100,000 m^3

3.4 Fuel reception

The fuel reception is the part of the facility where most of the incoming and outgoing materials are handled.

The building has two levels below ground, one at ground level and a hall building above. The handling (operation) level is at the same height as the water surface of the pools. Personnel has access to

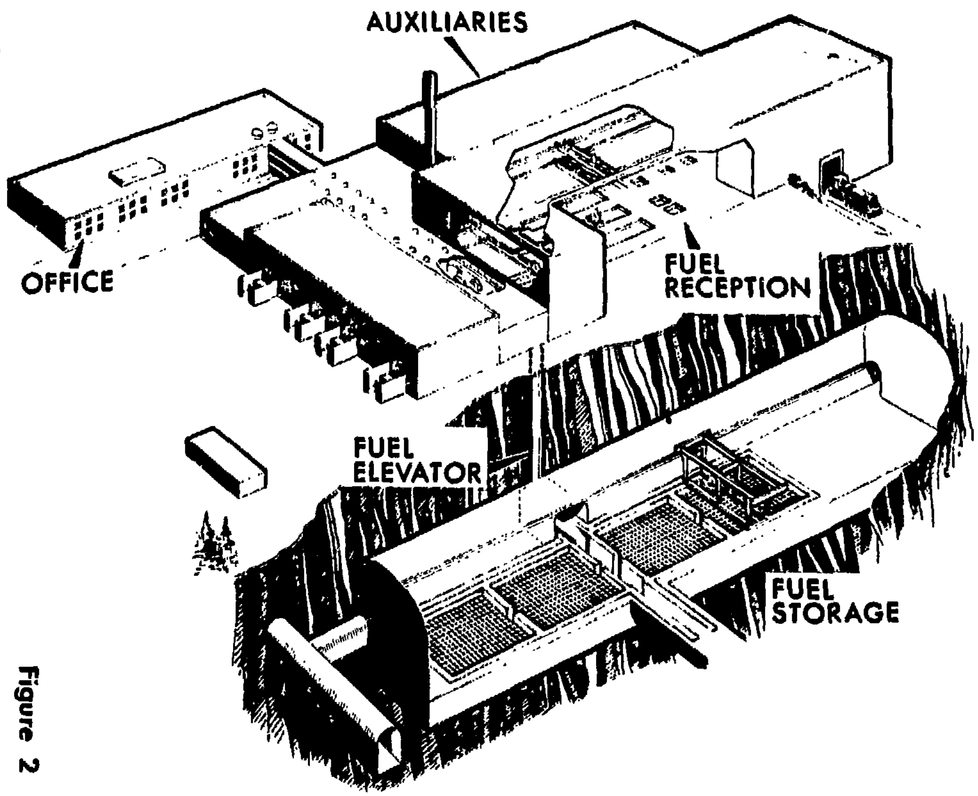

AUXILIARIES
OFFICE
FUEL RECEPTION
FUEL ELEVATOR
FUEL STORAGE

Figure 2

the reception building, which represent a controlled area, from the entrance building through a corridor in the auxiliary system building.

When the shipping cask has been unloaded from the ship, it is transported on a trailer to the fuel reception building. The unloading of the cask takes place in a transverse passage below the floor of the reception hall. The passage is designed as a sluice. For handling the shipping casks, the reception hall is equipped with a 120 ton overhead travelling crane.

A special lifting yoke is connected to the cask, which is then lifted by means of the 120 ton crane up through the transport opening of the sluice and is placed in one of the radiation shielded transit stations at the floor level.

In the transit station, the shock absorbers and other equipment fitted on the cask during transport are removed.

Prior to moving the cask to the "cask cooling cell", the cask is fitted with a shirt in order to protect the outer surface from being contaminated.

The cask is then connected to a special offgas and circulation system used for decompression and cooling of the internal cavity. The activity level of the water leaving the cask is checked during this process, which provides further information concerning possible defects in the fuel canning and the progress of the cooling/flushing procedure. After this operation the cask is moved to the unloading pool. The cask, which will be of a standardized type designed for the transport requirements within Sweden, is then lowered into a water filled shaft and is placed on a transfer trolley, which is moved to a position below the unloading pool.

The top of the cask is connected to a transfer opening in the bottom of the pool by means of a movable mechnical sealing device.

The above method of transfer to the unloading pool demands a standardized type of cask and thus cannot be generally applied. In the case of transport to foreign reprocessing plants, for instance,other types of casks may also have to be used. Such caskscan be lowered directly into the unloading pool in the conventional manner.

The advantage of the former procedure is that contamination of the outside of the cask during unloading will be eliminated and that remote operation can be applied.

After unloading of the fuel elements, the cask is moved to a cell where it is drained, the internal cavity rinsed and dried. The tightness of the lid and the connections is checked and the cask finally externally controlled for possible contamination prior to transport to the transit station.

3.5 Fuel transfer system between fuel reception and fuel storage

Upon unloading of the transport cask the fuel elements will be placed in canisters and temporary stored before transport to the fuel storage. Each canister can accommodate 16/4 BWR/PWR elements.

The transport of the canister from its temporary storage position to the storage pools in the rock cavern is performed by an upper and a lower canister handling-machine and by means of a fuel elevator. The fuel elevator consists of a conventional elevator machinery placed on a turnable concrete platform which in addition constitutes the ceiling of the hot cell located above the vertical transfer shaft in the fuel reception area.

On the floor of the hot cell there are two openings, one communicating with the intermediate storage in the fuel reception and the other with the vertical transfer shaft which is the communication link between the fuel reception and the fuel storage. The vertical transfer shaft (Ø 2 m) is lined with stainless steel.

Upon arrival of the canister in the fuel storage, the canister is transferred by means of a handling machine to the fuel storage area from where the canister is transferred by a travelling bridge to the selected position in one of the storage pools. The whole operation is performed having the canister submerged in water.

The elevator is equipped with double stainless steel cables and a common wire drum. The machinery is equipped with two of each,other independent brake systems.

3.6 Fuel storage

The storage part consists mainly of water filled pools interconnected by "gates". The storage is built up of four storage pool compartments and a transfer pool to which the fuel is delivered from the reception area. The four pools consist of one single monolite. The monolite is fixed to the rock in the centre with the pools arranged in a line with two pools on each side of the transfer pool.

Each storage pool can accommodate 750 tons of uranium and has a gross water volume of about 3,500 m^3. The depth of the pool is 13 m.

The pools are internally lined with stainless steel. The outside of the walls are accessible for inspection and any leakage is drained away through collection ducts behind the welded joints of the stainless steel liner. This drainage is collected to a drain system where a localization of the leak can be done.

The storage section is a controlled area and access to it takes place from the reception building through a vertical communication shaft. The upper part is surrounded by concrete walls and roof, which protect the underground section from pressure waves, missiles etc.

3.7 Auxiliary systems

The auxiliary systems are located adjacent to the reception part of the building and comprise the following systems:

- cooling and purification of pool water and cooling and cleaning the fuel shipping casks:
- systems for collecting, treating and release of water:
- waste treatment:
- electrical power supply:
- control equipment and ventilation systems

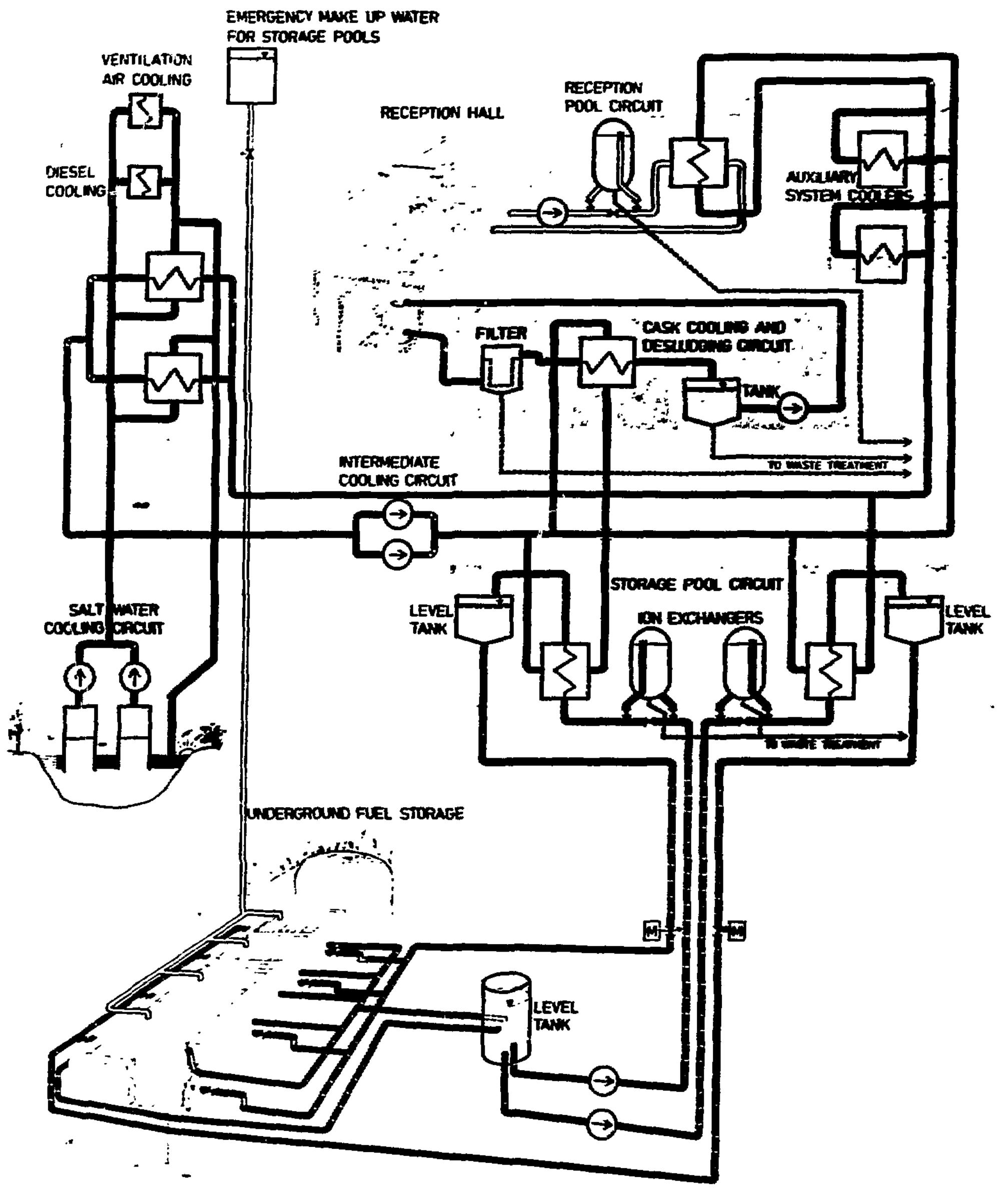
Only the cooling and water purification systems will be described here.

3.7.1 Cooling system

The cooling system shown in fig 3 consists in principle of three main circuits, a sea water cooling circuit, an intermediate cooling circuit, and a circuit for primary process purposes.

The function of the cooling circuits are:

- to cool the stand-by power supply diesel unit
- to maintain the specified temperature of the water in the fuel



CLAB

PRINCIPAL COOLING AND
WATER PURIFICATION SYSTEMS

Figure 3

storage pools

- to cool other objects which require cooling during normal operation (fuel reception pools, cask cooling, ventilation etc).

The sea water cooling circuit consists of two pumps in parallel and a single pipe system, which feeds the heat exchangers in the intermediate cooling system with the required amount of sea water. The heated water is returned to the sea. This circuit cools in addition the stand-by power supply unit and the ventilation air cooling unit.

The intermediate cooling system consists of a closed loop between the sea water cooling system and the storage pool cooling system (primary process circuit). All components are located in the auxiliary building above ground. The intermediate circuit consists of two pumps in parallel and a set of heatexchangers in the process systems. The system is designed in such a way that all connected cooling objects can be maintained at the required temperature having the two pumps and heatexchangers in operation and assuming that the temperature at the sea water intake does not exceed 18 °C.

The storage pool circuit consists of two physically separated loops, each of which having one pump and one heat exchanger. The two pumps are located down in the rock cavern and all the other main components in the above ground auxiliary building.

The temperature in the pools during normal operation will be about 32 °C. If only half of the cooling capacity is available at the design decay heat (6.5 MW) assuming the design sea water temperature (18 °C) , the temperature will not exceed 45 °C.

In the very unlikely event of total loss of cooling capacity, the decay heat will be removed by the ventilation system. Even in the case of simultaneous failure of this system, the temperature of the pools will not reach the boiling point because of the natural air circulation to the stack.

To compensate for the evaporation, make up water is fed to the pools by gravity from a tank at the ground level.

3.7.2 Water treatment systems

The purpose of this systems is:

- to clean the water from the incoming fuel shipping casks from corrosion and fission products
- to remove solid inpurities and fission products from the water in the unloading and storage pools.

The internal cask cooling system consists of a closed loop equipment with a mechanical filter and a heat exchanger. The cavity of the cask is flushed (cleaned) by closed circuit circulation from the bottom to the top of the cask. When the fuel elements have been sufficiently cooled the direction of water is reversed. In the latter operation the particles (crud) are entrained towards the mechanical filter, and unnecessary contamination of the unloading pool avoided.

The water treatment of the unloading and storage pools are similar. All the loops are equipped with a precoatfilter coated with resins.

The filters are backflushed to the waste treatment system and new resins are fed to the filters from a common auxiliary unit.

4. TRANSPORTS

In parallel with the pre-project of the central fuel storage facility. SKBF is examining various alternatives for securing a reliable supply of transport resources within Sweden.

In 1976, discussions were initiated with European and American organisations which work with the transportation of spent nuclear fuel for the purpose of examining the possibilities of procuring transport casks.

Negotiations will start during the second half of 1978 with some European organisations in order to secure the transport within Sweden. It is considered as important that any transportation system which is adopted should be compatible with any existing standard European system.

It is forseen to transport spent nuclear fuel to the central storage facility by sea. The construction of a ship especially adapted for that purpose is considered economically justifiable.

A suitable size for such a ship is approximately 1,000 tons dwt. Such a ship can take up to 8 transport casks of the forseen size at a time. Available Swedish tonnage in this size class is very limited. Moreover, it is difficult to adapt existing ships to the requirements which must be met by a ship which is used regularly for the transportation of spent nuclear fuel. Existing ships could be chartered for occasional transports, but since fuel will be transported throughout most of the year, this alternative would be uneconomical in the long run.

The transport vessel must be equipped with particularly effective steering and mooring equipment. Its draught will be limited to 3-4 m, which means that existing channels and harbours can be used. The ship will be designed either for conventional cargo handling or for roll-on roll-off. With conventional handling, the cargo is lifted directly down into holds by means of dock-based cranes. This method is used today at the nuclear power plants. With roll-on roll-off handling, the transport vehicle - the trailer - can drive both onto and off of the ships without requiring any lifts by harbour cranes. The harbours at all of the nuclear power plants can be adapted for such rational handling.

The cargo must be anchored in the transport vessel in such a manner that it will not come loose in the event of a collision or if the ship runs aground. The hold is divided by watertight bulkheads for added security against sinking. Should the ship nevertheless go to the bottom, it must be easy to locate. It will therefore be equipped with some such device as an underwater transmitter which is automatically activated if the ship should sink. The shipping lanes and channels are shallow enough to permit salvage of both ship and cargo.

The hull of the ship must be designed for running through ice. But a vessel of the size in question cannot function as an icebreaker, which means that the assistance of icebreaker will be required under difficult ice conditions.

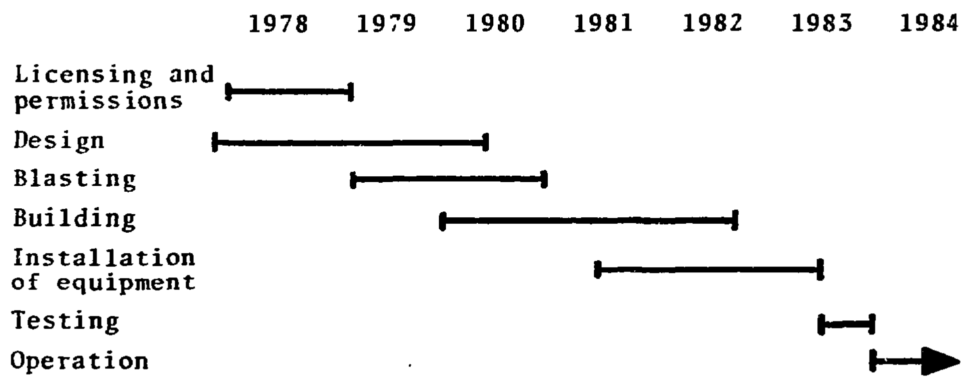
The time for delivery of a vessel of the type described here from a Swedish shipyard is currently 1 1/2 to 2 years.

5. TIME SCHEDULE

Assuming the licensing procedure will be finalized in early 1979, construction is planned to start during spring 1979. The storage facility is planned to be operative in early 1984. The time schedule for the construction period is given in fig 4.

Figure 4

Time schedule for the construction period



6. INVESTMENT AND OPERATION COSTS

A preliminary cost estimate based on a conceptual study including transport equipment has been estimated to about 650 million Sw cr.

The required operational staff including transports will be about 100 persons. The preliminary operation costs is estimated to be about 30 million Sw cr yearly.