SLOVAK ELECTRIC, p.l.c., BRATISLAVA

SLOVAK REPUBLIC

EXISTING AND NEAR FUTURE PRACTICES OF SPENT FUEL STORAGE IN THE SLOVAK REPUBLIC

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1. Reactor operation and spent fuel production

Slovak Electric, p.l.c. (SE, a.s.) is only operator of nuclear power reactors in Slovakia. At present time there are four reactor units in operation at Bohunice site and one reactor unit at Mochovce which has been put into operation in July 1998. Other three units are under construction at Mochovce site. The second unit at Mochovce is planned to be put into operation at the end of 1999 or beginning of 2000. No decision has been taken yet on the completion of other two reactors on that site.

All these reactor units exploit VVER-440 reactors and use identical fuel assemblies (FAs) which are of hexagonal shape with 126 fuel rods of uranium dioxide pellets in zirconium-niobium alloy cladding. Fresh fuel enrichment is 3.6, 2.4, and 1,6 % U-235, and average discharge burn-up is around 32 GWd/tU. Fuel stays in reactor for maximum 4 cycles with average 280 EFPD per cycle. Maximum fuel burn-up is 38 GW/tU for 3,6 % enriched fuel.

Fresh fuel for all VVER 440 reactor units in Slovakia has been supplied from Russian Federation (or Soviet Union) - with Elektrostal' as a manufacturer. New fresh fuel contract for 4 reactor units had been negotiated and signed in 1998, again with Russian supplier. According to this contract fresh fuel with only enrichment of 3,82 % will be delivered. In the assemblies of new contracted fuel radius profiled enrichment will be applied with maximum garanted assembly burn-up up to 45 GWd/tU (42 GWd/tU for control rod follower). First loading of this fuel into the reactor of unit 1 of Mochovce NPP will be realized in 1999.

First two reactors at Bohunice site are of older type V-230 and all others are of newer type V-213. Cores of all VVER - 440 reactors were designed to be formed by 349 fuel assemblies but in both reactors of V-230 (Bohunice units 1 and 2) only 313 fuel assemblies have been used for many years. There are 36 dummy assemblies which are placed in the periphery part of the core in order to reduce fast neutron fluency on pressure vessel .

At Bohunice site spent fuel discharged from the reactors is first stored in at - reactor (AR) pools for approximately three years and then this fuel is transferred, for long-term storage, to the away-from-reactor (AFR) water pool storage facility which is located on that site. Design storage capacity of AR pools of Mochovce units is higher compare to Bohunice units, so it allows to store spent fuel for seven to eight years. Long-term storage of the spent fuel from Mochovce units will be solved in the near future.

During operation of all VVER-440 reactor units in the Slovak republic it has been produced some 800 ton_{HM} of spent fuel (approximately 6 663 FAs). Only small part of spent fuel (697 FAs) had been transferred back to the former Soviet Union (for reprocessing) by the

year 1987. There are 5 966 FAs (716 ton_{HM}) stored in AR pools and AFR storage facility in Slovakia at present time (as for June 30, 1999).

Prognosis for the total amount of spent fuel which can be produced in all reactor units varies from 2 100 to 3 300 ton_{HM} dependent on how many units will be put into operation and what will be the real lifetime of the units in operation.

2. Past policy in spent fuel storage

Nuclear electricity generation in Slovakia has been, from its beginning, built as a part of the Czechoslovak nuclear power program, and that program has been developed in close co-operation with the former Soviet Union (SU). The co-operation concerned not only construction of new nuclear power plants but also supplying of fresh nuclear fuel and management of back-end fuel cycle.

Original policy for spent fuel management in Czechoslovakia was based on the assumption that spent fuel would be sent back to the Soviet Union for reprocessing without returning ra-waste and other products from reprocessing back to Czechoslovakia. The spent fuel before sending for reprocessing should have been cooled/stored in at-reactor cooling/storage pools for approximately three years.

Later on, it was, from the Soviet side, required to store spent fuel on Czechoslovak territory for approximately ten years before its shipment back to SU. To be able to comply with this requirement, it was, at the beginning of eighties, decided to construct a new spent fuel storage facility (away-from reactor storage facility) at the Bohunice NPP site (Slovakia) for ten years storing of the spent fuel produced on that site. Construction of the new AFR storage facility had been accomplished in 1986 and permanent operation started in 1987.

In 1984, however, it was, by the Soviet, side suggested to shorten the storage/cooling time of the spent fuel on the Czechoslovak territory from ten to five years only. In that situation it was abandoned to construct a new storage facility at Dukovany NPP site (ČR), and was decided to store spent fuel from all Czechoslovak VVER 440 units in Bohunice storage facility before its planned transportation back to SU.

Transportation of spent fuel from NPP Dukovany to Bohunice storage facility started in 1989 and lasted until 1992. Totally 1 176 fuel assemblies (FAs) had been transported and stored in Bohunice storage facility, and 11 transports had been realised. For the first transport from Dukovany to Bohunice TK-6 transport casks had been used, and for other ten transports, C-30 transport casks had been in use.

After political and economical changes which took place in middle and east Europe, transportation of spent fuel from Czechoslovakia/Slovakia back to SU/Russian Federation (RF) has been stopped. The last transport was carried out in 1987, after that no transport from the Czech or Slovak republics has been realized.

After splitting of Czechoslovakia, a new spent fuel storage facility started operation on the Dukovany NPP site in the Czech republic in 1995. It is a dry storage facility making use of double purpose transport/storage casks CASTOR 440/84.

Transport of the „Czech" spent fuel from Bohunice storage facility back to the NPP Dukovany site started in 1995 and lasted until 1997. For the first 8 shipments, C-30 transport casks have been used and for the 6 further transports CASTOR 440/84 casks have been employed.

3. AFR storage facility at Bohunice NPP site

The AFR spent fuel storage facility at Bohunice site is of water pool type of Soviet design, and has been operated since 1987. Design storage capacity is 5 040 FAs (600 Mt_{HM}). It was originally designed for storing the fuel produced by Bohunice NPPs for period of approximately 10 years, before its planned transportation back to the SU.

The storage facility consists of four storage pools interconnected by one transport corridor. Three pools are in use for storage, and one is kept as a reserve for emergency case. No rack arrangement is in the pools, fuel is stored under water in open baskets (T-12) placed on the pool bottoms. Storage pools are double lined. Upper liners and all piping and auxiliary systems are made of stainless steel, pool concrete pit liners are made of carbon steel.

The storage pools are equipped with leak collection system which allows to check leak rate and collect leaking coolant in order to avoid activity release to the environment. Till now no water leaks from storage pools have been observed. The pools are overlaid by cover plates made of carbon steel coated with epoxy painting.

During 12 years since the start, no significant problems in the operation of this facility have appeared. There are not any symptoms of fuel cladding deterioration or storage component corrosion. Visual observation of selected fuel assemblies' outer surface (shroud tube, top and bottom end-fittings) using underwater camera has been carried out. This inspection did not reveal any significant differences between newly loaded and oldest stored FAs, and there was no corrosion identified at inspected FAs.

Demineralized water with no special treatment is used for storage and cooling in the pools. Water quality is monitored by continuous conductivity measurement and weekly sampled with chemical analysis and activity measurement. Clean-up system (3 ion-exchange filters, 40 m^3/h) is started periodically mainly for water activity decrease.

Growth of biological species has been recognised in the pool water in 1990 and the years afterwards. This resulted in water turbidity increase. As a main part of biological mass micromysetes were identified, and no corrosive anaerobic bacteria were found. Biological mass has fixed a part of pool water activity and increased and flocked at water surface. Clean-up system operation has not been efficient enough in all cases. Biological growth (and mass) at present operation has been decreased although no special provisions have been made yet. Microfiltration proved to be efficient for biological impurities purification.

In the AFR storage facility also (slightly) leaking assemblies can be stored. Leaking fuel assembly must be put into separate sealed canister. Such canisters can be placed into specially designed open basket (T-13) and stored in the pool. This storage facility is not provided with any sipping equipment yet.

1. Present Policy in spent fuel storage

At present time the policy of long-term storage of spent fuel and its subsequent disposal into deep underground repository is accepted and followed in SE, a.s.

In order to ensure the capacity for all spent fuel produced in SE, a.s. to store for period of approximately 40 years, SE, a.s. (former SEP), some years ago, had the intention to build a new spent fuel storage facility/facilities - either one facility for spent fuel produced on both sites (Bohunice and Mochovce), or two separate facilities for both sites.

For that purpose an international tender had been called by SEP in 1993. Bid evaluation process was first suspended and than stopped in 12/1994 by the top management. At the same moment it was decided to carry out technical and cost analyses of possibilities for the capacity and lifetime extension of the existing AFR storage facility at Bohunice NPP site. The analyses showed that the facility can be upgraded to fulfill desired goals, at reasonable costs, by partial remodification and reconstruction. Storage capacity increased by reconstruction would be enough for long-term storage of all the spent fuel produced on Bohunice NPP site.

4.1 Capacity and lifetime extension of AFR storage facility at Bohunice NPP site

Three main goals have been outlined in the project of reconstruction of this facility:

- to improve the seismic resistance of the construction, technology components and systems up to the level of 8 ° MSK-64 intensity scale, for the seismic conditions valid for the Bohunice NPP site.
- to increase the storage capacity - reconstruction modified design considers capacity of 14 112 FAs (1 693,5 ton_{HM}).
- to extend the lifetime of the facility at least to 40 years after the reconstruction

Some of the important issues which had to be solved before and during reconstruction of the facility:

- **Increase of structural loads in walls and/or bottoms of the pools.** It has been proved sufficient bearing capacity of pool bottoms for new load, and analysed and prevented subsidence of the construction with the new-load.
- **Seismic resistance of the facility.** The resistance of all important construction and technological parts has been improved by new adjustment. Replaced or new included systems have been designed to the new applied seismic resistance level.
- **Storage capacity extension.** The capacity has been increased by using of new, more compact storage baskets KZ-48 with capacity of 48 FAs, instead of old ones with capacity of 30 FAs. New arrangement of baskets in the pools makes possible to store totally 14 112 FAs in the three storage pools.
- **Subcriticality and shielding of newly arranged fuel in the pools.** It has been proved sufficient subcriticality of the fuel stored in the baskets KZ-48, densely arranged in pools as well as shielding of such arrangement. Boronated steel plates (boron 1,1 %) are used in the structure of KZ-48 baskets.
- **Pool water cooling and clean-up systems.** Cooling system (pumps, heat exchangers) has been replaced by a more efficient one. New independent circuit of secondary cooling water has been added to the system. Water clean-up system is

being upgraded and partly replaced. New filter (microfilter) UV 120-4 (fa Balduf) with biological species sterilisation equipment will be included into the system.

- **Transfer of FAs from old to new storage baskets.** For this purpose the manipulator MAPP-400 has been designed and already put into operation which performs this transfer semiautomatically.
- **Lifetime extension of the facility.** Life expectancy of the construction and technology components has been analysed. Program of corrosion test samples of the pools, cooling and clean-up systems materials has been designed and included. For the purpose of tracking the changes in facility state, a complex Monitoring program to long-term monitor the state of the facility construction and technology and also the state of the stored fuel has been required by Nuclear Regulator. This program is being prepared/designed now, and will be brought into action in 2 or 3 years.

Besides already mentioned, many components and systems have been (or are being) upgraded during the reconstruction, as e. g.: instrumentation and control, radiation control and ventilation systems. SIPPING POOL stand (fa SIEMENS) for FAs/rods tightness examination will be installed in this facility.

First new KZ-48 baskets have been loaded with spent fuel and placed into the pools in April 1999. Reconstruction process is still going on. Completion, except Monitoring program and full set of KZ-48 baskets, is expected in December 1999.

4.2 Spent fuel storage facility at Mochovce NPP site

AFR spent fuel storage facility at Bohunice, after the reconstruction, will solve long-term storage of all spent fuel produced by all reactor units during their lifetime on that site.

First spent fuel on Mochovce NPP site will be discharged from the reactor at the end of 1999. As the storage capacity of more compact AR pools of Mochovce units is sufficient for 7-8 years reactor operation, the need for additional storage capacity on that site, in our case long-term storage capacity, will be urgent in approximately 2006.

To solve long-term storage problem of Mochovce NPP spent fuel, SE,a.s. plans to construct a new AFR storage facility on Mochovce site. International tender to the effect will probably be called in 2000.

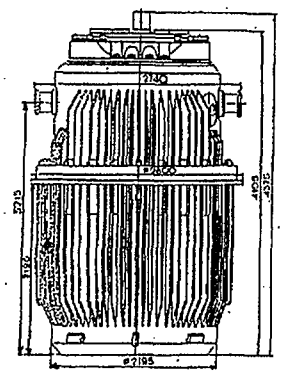
5. Final disposal of spent fuel

Once through fuel cycle is now accepted in the operation of power reactors in SE,a.s., with the last step - final disposal of spent fuel into deep underground repository. The long-term program of spent fuel / HLW deep geological repository development has been initiated some five years ago. Two types of host rocks are considered in the program: granite and clay/claystone. Present activities in the development program are directed to the characterisation and specification of such perspective areas on the Slovak territory (3-4 areas) in which detailed investigation is planned to be performed.

Start of deep underground repository operation in our country is scheduled after the year 2030.

NUCLEAR POWER PLANTS				
SLOVAK REPUBLIC (SE)				
PLANT	NET CAPACITY	TYPE	CORE	COMMERCIAL OPERATION
Bohunice A 1	1 x 150	HWGCR		1972-77 (Demonstr.)
Bohunice 1, 2	2 x 408	VVER - 440 V - 230	Reduced, 313 FAs	12/1978 3/1980
Bohunice 3, 4	2 x 408	VVER - 440 V - 213	349 FAs	8/1984 8/1985
Mochovce 1, 2	2 x 408	VVER - 440 V - 213	349 FAs	7/1998 - /1999
Mochovce 3, 4	2 x 408	VVER - 440 V - 213	349 FAs	?

Transport Devices



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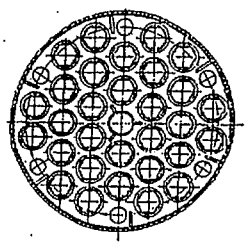
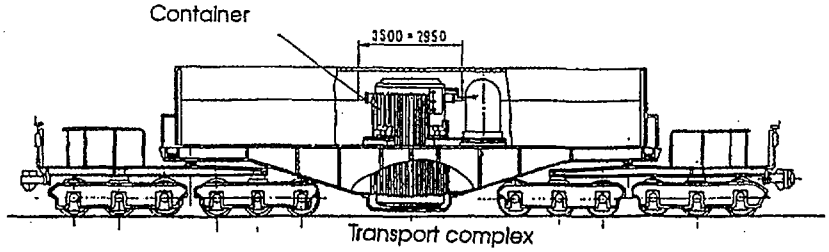


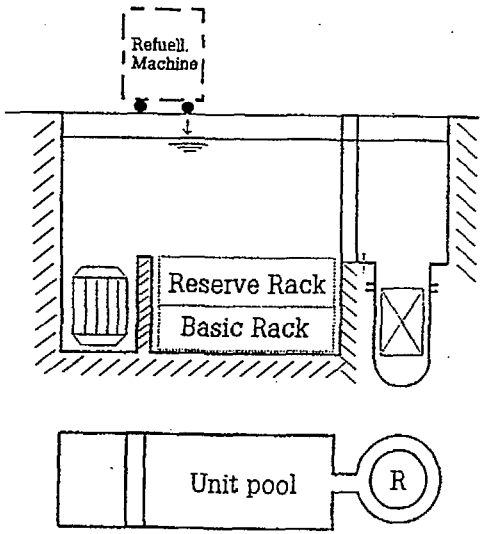
Cask - cross section



Transport complex

SLOVENSKE ELEKTRÁRNE

Unit Pool Characteristics
V 230 type

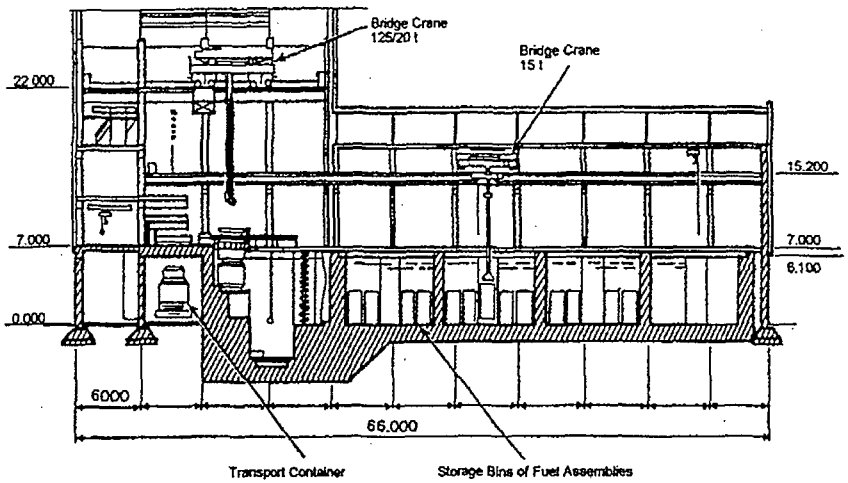


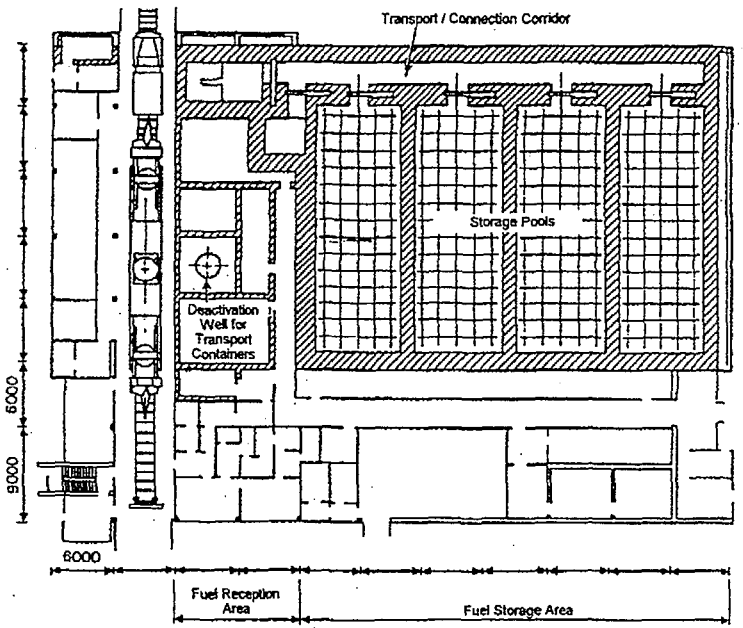
Fuel: Hexaqonal 144mm, L = 3200 mm, 120 kg U

Assemblies in unit:	reactor R	basic rack	reserve rack
EBO 1,2 (V1)	313	350	350
EBO 3,4 (V2)	349	350	350
EMO 1,2,3,4	349	700	350

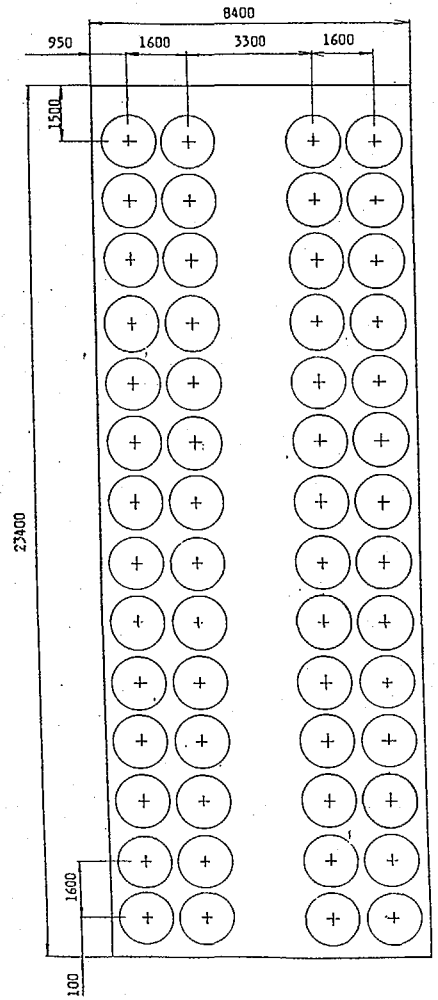
SLOVENSKÉ ELEKTRÁRNE

SPENT FUEL STORAGE FACILITY
EBO



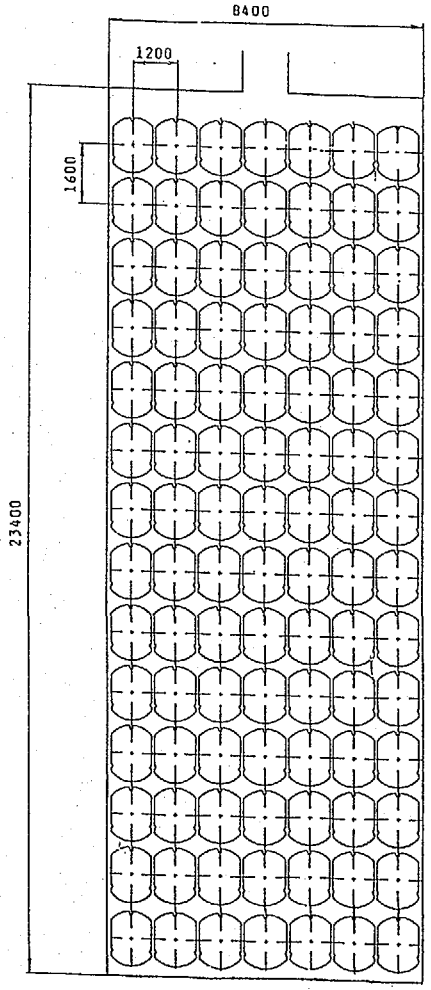


ARRANGEMENT OF T - 12 BASKETS IN STORAGE POOL



SLOVENSKÉ ELEKTRÁRNE

ARRANGEMENT OF KZ - 48 BASKETS IN STORAGE POOL



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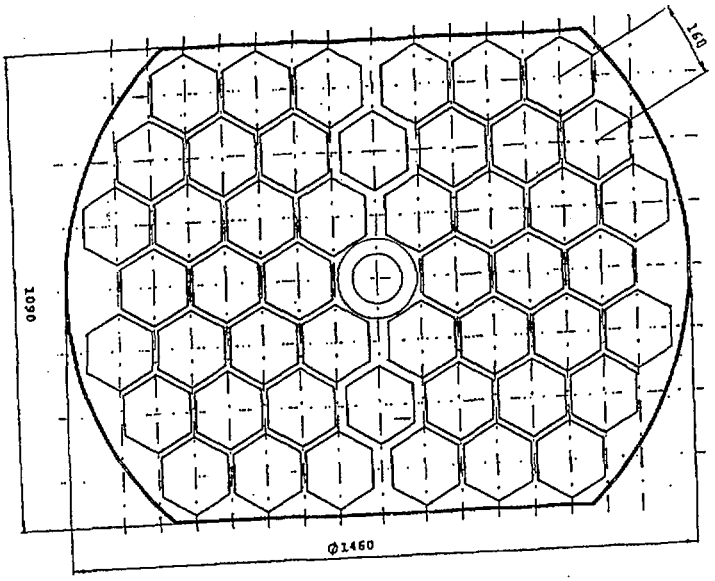
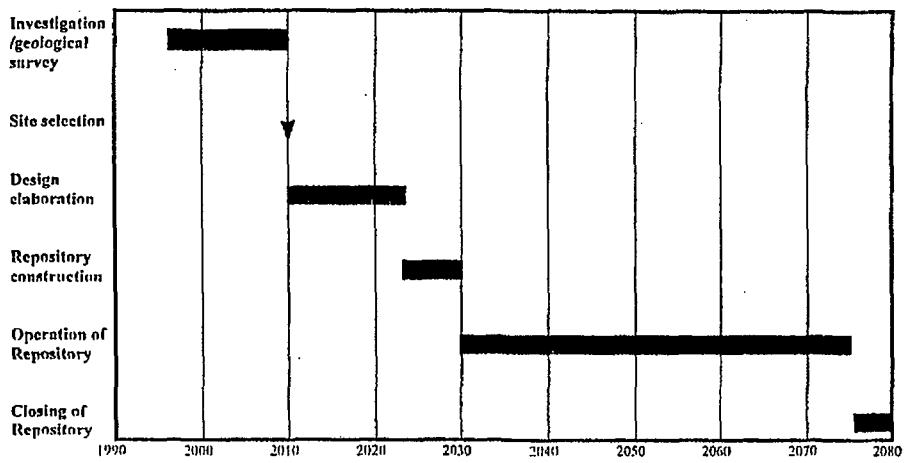


STORAGE BASKET KZ - 48

cross section

TIME SCHEDULE OF SPENT FUEL AND RA - WASTE FINAL REPOSITORY



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