International
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# INFCE

INFCE/DEP./WG.7/10

Intermediate Storage Facility for Vitrified
High Level Waste from the Reprocessing of
Spent Nuclear Fuel

INFCE/DEP/ WG7/10

# Sweden - Intermediate Storage Facility for Vitrified High Level Waste from the Reprocessing of Spent Nuclear Fuel


## Abstract

An intermediate storage facility for vitrified high level waste is described. The design was made specifically for Swedish conditions but can due to modular design be applied also for other conditions. Most of the plant is located underground with a rock cover of about 30 m in order to provide protection against external forces such as acts of war and sabotage. The storage area consists of four caverns each with 150 pits. Each pit can take 10 waste cylinders of 0.4 m diameter and 1.5 m length containing 150 liters of glass. The capacity can be increased by adding additional caverns. Cooling is obtained by forced air convection. Reception areas, auxiliary systems and operation of the plant are also described.


## References


1 Handling of Spent Nuclear Fuel and Final Storage of Vitrified High Level Reprocessing Waste
Volume III. Facilities
Kärnbränslesäkerhet, 1978

2 Saint Gobain Techniques Nouvelles.
Project for the handling and storage of vitrified high-level waste.
KBS Technical report 35
October 1977.

# INTERMEDIATE STORAGE FACILITY FOR VITRIFIED HIGH LEVEL WASTE FROM THE REPROCESSING OF SPENT NUCLEAR FUEL

## INTRODUCTION

In April 1977 the Swedish Parliament passed a law, which stipulates that new nuclear power units cannot be put into operation unless the owner is able to show that the waste problem has been solved "in a completely safe way". In response to the government bill proposing the law, the nuclear power industry decided in December 1976 to organize the Nuclear Fuel Safety Project (KBS) and in December 1977 a report entitled "Handling of spent nuclear fuel and final storage of vitrified high level reprocessing waste" was submitted to the government in connection with an application for permission to take a reactor in operation after its completion in mid-1978. The handling chain for the spent nuclear fuel and the high level reprocessing waste proposed in that report includes an intermediate storage facility in which the vitrified waste is to be kept during at least 30 years before it is placed in the final repository. In the following a brief description of the main features of this facility is presented.

## WHY INTERMEDIATE STORAGE?

An important factor for the design of a final repository (which in accordance with the KBS proposal will be located in crystalline rock 500 m below the ground level) is the thermal loading caused by the heat emitted by the waste. In order to minimize the effect on the rock and the ground water flow caused by this thermal loading the KBS design is based on:

- a content of fission products in the vitrified waste of only 9%. (The reprocessing will be made in La Hague, France, and the glass is of the borosilicate type)

- an intermediate storage of the vitrified waste during at least 30 years. During this storage time the heat flux is reduced to about one half. (It is assumed that the reprocessed waste is returned to Sweden about 10 years after the spent fuel was taken out of the reactor).

In addition to reducing the heat flux the intermediate storage also provides time for further development and optimization of the design of the final repository.

1978-04-26

## LAYOUT OF PLANT

The layout of the plant is shown on Fig. 1. It has three main sections: receiving station, intermediate storage and encapsulation station. (In the encapsulation station, which is not described in the following, the vitrified waste is enclosed in a lead-titanium canister prior to the transfer to the final repository). Most of the plant is located underground with a rock cover of about 30 m in order to provide protection against external forces such as acts of war and sabotage. The only surface facilities will be an entrance building with administration and service quarters and ventilation inlets and outlets. Access to the plant is through an entrance tunnel and through vertical shafts.

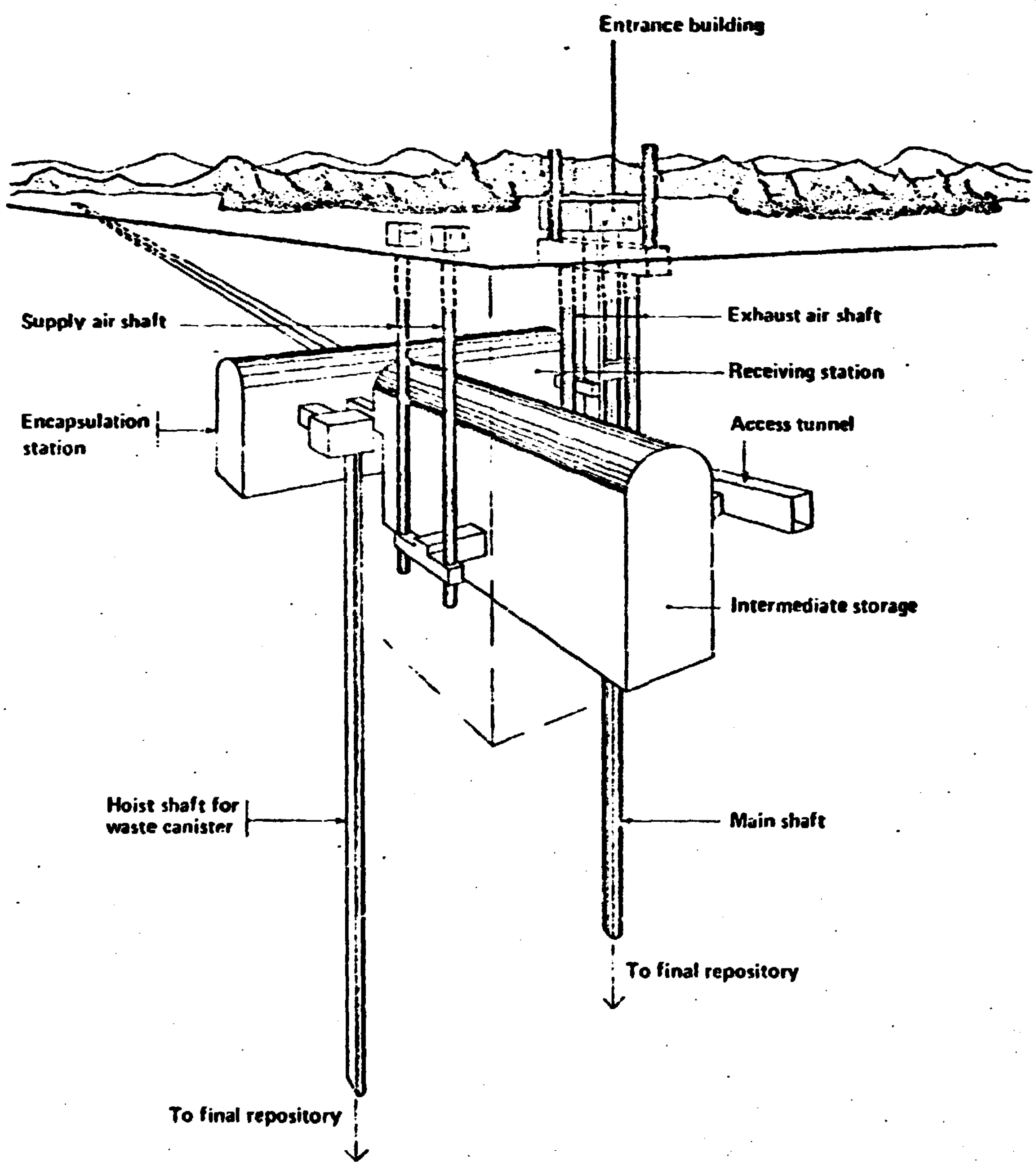
The storage capacity of the plant is 6000 containers each with a content of vitrified waste corresponding to the equivalent of 1 ton uranium. The design has been prepared in cooperation with Saint Gobain Techniques Nouvelles and is similar to the newly completed storage facility at Marcoule in France. For a more detailed description of the plant facilities reference is made to the attached drawing No. 1879 DC016 (Fig. 5).

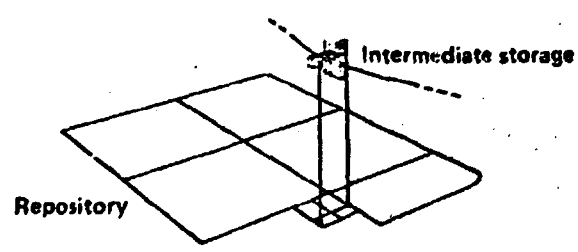
## RECEPTION

When despatched from the reprocessing plant the vitrified waste is enclosed in a cylindrical chromium-nickel container, see Fig. 2. The waste cylinders have a diameter of 40 cm, a height of 150 cm and contain 150 litres of vitrified waste. The waste cylinders arrive to the intermediate storage facility in a transport cask on a trailer. The cask will have to comply with IAEA regulations. A cask of type VTL 12 holds 15 waste cylinders. At the arrival each waste cylinder has a heat flux of about 1200 W.

After external washingin the arrival hall, the transport cask is lifted from the trailer through an air lock into the receiving room (see Fig. 3), where it is placed on a wagon in a vertical position. The radioactivity content of the air which is blown through the cask is monitored to check whether the cask is internally contaminated. The bolts which retain the cover are removed, and the cask is moved to a position underneath the unloading cell and connected to an opening in the floor of the cell. When all glass cylinders have been lifted out of the transport cask into the unloading cell, the cask is flushed with water if the monitoring indicated that its inside was contaminated. The transport cask can then be returned to the reprocessing plant.

Fig. 1

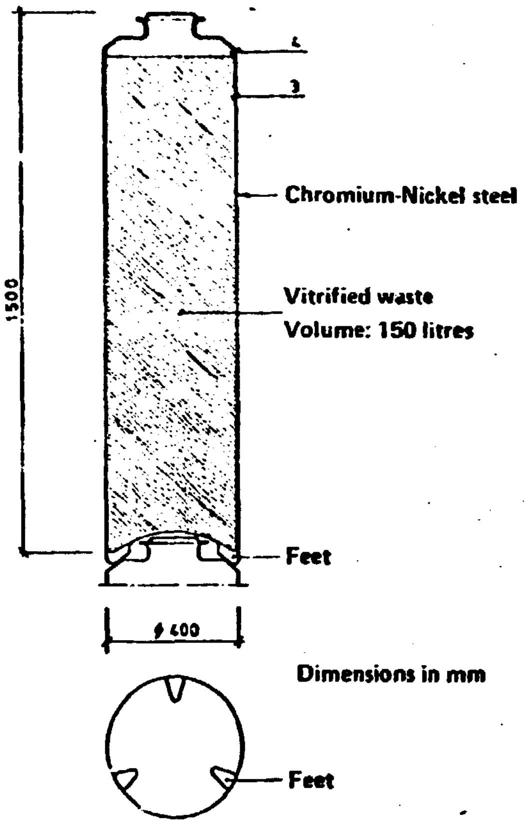



KEY PLAN

*Perspective drawing of plant for intermediate storage and encapsulation. It is located underground with a rock cover approximately 30 metres thick. The plant is located above the final repository.*

Fig. 2




*Waste cylinder. The vitrified waste is cast in a container made of chromium-nickel steel. The container is sealed with a welded-on lid. The feet enable the waste cylinders to be stacked on top of each other.*

The cylinders are unloaded from the transport cask in the unloading cell. This cell is enclosed in concrete of sufficient thickness to provide radiation shielding for the personnel. The cell has four handling stations, each equipped with a radiation-shielded window and a pair of master-slave telemanipulators so that work in the cell can be done from the outside.

Materials are moved inside the cell by means of a remote-controlled overhead crane with a lifting capacity of 8 tons.

When it is not being used or when it requires maintenance, the crane is moved to an intervention cell through an opening which can be closed by a radiation-shielded sliding door.

The waste cylinders are brought into the unloading cell through an opening in the floor which is connected to the transport cask in the receiving room. The opening is closed by means of a radation-shielded sliding door when it is not being used.

When the transport cask has been connected, its cover is removed by the overhead crane and placed in a sealed box in order to prevent spread of any contamination.

The waste cylinders are lifted out of the transport cask and placed in a temporary storage in the cell by the overhead crane, which is equipped with a special grapple.

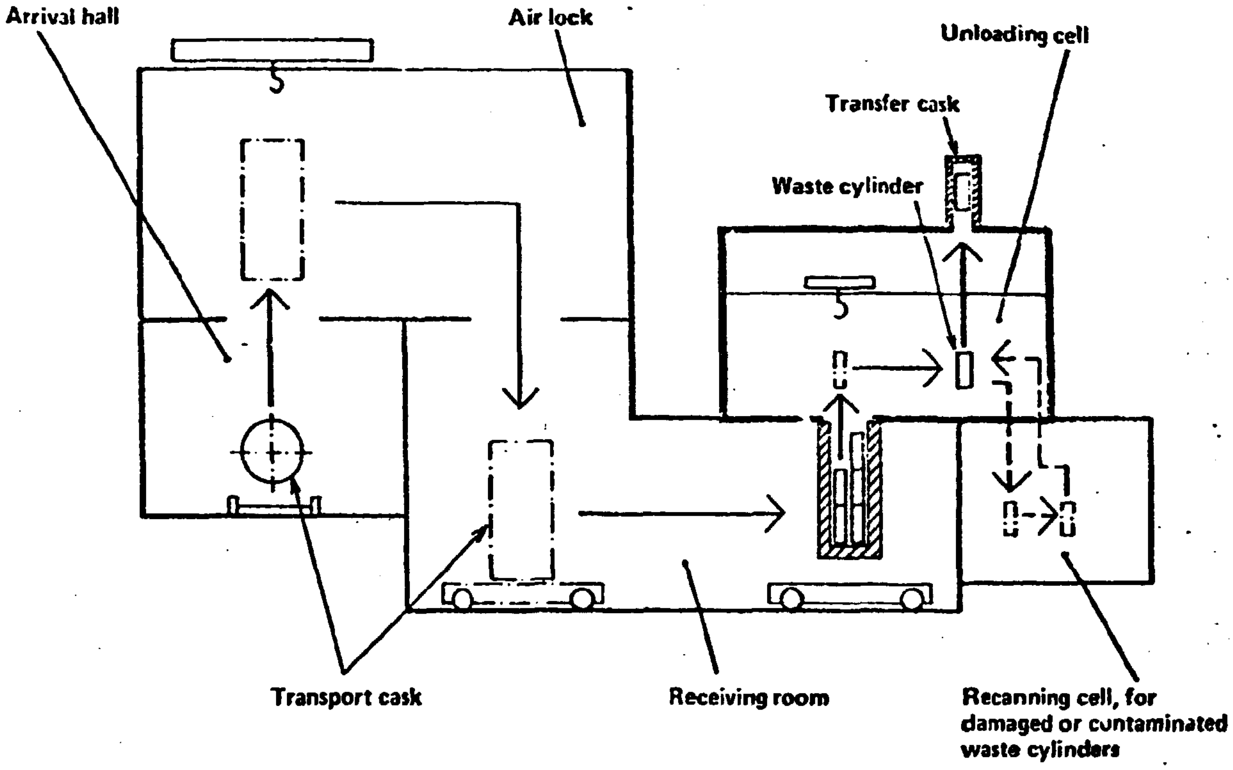
When a waste cylinder is to be transferred to the intermediate storage section, it is placed by the crane in a position underneath an opening in the roof of the cell. This opening is covered by a radiation-shielded sliding door when it is not being used.

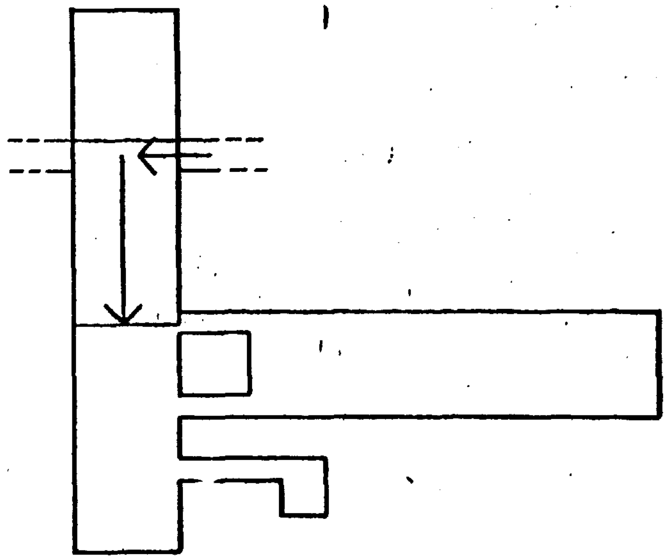
If the inside of the transport cask has been found to be contaminated, all waste cylinders from such a cask are assumed to be contaminated and are taken to the recanning cell, where they are encased in an outer container similar to the one with which they were provided in the reprocessing plant in order to prevent contamination of the intermediate storage section.

The recanning cell has two handling stations, each equipped with a radiation-shielded window and a pair of master-slave telemanipulators. It is connected to the unloading cell through two openings in the roof, one to lower the waste cylinders into the cell and one to lift them out. The openings can be sealed by concrete plugs.

A radiation-shielded arrangement makes it possible to bring empty outer containers and their lids into the cell from the maintenance cell. They are placed on a carousel which brings

Fig. 3



KEY PLAN

*Schematic diagram of reception. In this section, transport casks are received and the waste cylinders are unloaded. Damaged or contaminated cylinders are encased in an outer container of chromium-nickel steel.*

them into a position where they can receive a waste cylinder as it is lowered from the unloading cell through the opening in the roof. In the next position, the lid is placed on the filled outer container and welded in place. It is then moved into a position underneath the second opening and lifted up into the unloading cell by the overhead crane.

In the unloading cell, the outer containers are decontaminated externally by washing with water under high pressure. They are then moved by the overhead crane into a position underneath the opening in the roof of the cell for transfer to the intermediate storage system.

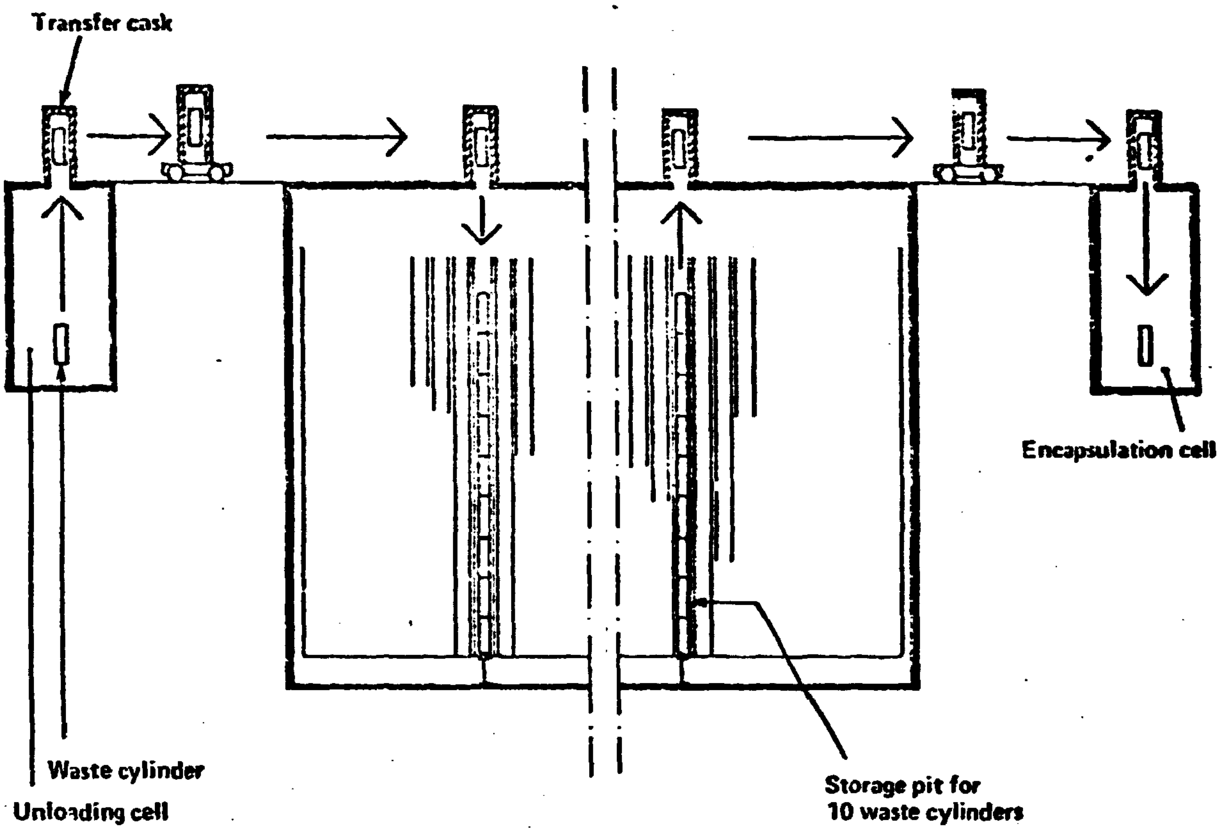
INTERMEDIATE STORAGE

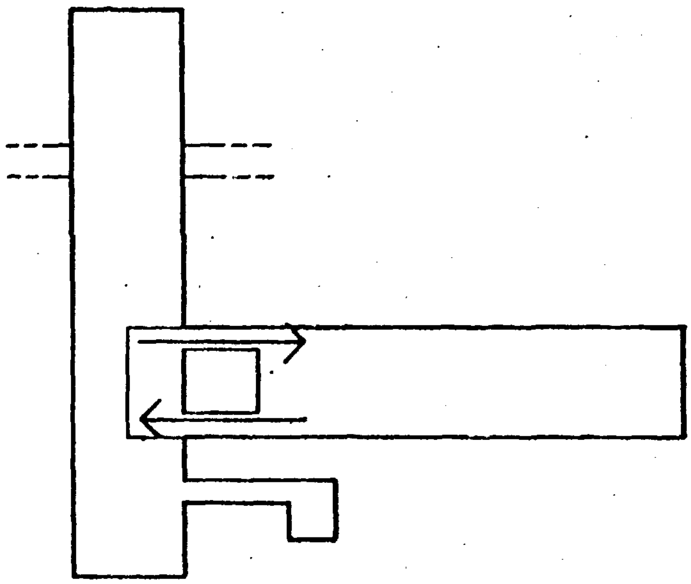
The waste cylinders are transferred to the intermediate storage section inside a radiation-shielded transfer cask.

The transfer cask is enclosed in a lead jacket 25 mm thick which is lined on the inside with stainless steel and covered on the outside with a 20 cm thick layer of polyethylene. These layers provide adequate radiation protection for the operating personnel. The transfer cask has its own ventilation system with a fan and filter at the air intake and outlet. When a waste cylinder is inside the transfer cask, the ventilation system is used for cooling (when required) and to check whether the outside of the waste cylinder is contaminated by monitoring of the radioactivity of the filter at the air outlet.

The transfer cask is positioned over the opening in the roof of the unloading cell, which is covered by a radiation-shielded sliding door. There is a similar door in the bottom of the transfer cask, and both doors are opened simultaneously. The waste cylinder, which is positioned underneath the opening in the unloading cell, is then lifted into the transfer cask by the hoist with which the cask is equipped. When the waste cylinder is inside the cask, both sliding doors are closed and the transfer cask is taken to the intermediate storage hall by a portal crane on rails to a position where it can be reached by the overhead crane in the intermediate storage hall.

In the intermediate storage section, the waste cylinders are stored in steel pits inside a steel frame in a concrete trench (se Fig. 4). Each trench contains 150 steel pits spaced at centre-to-centre intervals of just under 1 metre and each with room for 10 waste cylinders stacked on top of one another. Each trench thus holds 1 500 waste cylinders. The intermediate storage section has four trenches in two groups with room for ventilation equipment between the groups. Each group has its own ventilation system. The total storage capacity of the facility is thus 6 000 waste cylinders.



KEY PLAN

*Intermediate storage. The waste cylinders are transferred to the intermediate storage section inside a transfer cask. After storage for at least 30 years, the cylinders are transferred to the encapsulation cell.*

The storage trenches are covered by a concrete slab which is thick enough to provide radiation protection for the intermediate storage hall above it. Furthermore, the air pressure in the hall is maintained at a higher level than that in the trenches, so air from the trenches cannot enter into the hall. Above each storage pit, the concrete slab has a hole which is sealed with a removable concrete plug.

The waste cylinders are cooled by the circulation of air through the storage pits by the ventilation systems in the intermediate storage section. The ventilation systems communicate with the atmosphere through ventilation shafts and stacks on the surface (see below ).

When a waste cylinder is to be deposited into a storage pit, a mobile radiation-shielded sliding door and a plug removal cask are positioned above the pit. After the plug has been lifted into the cask, the sliding door is closed and the cask with the plug is lifted away. The transfer cask containing the waste cylinder is then positioned on top of the sliding door, which is opened at the same time as the transfer cask door. The waste cylinder is then lowered into the storage pit by means of the hoist in the cask. The doors are then closed, the transfer cask is removed and the plug is replaced by the reverse of the procedure which was used to remove it. All handling is done by the overhead crane in the intermediate storage hall, which has a lifting capacity of 35 tons.

When the waste cylinders are to be transferred to the final repository after 30 years (or more) in intermediate storage, they are moved to an encapsulation cell by means of a procedure which is the reverse of that which was used when they were transferred from the unloading cell to the intermediate storage section. In this cell the waste cylinders are enclosed in a lead-titanium canister prior to the transfer to the final repository.

AUXILIARY SYSTEMS

The facility will contain systems for decontamination of transport casks and waste cylinders, for floor and groundwater drainage etc. These systems are similar to the ones in a nuclear power station. Low- and medium-active waste (water, filters, solid waste etc.) arising from the operation of the intermediate storage facility will be collected and sent to plants which are equipped to receive and treat such material.

Diesel-powered generators will supply auxiliary power to essential systems (ventilation, drainage etc.) in the event of an external power failure. In the event of malfunctions of pumps for the groundwater drainage system, the water will be collected in a basin with enough capacity to prevent the facility from being flooded, even in the event of an extended power failure.

A cascade of differential pressures will be maintained by the ventilation system in the underground part of the facility in accordance with the potential risk of contamination in the various areas. The intake air will be filtered and conditioned to provide comfortable working conditions.

Air for the unloading cell will be supplied through a damper and a non-return valve in order to prevent over pressure in the cell.

The ventilation system for the intermediate storage section is designed to maintain negative pressure in the storage trenches. It has a capacity of 150 000 $m^3/h$ for each group of two trenches. The air enters through a low pressure chamber on the surface and passes through a bank of filters before entering the storage trenches.

All exhaust ventilation air from the underground part of the facility passes through absolute filters with an efficiency of 99.99% before it is released into the atmosphere. (It is possible that modifications in the design of the facility will eliminate the necessity of such filters in parts of the ventilation system.)

Air is circulated in the storage trenches by two fans, with a third fan in reserve. These three fans are located in a room next to the storage trenches. A fourth fan, with the same capacity but located above ground for better accessibility in emergency situations, provides additional reserve capacity. If only one fan is in operation, 65% of the air flow provided by two fans can be maintained. In the event of a failure of all fans, a bypass line with an automatic damper permits air to circulate with natural convection without passing through the filter systems.

In normal operation, the temperature of the exhaust air will rise to 80°C at an inlet temperature of 20°C when the maximum total heat produced by the waste cylinders is 3000 kW in a group of two storage trenches. With only one fan in operation, this temperature increases to 112°C after 40 hours. If all fans are out of operation and the storage section is being cooled by natural air convection alone, the temperature of the exhaust air will be 336°C after 40 hours. The surface temperature of the hottest cylinder will only be a few degrees higher than the temperature of the exhaust air and the centre temperature of the glass will only be 20-30° higher than the surface temperature. Since the glass does not crystallize at temperatures below 550°C, the waste cylinders will not be damaged even if all fans are out of operation.

The facility has been designed in such a manner that the hot air will not cause any damage to building structures and installations. To this end, the storage trenches and ventilation ducts are lined with steel sheet with an air space between the sheet and the concrete.

## OPERATION OF FACILITY

Some 30-40 persons will be required for the operation of the facility.

The entire underground part of the facility is classified as a controlled area and is divided into zones according to the potential risk of contamination, in the same manner as in a nuclear power station.

All handling of waste cylinders is done by remote control when the cylinders are in radiation-shielded cells or with the aid of a radiation-shielded transfer cask. If a power failure should render motor-driven equipment inoperable, the work can be done manually.

All cells are connected to an intervention cell to which all equipment in the cells may be transferred by means of remote control and in which minor repairs can be effected. If major repairs are required, the equipment can be decontaminated and taken out of the intervention cell into a metal-lined room situated above the cell. From here, the equipment can be sent away for repair.

The facility's operating systems are based on existing technology and on experiences from similar systems in existing facilities.

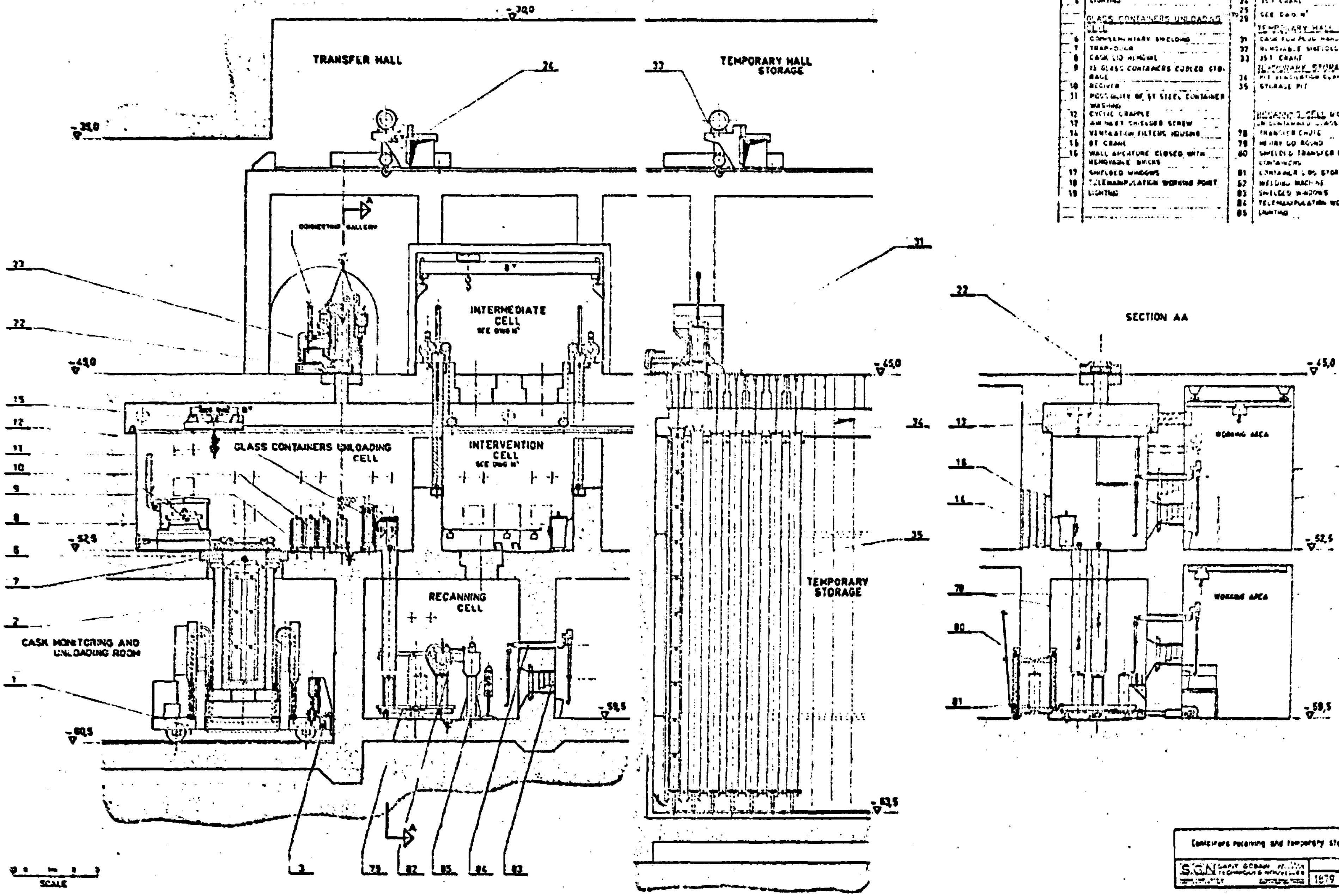
The facility will be under the supervision of authorities such as the Swedish Nuclear Power Inspectorate and the National Institute of Radiation Protection in the same manner as a nuclear power station. The facility will be designed in compliance with the regulations issued by these authorities and by the occupational safety authorities and in consultation with concerned personnel organizations.

## TIME SCHEDULE

The intermediate storage facility should be completed in 1990, when the first waste cylinders are scheduled to be returned to Sweden from the reprocessing plant.

| ITEM | DESIGNATION |
|---|---|
| | CASK MONITORING AND UNLOADING ROOM |
| 1 | LIFTING CART |
| 2 | TRANSPORT CASK NCT 12 TYPE |
| 3 | STUFFING AND [illegible] OF THE CASK |
| 4 | LIGHTING |
| | GLASS CONTAINERS UNLOADING CELL |
| 6 | COMPLEMENTARY SHIELDING |
| 7 | TRAP-DOOR |
| 8 | CASK LID REMOVAL |
| 9 | 15 GLASS CONTAINERS COOLED STORAGE |
| 10 | RECEIVER |
| 11 | POSSIBILITY OF ST STEEL CONTAINER WASHING |
| 12 | CYCLIC GRAPPLE |
| 13 | AIR HEET SHIELDED SCREW |
| 14 | VENTILATION FILTERS HOUSING |
| 15 | 8T CRANE |
| 16 | WALL APERTURE CLOSED WITH REMOVABLE BRICKS |
| 17 | SHIELDED WINDOWS |
| 18 | TELEMANIPULATION WORKING POINT |
| 19 | LIGHTING |

| ITEM | DESIGNATION |
|---|---|
| | [illegible] HALL |
| 21 | COMPLEMENTARY SHIELDING |
| 22 | TRAP-DOOR |
| 23 | CASK FOR TRANSFER TO TEMPORARY STORAGE (AIR COOLED) |
| 24 | 35T CRANE |
| 25 TO 29 | SEE DWG N° |
| | TEMPORARY HALL STORAGE |
| 31 | CASK FOR PLUG HANDLING |
| 32 | REMOVABLE SHIELDED CHAMBER |
| 33 | 35T CRANE |
| | TEMPORARY STORAGE |
| 34 | PIT VENTILATION CLOSET |
| 35 | STORAGE PIT |
| | RECANNING CELL FOR DETERIORATED OR CONTAMINATED GLASS CONTAINERS |
| 78 | TRANSFER CHUTE |
| 79 | MERRY GO ROUND |
| 80 | SHIELDED TRANSFER DEVICE FOR CONTAINERS |
| 81 | CONTAINER LOG STORAGE |
| 82 | WELDING MACHINE |
| 83 | SHIELDED WINDOWS |
| 84 | TELEMANIPULATION WORKING POINT |
| 85 | LIGHTING |




Containers receiving and temporary storage

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Fig. 5