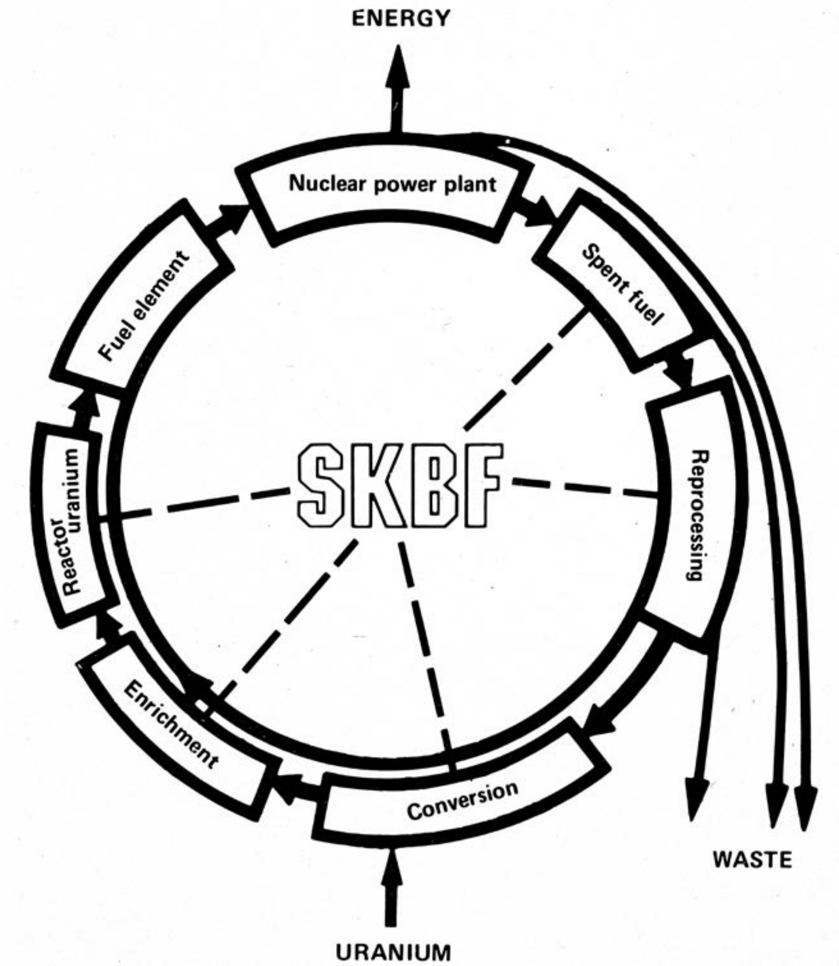
Report on the current situation with regard to nuclear fuel and the operations of Svensk Kärnbränsleförsörjning AB (Swedish Nuclear Fuel Supply Company) during the period November 1981-October 1982

Report to the Swedish Ministry of Industry, November 1982



SVENSK KÄRNBRÄNSLEFÖRSÖRJNING AB
SWEDISH NUCLEAR FUEL SUPPLY COMPANY

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Svensk Kärnbränsleförsörjning AB
Stockholm, November 1982

SKBF

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REPORT ON THE CURRENT SITUATION WITH REGARD TO NUCLEAR FUEL AND THE OPERATIONS OF SVENSK KÄRNBRÄNSLEFÖRSÖRJNING AB (SWEDISH NUCLEAR FUEL SUPPLY COMPANY) DURING THE PERIOD NOVEMBER 1981 – OCTOBER 1982

SUMMARY

The planning of activities within the Swedish nuclear fuel cycle - including the various stages of the back end of the cycle, i.e. management and disposal of radioactive wastes - is affected by the decisions taken by the Swedish Parliament during 1980 concerning nuclear power in Sweden and by the international situation in the nuclear field.

The flow-sheet on page 6 of this report illustrates schematically the policy and the plan that have been developed in the light of these considerations.

The situation for the various parts of this scheme can be summarized as follows.

The international market serves as a source of uranium and of conversion and enrichment services. Capacity for the fabrication of fuel elements exists in Sweden. Protection against disruptions in external supplies is provided by a reserve stockpile of enriched uranium and zircaloy material. The size of the stockpile at the end of 1982 is estimated to correspond to 36 TWhe. Some domestic

prospecting for uranium is being conducted.

The cost of supplying nuclear fuel, including the reserve stockpile, has averaged about SEK 0.033/kWhe during the report period.

The situation as regards the back end of the nuclear fuel cycle is as follows.

Within the sea transportation system, the ship m/s Sigyn was delivered during the month of October. The motor vehicle has also been delivered, and the first transport cask will be delivered during the month of November.

The temporary storage facility for spent fuel, CLAB, is scheduled to be completed at Simpevarp at the beginning of 1985 and will have a storage capacity of 3 000 tonnes, counted in terms of the uranium content of the fuel.

Licensing applications have been submitted to the appropriate authorities for the construction of a final repository for reactor waste (SFR) in an underground facility to be built in the rock adjacent to the Forsmark nuclear power station. The repository is intended for waste with a "toxic life" of less than 500 years.

The last shipment within the framework of the reprocessing contract between OKG Aktiebolag (OKG) and British Nuclear Fuel Ltd. (BNFL) for 140 tonnes of uranium in spent nuclear fuel took place during the summer of 1982. The first outbound shipment from Ringhals under the reprocessing contract between SKBF and COGEMA of France is planned to take place around the start of 1983. Reprocessing will commence in 1985 at the earliest.

The uranium (approx. 850 tonnes) and plutonium (approx. 6 tonnes) obtained from reprocessing is Swedish property. The power utilities and SKBF plan to utilize the uranium and the plutonium as raw material for the fabrication of new nuclear fuel for the Swedish nuclear power plants.

In the light of the reports KBS-1 and KBS-2, SKBF believes that it has been shown that a safe final storage of the high-level and long-lived radioactive waste products of nuclear power is possible employing known technology. Broad and long-range research is currently being conducted in order to further refine the technology and select a site for the final repository, SFL.

Efforts are now being concentrated on the final storage of spent fuel without reprocessing. The research and development work covers many disciplines such as geology, hydrology, chemistry, materials science, data on waste forms, technology and safety analysis. Within the framework of the long-range plan, some 10 typical areas will be studied during the 1980s with the ultimate choice of site taking place around the turn of the century. Construction of the repository is scheduled to start in 2010 and operation in 2020.

Some 200 people at universities, institutions, engineering firms etc. are engaged in the work.

The guidelines that have been followed in Sweden for the work - a deep-lying rock repository with multiple barriers - are also being followed in similar efforts in other nuclear power nations, and an extensive international exchange of information and experience is taking place.

SKBF has been entrusted with the management of the international Stripa project, where investigations are being conducted under realistic conditions in rock at a depth of 350 metres.

Current efforts include the preparation of documentation to accompany applications for fueling permits for the F3 and O3 nuclear power reactors pursuant to the Stipulation Act. These applications are expected to be submitted by the various power utilities during the spring of 1983.

Pursuant to the new Financing Act, SKBF submitted a report on 30 June of this year to the National Board for Spent Nuclear Fuel (NAK). Besides a description of its work and plans, the report included a cost estimate in 1981 prices for the management and various stages in the back end of the nuclear fuel cycle. The estimate, which is currently being examined by the NAK, comes out to SEK 32 billion, which represents about 10% of the value of the electrical power produced by the nuclear power plants.

The Government has decided upon a rate of SEK 0.017/kWhe of electricity generated by nuclear power as the 1982 charge to be paid to the state(NAK)-controlled reserve intended to cover the costs referred to in the Financing Act. An additional SEK 0.001/kWhe is needed for the management of reactor waste.

The total cost picture for nuclear fuel (including provision for the costs of decommissioning of nuclear power plants) is then:

fuel supply incl. reserve stockpile	SEK 0.033/kWhe
back end incl. decommissioning	SEK 0.018/kWhe
Total	SEK 0.051/kWhe

The owners of Svensk Kärnbränsleförsörjning AB are

- Swedish State Power Board 36 %
- Forsmarks Kraftgrupp AB 30 %
- OKG Aktiebolag 22 %
- Sydsvenska Värmekraft AB 12 %

INTRODUCTION

The present report proceeds along the same lines as the previous reports submitted by the SKBF to the Government. This report is primarily concerned with developments and activities during the report period. The entering into effect of the new Financing Act entails important changes as regards conditions for planning and financing. An account of these conditions is provided in chapters 2.5 and 3.

SKBF is involved in supplying the Swedish nuclear programme with fuel and is arranging for the management and disposal of the residual products of nuclear power generation.

The main premises for the planning of these activities are the 1980 parliamentary resolution setting forth guidelines for nuclear power in Sweden and the international situation.

The framework for the technical planning is illustrated schematically by the flow-sheet on next page.

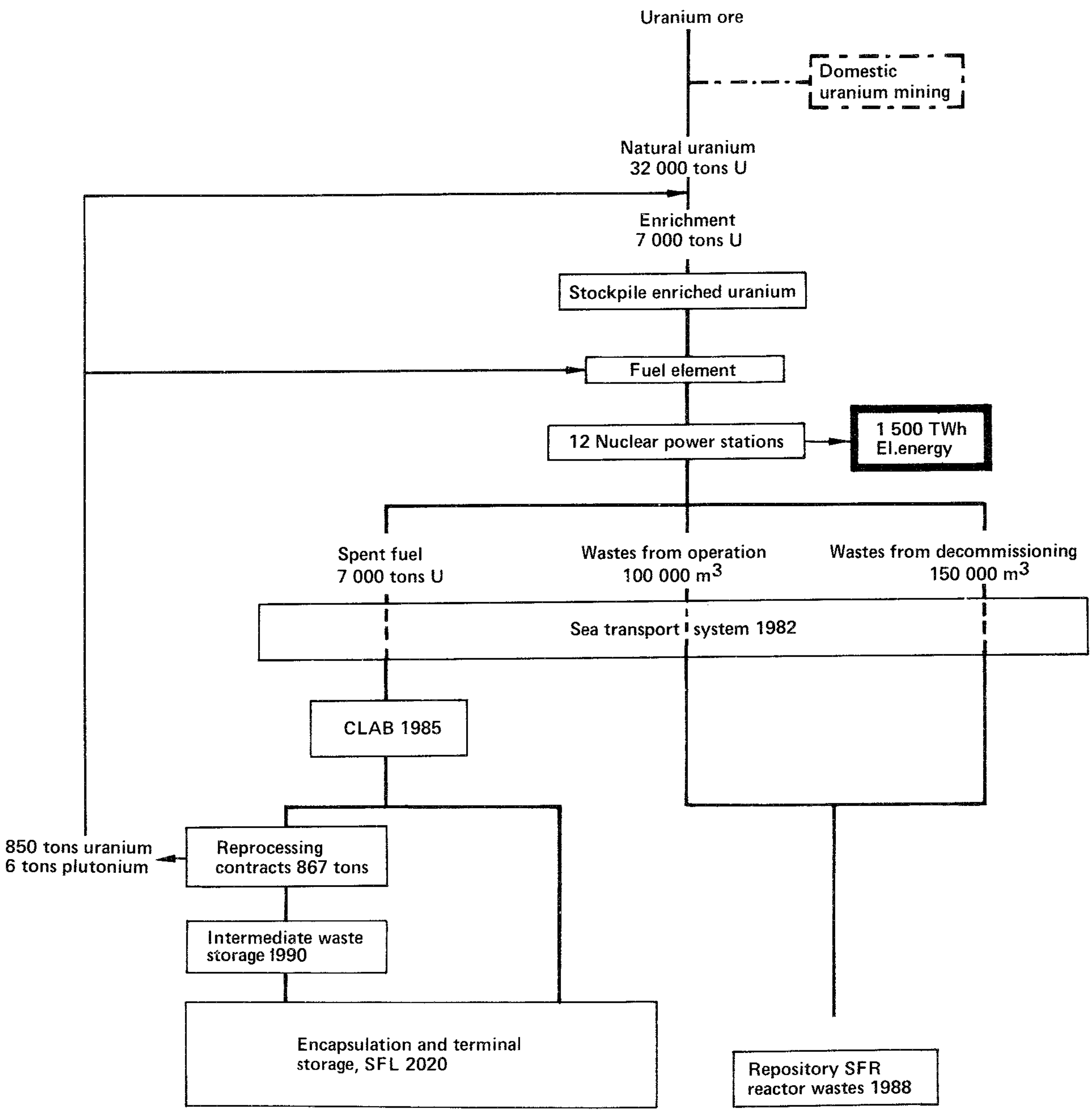

Figure 1. The Swedish nuclear power programme

1 SUPPLIES OF NUCLEAR FUEL

1.1 NATURAL URANIUM

1.1.1 The international situation

1.1.1.1 Uranium demand

At its annual meeting in September of 1982, the Uranium Institute presented an update of nuclear power plant construction and uranium demand in the world (except for the Eastern bloc countries) for the period up to 1995. Three cases were dealt with:

- plants in operation (159 000 MWe) and plants under construction or on order (156 000 MWe);
- probable case, which, in addition to the above, assumes certain new orders for nuclear power plants;
- high growth.

The table below shows the uranium demands for the three cases in tonnes of uranium per year*)

	1982	1983	1985	1990	1995
Plants in operation, under construction and on order	35 000	41 000	45 000	45 000	45 000
Probable case	35 000	41 000	47 000	57 000	66 000
High growth	35 000	41 000	47 000	63 000	80 000

*) 0.25 % U-235 in depleted uranium.

The so-called "probable case" involves an increase of the uranium demand by 5 % per year during the period 1982-1985. Plants that are under construction or on order alone entail an increase of uranium needs. The "high growth" case presumes such factors as economic growth, political backing and new orders in the United States. Events to date have not made such "high growth" probable.

The figures shed light on the possible long-term uranium need. In the short term, however, the uranium demand is determined by existing enrichment contracts. For 1982, these enrichment contracts entail a requirement of about 42 000 tonnes of uranium, which is higher than the actual consumption of 35 000 tonnes of natural uranium.

Considerable reserve stocks - on the average about 3 times current annual consumption - have been established. Policies with regard to the size of these reserve stocks in different countries will be of essential importance in any assessment of the supply and demand picture for many years to come.

1.1.1.2 Uranium production

Uranium production in the world (except for the Eastern bloc countries) is shown in the table below, where production for each country is given in tonnes of uranium per year:

	1980	1981	1982 (NUKEM's forecast)
Australia	1 561	2 860	4 600
Canada	7 149	7 802	8 290
Europe*)	2 955	2 914	2 900
Gabon	1 035	1 020	1 100
Namibia	4 039	3 970	4 000
Niger	4 105	4 361	4 200
South Africa	6 148	6 135	6 350
USA	16 800	14 800	11 100
Other countries	250	250	250
Total	44 042	44 112	42 790

*) Mainly France, but also Portugal and Spain

Production increased between 1980 and 1982 in Australia and Canada, owing to the fact that new uranium plants went into production. In the United States, production decreased as a result of high costs. Power companies wishing to reduce their uranium stocks due to high interest rates in 1982 have sold some uranium.

In 1983, a further drop in production can be expected in the United States, while other countries will produce approximately the same amount as before, in other words, an overall decrease can be expected. At present, only one large uranium plant is under construction. It is expected to go into production towards the end of 1983 and is located at Key Lake, Saskatchewan, Canada.

1.1.1.3 Supply and demand, prices

Production has been higher than consumption during 1981 and so far during 1982. The price for spot purchases, which is quoted monthly by NUKEM, was about US$ 24.50 per lb of U_3O_8 in September of 1981, and declined to about US$ 17.50 per lb of U_3O_8 in September of 1982. The price in Swedish crowns has not fallen as much, since the exchange rate for the dollar has risen during the same period. Spot purchases represent only a small portion of the market, however: about 10%.

Long-term contracts cover approximately 90% of the market. The price under long-term contracts rose in the United States from US$ 28.15 in 1980 to US$ 32.20 in 1981. This price increase stems from the fact that deliveries are made under old contracts with price clauses that give higher prices. The prices for deliveries under long-term contracts are considerably higher than the prices for spot purchases in 1982.

Production and consumption are expected to be nearly in balance in 1983. There may still be some stock reductions, however.

According to the table, increased uranium production will be needed in the late 1980s. Ore reserves exist for this. Whether or not uranium production will be expanded will depend upon the price trend and the uranium industry's projections for the future as well as on political circumstances, licensing etc.

1.1.1.4 Uranium reserves

The reasonably assured and estimated reserves from which uranium can be extracted at a cost of less than US$ 50 per lb of U_3O_8 (less than SEK 950/kg of uranium at an exchange rate of 7.30) have been estimated by the OECD and the International Atomic Energy Agency to be 5.0 million tonnes of uranium as of February, 1982. This is the same total quantity that is given in an earlier report from 1979. The reasonably assured quantity of uranium has decreased by 0.3 million tonnes, while the estimated quantity has increased by 0.3 million tonnes.

The OECD's price limit of US$ 50 per lb of U_3O_8 lies above the prices for spot purchases and long-term contracts during 1982, which means that all of the above-mentioned uranium reserves cannot be extracted economically at the present-day price level.

1.1.2 Domestic uranium resources

1.1.2.1 Ranstad

Ranstad in Västergötland County is surrounded by an area containing alum shale, the most uranium-rich portion of which contains about 300 g of uranium per tonne of shale. The uranium is contained in a homogeneous large ore body, but the concentrations are low. A method has been developed and demonstrated on an industrial scale for uranium recovery from this type of uranium ore. The cost of recovery would be well above the prices prevailing on the international market.

The shale also contains other substances such as molybdenum, vanadium, aluminium, potassium and kerogen, but in relatively low concentrations.

For four years now, Ranstad Skiffer AB (RSA) has been conducting a development project to evaluate the recoverability of different products from the shale.

In the spring of 1981, the Parliament consented to allowing certain remaining funds - about SEK 20 million - to be used for continued development work over the next three years. As a consequence of this decision, research on the extraction of valuable products from the shale will continue on a limited scale.

The work on the recultivation of reclaimed strip-mined areas is continuing.

1.1.2.2 Pleutajokk

After the Pleutajokk project was terminated in September of 1981 (see preceding report), LKAB carried out restoration work there during the summer of 1982.

1.1.2.3 Prospecting

In its 1981 Budget Bill, the Government declared that prospecting for uranium ore should be paid for by the power utilities. Only measurements of the natural radioactive field will be paid for by state funds.

SKBF applied to the Government for permission to take over 20 exploration licenses and applications for such licenses from the state. The Government and the National Industrial Board have granted such permission.

SKBF currently has 36 exploration licenses in the following municipalities: Arjeplog, Arvidsjaur, Boden, Bräcke, Härjedalen, Krokom, Ljusdal, Ovanåker, Ragunda, Sorsele, Ånge, Åre and Östersund. Applications for exploration licenses have been submitted in the municipalities of Berg and Åsele. SKBF finished its explorations in the Trolltjärnshockeln area in the municipality of Ljusdal during 1981-1982 with negative results and has therefore relinquished this license.

SKBF has previously carried out regional studies in the form of aerial surveys and geochemical investigations. Starting in 1982, the work is being concentrated on local surveys at places where indications have been obtained of an elevated uranium concentration, such as local geological and geophysical investigations, radon measurements and test drillings.

The aerial surveys from 1981 are being followed up, however.

SKBF has a cooperation agreement with the Swedish Board for Government Mining Properties, which means that uranium prospecting efforts will also be of value in connection with other prospecting activities. A similar agreement has been reached with the Norrland Fund with respect to certain areas in Jämtland County.

A uranium mineralization has been test-drilled at Lilljuthatten in the municipality of Krokom. The quantity of uranium may be around 2 000 tonnes, with a uranium concentration of more than 1 000 g of uranium per tonne. Continued test drilling activities are now being conducted in surrounding areas of elevated uranium content.

Uranium mineralizations have also been found at Skupiesavon in the municipality of Arjeplog, Kvarnån in the municipality of Boden and Sågtjärn in the municipality of Ånge. Only small amounts of uranium or very low concentrations have been found in other areas (St. Doubblon in Sorsele).

It is still too early to conclude whether any of the uranium mineralizations found can be profitably exploited. Owing to the limited life of the Swedish nuclear power programme, SKBF is concentrating its efforts and subjecting them to continuous review.

1.1.3 Supplies of natural uranium

Plans are aimed at meeting the needs of 12 nuclear power reactors through the year 2010.

The total remaining requirement is estimated to be 25 000 - 38 000 tonnes of uranium.

The uranium demand can vary within relatively wide limits, depending on a number of different factors. It is therefore important that supply planning be rolling and flexible.

The Swedish nuclear power utilities have contracts with suppliers of uranium from Australia, France (uranium from Niger and Gabon), Canada and the United States. These contracts provide for a total of about 5 250 tonnes of natural uranium for the period 1982-1990. The total need for the same period is about 11 000 tonnes of uranium. During 1982, the Swedish power utilities have negotiated with Canadian producers in order to meet a large portion of the need not yet covered.

Contracts have been signed for the period 1991-2000 for 900 tonnes of uranium, while the total need for this period can be estimated to be 10 000 - 14 000 tonnes of uranium.

Considerable uncertainty exists with regard to the uranium requirement for the period 2001-2010.

SKBF purchased 1.5 tonnes of uranium concentrate collected in connection with laboratory tests from Ranstad Skiffer AB in 1982.

1.2 CONVERSION

Conversion entails the transformation of uranium concentrate to uranium hexafluoride.

There are five plants in the Western countries for conversion: Allied Chemical and Kerr McGee in the United States, Eldorado Nuclear in Canada, British Nuclear Fuels Ltd. in Great Britain and Comurhex in France. Total capacity in 1982 is about 49 000 tonnes of uranium at 100% capacity utilization. In practice, capacity utilization is now 70-85%.

Eldorado Nuclear is in the process of expanding its capacity with an additional 9 000 tonnes of uranium in a new plant at Blind River in Ontario, where the first part of the process will be carried out, while the second part will be carried out in the present-day plant at Port Hope, Ontario, after an addition has been completed. The new and expanded plants will be put into operation in 1984.

Conversion services can also be purchased from the Soviet Union in connection with enrichment contracts. Small conversion plants are being planned in Japan, Brazil and South Africa.

The current assessment is that conversion capacity will be sufficient during the 1980s and that additional expansion is possible, if required.

1.3 ISOTOPE ENRICHMENT

1.3.1 Plants

USA

There are three isotope enrichment plants employing the gas diffusion method in operation in the United States. They have been rebuilt in recent years and now have a total capacity of 27 million separative work units (SWU) per year.

A plant utilizing the gas centrifuge method is also currently being built in the United States. The first building, with a capacity of 2 million SWUs, is scheduled to go into production during 1988. There are plans for an expansion to 8 million SWUs by 1994. The advantage of the gas centrifuge method over the gas diffusion method is a lower energy requirement.

Soviet Union

The Soviet Union has isotope enrichment plants that are used both to meet enrichment requirements in the Soviet Union and Eastern Europe and for sales to the Western countries. Exports to the West amount to about 3 million SWUs annually.

France

Eurodif in France is now operating its gas diffusion plant with a capacity of 10.8 million SWUs.

Research is currently being conducted on a new method of chemical exchange. It is said that this method cannot be used to produce high-enriched uranium, which means that it cannot contribute to the risk of nuclear weapons proliferation.

Urenco

Urenco has two gas centrifuge plants in operation: one at Almelo in The Netherlands and one at Capenhurst in Great Britain. Both of these plants are being expanded in stages, and construction was begun on a new gas centrifuge plant during the autumn of 1982 at Gronau in West Germany. Capacity just now is about 0.6 million SWUs per year and is estimated to be 2 million in 1986.

Other plants

There is a small gas centrifuge plant of 0.08 million SWUs per year in operation in Japan. An expansion to 0.25 million SWUs is planned to be completed by 1984.

A prototype plant using the helicon process is in operation in South Africa. An expansion to 0.3 million SWUs is planned to go on line in 1987.

A study is currently being conducted in Australia to determine whether an isotope enrichment plant should be built within the country. The justification for such a plant is that Australian uranium could be processed within the country, creating more jobs in industry. The industrial group recently chose to study Urenco's gas centrifuge technique more closely.

1.3.2 Market

Total enrichment capacity currently existing and under construction is estimated to be sufficient for international nuclear power programmes during the 1980s. Further expansion is deemed quite feasible, given an increase in demand.

The US Department of Energy's price of enrichment under long-term fixed commitment contracts rose rapidly during the period 1978-1981. In August of 1982, the price was raised to US$ 138.65 per SWU from its previous level of US$ 130.75 - a 6 % increase, which is lower than the increase in previous years.

The US Department of Energy's price under requirement contracts rose in August of 1982 to US$ 149.85 per SWU. This type of contract has better flexibility terms, but a higher price.

The price increases in the United States, in combination with the higher exchange rate for the dollar, mean that the United States no longer has lower prices than Eurodif or Urenco.

Over the next few years, the enrichment price in US$ is expected to increase at the same rate as inflation, or at a slightly slower rate. The price in Swedish crowns will then depend on the exchange rate.

1.3.3 Swedish supplies

The Swedish power utilities have requirement contracts with the US Department of Energy for Oskarshamn units 1 and 2, Ringhals units 1 and 2 and Barsebäck units 1 and 2.

SKBF is the Swedish party to additional contracts of a later type with the US Department of Energy providing for more fixed commitments (long-term fixed commitment contracts), which have been signed for Ringhals units 3 and 4 and Forsmark units 1, 2 and 3.

The Swedish power utilities are jointly investigating the possibilities of making optimum use of the flexibility in the American contracts. An agreement has been reached for the transfer of an enrichment quantity from the Swedish State Power Board's long-term fixed commitment contract to Sydsvenska Värmekraft AB for use at Barsebäck.

SKBF has also signed a long-term contract with Techsnabexport in the Soviet Union extending through the year 2000. This contract is being used to build up a reserve stockpile and to meet the needs for Oskarshamn unit 3.

SKBF and the power utilities are currently studying contract forms and suppliers for the future. The US Department of Energy is offering a new type of contract with better flexibility than the present-day long-term fixed commitment contract. It is called an FR contract. European suppliers are offering contracts with other flexibility and cost terms.

1.4 RESERVE STOCKPILE

SKBF is in charge of reserve stocks of products required for the fabrication of fuel elements for the nuclear power plants. The reserve stockpile of enriched uranium amounted to about 23 TWhe at the end of 1981.

The reserve stockpile was increased during 1982 by isotope enrichment of the natural uranium purchased from Gulf Minerals Canada Ltd. by Techsnabexport in the Soviet Union. By the end of 1982, the reserve stockpile will contain enriched uranium equivalent to about 36 TWhe. Together with the nuclear fuel in reactors, the fuel bundles at the nuclear power plants and the fuel under fabrication within the country, this provides a reserve capacity that will enable the Swedish reactors to hold out for 22-23 months at the normal operation level of 12 units.

SKBF is also stockpiling the amount of zircaloy that is required for fuel fabrication from the enriched uranium.

On 1982-06-04, the Swedish Parliament passed the Government Bill concerning the stockpiling of nuclear fuel, calling for the stockpiling of enriched uranium equivalent to 35 TWhe. This stockpiling will be performed by SKBF. It is proposed that a stockpiling agreement be concluded with the National Board of Economic Defence.

Under the SKBF plan, the goal established by the Parliament for a nuclear fuel stockpile can be met by the end of 1982.

2 MANAGEMENT OF RESIDUAL PRODUCTS

The overall plan with regard to quantities, activities and times for the management of the various products and wastes created by nuclear power generation is illustrated schematically in the flow sheet on page 6, which corresponds to the programme decided on by the Parliament in 1980.

2.1 CENTRAL STORAGE FACILITY FOR SPENT FUEL

The civil engineering work for CLAB was started in May of 1980. Receiving of spent fuel is scheduled to be able to begin in January of 1985. During the past year, both construction work and work on systems design and procurement have been conducted.

The rock blasting work was completed at the end of the year. In October of 1982, approximately 70% of the concrete work had been completed. Contracts had then been signed for about 50% of the equipment. The erection and installation work started in August. Overall, the work has proceeded according to schedule. Operational experience from the NPH plant (the receiving plant) in La Hague has been taken into consideration, which has reduced the margins in the timetable.

The design of the plant is reported regularly to the concerned authorities.

As of the autumn of 1982, activities on the site are taking on a new character. The construction work is almost completed and the installation work is entering an intensive phase.

In September of 1982, some 430 persons were engaged in construction work on the site and some 40 persons in installation work.

According to an agreement between SKBF and OKG, OKG is in charge of project management and the construction of the CLAB. Under a special agreement, OKG's operating organization will also be in charge of the operation of the plant. The recruitment of operating personnel for the CLAB started during the year.

The cost of construction of the CLAB is estimated at about SEK 1 600 million at current prices. SEK 500 million had been spent through August of 1982.

2.2 TRANSPORTATION SYSTEM

2.2.1 Ship

M/S Sigyn was launched in February, 1982, at the shipyard in Le Havre. The ship was named on September 10, 1982, and was delivered from the shipyard at the end of October, 1982. At first, the ship will sail under the French flag, and the operator is CMCR (Compagnie Maritime des Chargeurs Réunis).

2.2.2 Transport casks

The four first transport casks for spent fuel, which are being made at Uddcomb in Karlskrona under contract to COGEMA, are in the completion stage and will be delivered during the period November 1982 - January 1983.

An additional six transport casks of the same type have been ordered directly for SKBF. Three casks are being made by Kobe Steel Ltd in Japan and three by Uddcomb. The casks will be delivered to the CLAB plant during the period January 1984 - January 1985.

A study is currently being conducted of transport containers for other radioactive material with a lower level of radioactivity.

2.2.3 Equipment

The specially-built vehicle and the transport frames for the transport casks were delivered during the year and tested at the shipyard at Le Havre. The equipment was then shipped to Ringhals, where further testing and training of personnel has taken place.

2.2.4 Government permits

In order to put the sea transportation system into operation, approval of the sea transport plan is required from the National Swedish Administration of Shipping and Navigation. This approval was obtained on May 12, 1982. The design and manufacture of the ship have been examined and supervised by both the Swedish and the French shipping and navigation authorities and their wishes have been acted on.

The transport casks have received an IAEA Type B (U) license. A certificate was issued by the French Ministry of Transportation on July 22, 1981. The approval of the Swedish Nuclear Power Inspectorate (certificate S/40/B(U)F) was obtained on July 6, 1982, and the casks are thereby approved for use in both Sweden and France.

According to a bilateral safety agreement between Sweden and the United States, a US MB-10 permit is required for the shipment of fuel enriched in the United States from Sweden. Such a permit was obtained in August of 1982 for a quantity equivalent to approximately one year's shipments.

2.2.5 Trial operation

Trial operation of the sea transportation system is expected to begin in November of this year. After completed trial operation of the system and testing of transport casks at the Barsebäck and Ringhals plants, the first fuel shipment is planned to take place from Ringhals to Cherbourg, and from there overland to La Hague.

2.3 REPROCESSING

An agreement exists between OKG and British Nuclear Fuels Ltd. (BNFL) providing for the reprocessing of 140 tonnes (counted as enriched uranium) of spent fuel from the OKG reactors. The last shipments of spent fuel under this contract went to Great Britain during the summer of 1982.

Contracts exist between SKBF and the French company of COGEMA for the reprocessing of 727 tonnes of spent fuel from the reactors in Barsebäck, Ringhals and Forsmark. The sea transportation system described earlier in this report will be used to ship the spent fuel to France. The first shipments are scheduled to take place around the beginning of 1983. Under the COGEMA contracts waste equivalent to the Swedish fuel may later (after 1990) be returned to Sweden.

The work on the UP3 reprocessing plant under construction at La Hague in France for Swedish and other foreign customers is proceeding. The first storage pool has been in operation since early 1981. About 300 tonnes of spent nuclear fuel have been received at the plant through April of 1982. As mentioned above, there have as yet not been any shipments from Sweden. COGEMA expects the rest of the plant to be completed in 1987.

Through April of 1982, a total of 454 tonnes of spent nuclear fuel from light water reactors have been reprocessed in the existing UP2 processing plant.

The plant for vitrification at Marcoule has functioned satisfactorily. Through April of 1982, 450 m^3 of fission product concentrate has been vitrified, which corresponds to a production of 673 glass cylinders.

Since the construction of further nuclear reactors in Great Britain has been postponed, BNFL has offered reprocessing services for 900 tonnes of spent fuel under the same terms as before. The Swedish power utilities and SKBF have declined the offer.

Work has continued on the Tokai Mura reprocessing plant in Japan. A total of 138.8 tonnes of spent fuel have been reprocessed since the end of March, 1982.

Uranium and plutonium are obtained from reprocessing. The uranium obtained from reprocessing has a level of enrichment slightly above that of natural uranium and can be used for the fabrication of new nuclear fuel.

The quantity of spent nuclear fuel covered by existing reprocessing contracts, mainly with COGEMA, is 867 tonnes, which gives slightly more than 6 tonnes of plutonium on reprocessing. This represents a certain energy value. A survey of the use of this plutonium in the Swedish light water reactors has been conducted. With the expected reprocessing programme, the amount of plutonium obtained annually will nearly meet the needs of two reactors. The

Swedish nuclear power utilities are currently intending to use the plutonium obtained from reprocessing as a raw material for fabricating new nuclear fuel for Swedish nuclear power plants. The aforesaid quantity of plutonium will thereby replace approximately 600 tonnes of natural uranium and approximately 600 000 SWUs of enrichment work.

No plutonium will be obtained from reprocessing before 1985 at the earliest, after which it will be obtained annually up to 1998.

The resultant spent nuclear fuel based on recycled plutonium possesses characteristics that do not differ significantly from those of spent fuel based solely on uranium and can be disposed of directly in the same manner.

The utilization of uranium and plutonium in this manner has been described in a report entitled "Plutonium use in Swedish reactors" (available only in Swedish), which was submitted to the Ministry of Industry on the 20th of September.

2.4 FINAL REPOSITORY FOR REACTOR WASTE (SFR)

Applications for the construction of a central final repository for reactor waste at Forsmark were submitted in March of 1982. Permits are required pursuant to the Nuclear Energy Act, the Building Act and the Environment Protection Act. A water court judgement is also required, as well as review under the terms of the Radiation Protection Act.

Provided that the necessary permits are obtained so that the civil engineering work can commence in the spring of 1983, it is estimated that the facility can be commissioned in early 1988.

The SFR is intended for the final storage of low- and medium-level waste from nuclear power plant operation with a "toxic life" of less than 500 years. The facility has also been planned and engineered to be able to accommodate radioactive waste of a similar type from industry and institutions that have no connection with electric power production. Negotiations concerning the technical and economic terms have begun.

After a subsequent expansion - which is not included in the present applications - low- and medium-level material from the decommissioning of nuclear power plants will also be able to be finally stored. This expansion will not come under consideration until after the year 2000.

2.5 FINAL REPOSITORY FOR HIGH-LEVEL AND LONG-LIVED RADIOACTIVE WASTES (SFL)

2.5.1 Purpose and principles of final storage of radioactive wastes

The purpose of the handling and disposal of industrial wastes is generally to ensure that the quantities and concentrations of hazardous substances that can reach man are low in relation to what can be deemed to be dangerous.

As far as radioactive substances and wastes are concerned, two factors must be considered.

The first is that radioactivity is a part of our background environment. Man tolerates a certain level of radioactivity.

The second factor is that the radioactivity of a substance declines with time in a regular fashion. No changes of the composition of the substance can alter this in either direction. This characteristic, that the degree of dangerousness is declining with time, differentiates radioactive wastes from other industrial wastes. However, in the case of certain radioactive elements, although the level of radioactivity is relatively low, the time required for the radioactivity to decay is so long that these elements must be equated with eternally toxic wastes.

The purpose of radioactive waste management is to retard or disperse the radioactivity in such a manner that levels ("doses") that can reach man will be low in relation to natural background radioactivity.

The simplest procedure - which is widely practised for "ordinary" wastes - is direct dispersion and dilution in the air, water and ground. This procedure is only employed on a limited scale for radioactive wastes. The dumping of radioactive wastes in the ocean is, incidentally, prohibited by Swedish law. Direct dispersion is not included in the procedures and development work in which SKBF is engaged.

The antipole of direct dispersion is concentration and containment. Such a principle is possible to apply in the case of radioactive wastes - in contrasts to the situation with some other types of waste - because of the small quantities that are involved in relation to the corresponding energy production.

Containment means surrounding the waste with barriers to limit the escape of radioactivity to man. The barriers may be engineered (artificial) or natural. A system of multiple barriers provides greater assurance that the radioactivity will have time to decay and that its escape to the biosphere will be retarded and can take place at an acceptable rate.

A further choice is either to make use of passive systems, which can be left without supervision after a moderate length of time, or to employ systems that require continued supervision and where the waste can be retrieved for possible retreatment.

The SFR described in 2.4 has been engineered as a passive system that will not require future supervision. The radioactivity in the SFR is less than one thousandth of the activity of the high-level and long-lived waste and declines relatively rapidly to low levels.

The final repository for high-level and long-lived waste (SFL) is also planned as a passive system. The reason for this is that passive systems do not place any burdens to speak of on coming generations. Moreover, fundamental safety is not dependent on whether the institutional systems of society should cease to function satisfactorily. At the same time, however, the Swedish principles envisaged for a final repository for high-level and long-lived waste include a relatively long period of time (temporary storage into CLAB) during which the material is accessible for both surveillance and treatment.

To sum up the above, Swedish plans call for a) a temporary supervised storage of the radioactive products (in the CLAB, in order to permit the heat flux from high-level materials to decline) and b) final storage in two types of repositories situated in rock at different depths: the SFR and the SFL. Most of the radioactivity - from products with a high level of radioactivity or long-lived radioactivity - will be isolated in the SFL.

The principles on which the research for a Swedish SFL is based, i.e. the development of a system with multiple barriers including the selected deep-lying bedrock, has increasingly become the main principle for similar work in numerous other nuclear power nations. Efforts have been intensified all over the world, which means that a large influx of information from abroad can be expected in the future. Nonetheless, forceful and determined Swedish efforts will continue to be necessary; among other things, information must be gathered on specific Swedish conditions for final site selection and design.

2.5.2 Research and development

The law concerning "financing of future expenses for spent nuclear fuel etc." (SFR 1981:669) has entered into force during the report period. In accordance with the provisions of this law, known as the Financing Act, SKBF has, on behalf of the nuclear power utilities, submitted a report entitled "Plan 82" to the National Board for Spent Nuclear Fuel, NAK. The report consists of two parts. The first part deals with research and development work and the second describes the facilities and estimated costs, including the costs for decommissioning of the nuclear power plants.

Since detailed information is provided in "Plan 82", only a very brief account of the activities and plans is given here.

The research and development programme is based on, among other things, the requirement that a very high level of safety shall be met and that foreign dependence and burdens on coming generations shall be avoided. This leads to final storage of the long-lived waste in deep-lying Swedish rock formations.

The research and development part of "Plan 82" mainly describes the programme planned for the 1980s. But the more long-range programme extending up to the time when the high-level and long-lived waste is to be terminally isolated as the final step at the beginning of the next century is also outlined. An account is given of the measures necessary to improve our present-day state of technical and scientific knowledge.

Research and development work is being conducted in the following areas:

- geology, hydrology
- chemistry
- materials science
- properties of and data for different waste forms
- technology
- safety assessment

The international Stripa project, the management of which has been entrusted to SKBF, has progressed according to plan (see also section 4.1).

SKBF has also been given overall responsibility for conducting a series of tests on high-level waste glass for Japan, Switzerland and Sweden jointly during a 3-year period.

Within the framework of the long-range overall plan for site investigations, involving the investigation of some 10 typical areas during the 1980s followed by more detailed studies of 2-3 areas during the 1990s aimed at the selection of a site for a final repository, comprehensive geological field studies have been conducted during the year in the municipalities of Ovanåker, Nyköping, Örnsköldsvik and Kalix. Considerable efforts have been made to develop new instruments and equipment for these studies.

The final repository is expected to be ready to receive high-level and long-lived waste by 2020.

Approximately 200 people at universities, technical institutes and consulting and industrial firms have participated in the R&D work through contracts.

3 COSTS OF THE NUCLEAR FUEL CYCLE

The costs of supplying nuclear fuel arise chronologically in close connection with the corresponding production of electricity. The time lag between purchasing and paying for natural uranium and its use in the nuclear power plant is on the order of about 2 years. The costs of supplying raw materials and services for the nuclear fuel can therefore be directly related to the corresponding production of electricity.

The cost of nuclear fuel naturally varies with the commercial terms of different contracts. The cost of finished nuclear fuel amounted to about SEK 0.033 /kWhe during 1982. The cost for different power utilities varies due to the different terms of long-term contracts.

This cost includes

- natural uranium	about 37%
- conversion	" 3%
- isotope enrichment	" 47%
- fabrication of fuel bundles	" 11% and
- reserve stockpile	" 2%

The situation is different for the "back-end" of the nuclear fuel cycle. Although a number of the steps in the back end of the nuclear fuel cycle are already under way and others are just beginning, the greater part of the cost of the final storage of high-level and long-lived waste will arise after the corresponding production of electricity.

In order to cover such future costs, the Swedish nuclear power producers have been making internal allocations for a number of years. The total reserves set aside in this manner amounted to SEK 2 230 million in December of 1981.

A change has now taken place in this system. In accordance with the aforementioned Financing Act (1981:669, law concerning financing of future expenses for spent nuclear fuel etc.), the nuclear power producer is now required to contribute an annual fee to government-administered reserves, based on a charge per kWh generated by nuclear power. The reserves shall cover the costs of all necessary handling and final storage of spent nuclear fuel and products thereof as well as of the decommissioning and dismantling of nuclear power plants. The costs of disposing of low- and medium-level reactor wastes are not covered by the Act and will continue to be paid directly by the nuclear power utilities, who make internal provisions for this purpose.

According to the Act, the responsibility for developing and implementing the necessary technical measures also rests with the holder of the license, i.e. the nuclear power utilities. The work of joint implementation has in turn been delegated by the nuclear power utilities to SKBF.

The reserves shall be administered by a government authority mentioned in chapter 2.5, the National Board for Spent Nuclear Fuel (NAK). The power utilities are able to borrow money back from the reserves.

The second part of the report to the NAK mentioned in chapter 2.5 - Plan 82 - contains a cost estimate for activities, facilities etc. for the management and final storage of radioactive products from nuclear power generation.

The total cost is estimated in the report at SEK 32 000 million at 1981 prices. The amount is to be distributed over 80-85 years up to the year 2060.

The cost calculation carried out by SKBF includes considerable adjustments to cover various contingencies. The estimated "back end costs" are equivalent to about 10% of the value of the electrical power produced by the nuclear power plants.

The NAK submits an annual proposal to the Government as to how much the nuclear power utilities should contribute to the reserves in order to cover these future waste disposal and decommissioning costs. The Government has set the fee for 1982 at SEK 0.017/kWh.

The total cost picture for the nuclear fuel, including decommissioning, is then:

- fuel supply incl. reserve stockpile	SEK 0.033/kWhe
- back end incl. decommissioning	SEK 0.018/kWhe
Total	SEK 0.051/kWhe

It may be enlightening to make a comparison with the alternative of coal-fired condensing power. Supplying fuel to Swedish ports is estimated in that case to cost SEK 0.15/kWhe, and a reserve stockpile for 0.4 year's consumption is estimated to cost SEK 0.005/kWhe. The costs of the handling of solid waste vary. The flue gas cleaning cost can be estimated at around SEK 0.03/kWhe.

Thus, the costs of the nuclear fuel cycle are less sensitive to international price conditions than the costs of coal fuel. Moreover, importing nuclear fuel places less of a burden on the country's balance of payments than coal. At a production of 6 TWh/y, the difference for a 1 000 MW power plant is around SEK 750 million/year in favour of nuclear fuel.

4 INTERNATIONAL COOPERATION

4.1 THE STRIPA PROJECT

The international Stripa project takes the form of an independent OECD/NEA project in which the following countries are participating: Canada,, Finland, France, Japan, Sweden, Switzerland and the United States. The project management has been entrusted to SKBF. The project has proceeded according to plan. The studies, which are carried out under realistic conditions at a depth of about 360 m, include:

- a large-scale test to shed light on the conditions in a final repository with a bentonite barrier
- hydrological and geochemical studies
- studies of the dispersion of simulated radioactive species in rock fractures.

Discussions are being held within the OECD/NEA concerning a continuation of the Stripa project with a second phase during the years 1983-86. The intention is to complete the dispersion studies, to perform experiments involving the plugging of boreholes, tunnels and shafts and to study the feasibility of various methods for cross-hole investigations.

4.2 OTHER COOPERATION

Besides in the Stripa project, an extensive exchange of information takes place bilaterally and multinationally with corresponding organizations in other countries. Thus, annual programme reviews are conducted within the framework of formal cooperation agreements with the UD Department of Energy, the Canadian AECL and the Swiss NAGRA. Informal meetings and exchanges of experiences have taken place with the French CEA and with the EEC's special group for radioactive waste management.

SKBF is participating in and supporting an international information system initiated by the OECD/NEA concerned with data of importance for the dispersion of various substances in rock fractures.

An agreement has been reached with the Japanese CRIEPI and the Swiss NAGRA concerning a joint 3-year programme for investigation of the mechanisms of dissolution in waste glass. SKBF/KBS has been entrusted with the management of this JSS project (JSS = Japanese Swedish Swiss cooperative study of radioactive waste glass).

SKBF is also a member of the Atomic Industrial Forum in Washington and the Uranium Institute in London. In the latter organization in particular, personnel from SKBF have participated in studies of the conditions of trade on the nuclear fuel market.

In the wake of the reprocessing contracts with COGEMA, joint consultation groups have been organized between COGEMA and its customers in which personnel from SBKF are participating.

Employees from SKBF are participating in the intergovernmental work being conducted in the nuclear energy field within the IAEA and the OECD.

4.3 INTERNATIONAL WORKING GROUPS

SKBF has participated in the work of the following groups:

- The IAEA Consultants Meeting concerning "Analysis of the Performance Requirements of the Waste Isolation System", Vienna, Austria, March 15-19, 1982
- The OECD/NEA Radioactive Waste Management Committee, February 10-11, 1982, Paris, France
- The Program Committee for the Fifth International Symposium on the Scientific Basis for Radioactive Waste Management, Berlin, June, 1982
- The Uranium Institute, London, Committee on International Trade in Uranium

- The Uranium Institute, London, Committee on Nuclear Energy and Public Acceptance
- The IAEA Guide-Book on Spent Fuel Storage.

5 INFORMATION ACTIVITIES AND PUBLICATIONS

5.1 INFORMATION ACTIVITIES IN SWEDEN

Once a year, SKBF submits a report to the Ministry of Industry on the situation in the nuclear field and on the company's activities.

A conventional annual report is also published.

In accordance with the guidelines laid down by Parliament in 1981, SKBF's programme with respect to important parts of the back end of the nuclear fuel cycle is reviewed by the National Board for Spent Nuclear Fuel. A proposed programme and a report on these activities must be submitted to the Board on the 1st of July every year, starting in 1982.

Important parts of SKBF's activities are tied to specific geographic areas within the country. Such activities include the siting of facilities and field surveys in connection with prospecting activities and site investigations for a final repository. At a relatively early stage, representatives from SKBF get in touch with local officials - i.e. the elected authorities in the local municipalities and county administrations - and furnish them with essential information. It has been left to the discretion of these authorities to invite representatives of the local population and the mass media to be present.

Research and development efforts within the field of terminal radioactive waste storage are normally described in a report series entitled "SKBF/KBS Technical Report". Each annual series is concluded with an annual report.

5.1.1 Final repository for reactor waste (SFR)

A joint consultation meeting, as required by the Environment Protection Act, concerning the SFR was held in Östhammar on May 10, 1982.

Representatives of the municipality and the county administration have been given information on the SFR project on a number of occasions.

A film providing a popular description of the SFR has been produced and distributed to interested parties.

5.2 PAPERS AND PUBLICATIONS

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L B Nilsson (SKBF)
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A Rasmuson, I Neretnieks (KTH)
J Geophys Res 86 (1981) 3749

Diffusion measurements in compacted bentonite submitted to MRS
B Torstenfelt, H Kipatsi, K Andersson, B Allard, U Olofsson (Chalmers University of Technology)
MRS Annual Meeting, Boston, 16-19 November 1981.

Formation and properties of americium colloids in aqueous systems
U Olofsson, B Allard, K Andersson, B Torstenfelt (Chalmers University of Technology)
MRS Annual Meeting, Boston, 16-19 November 1981.

Sea Transport Plan - Transportation system for spent nuclear fuel
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Technical, economic and political factors influencing nuclear energy growth
E Svenke (SKBF)
Address at the High Level Workshop on Nuclear Energy Prospects; Paris, 11-12 February, 1982.

Transportation system for spent nuclear fuel -
Final safety report
SKBF, March 1982.

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L B Nilsson (SKBF)
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Communications, Tucson, Arizona, 8-11 March 1982.

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temporary storage facility and sea transportation
system presently under realization in Sweden
B Gustafsson (SKBF)
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April 26-30, 1982.

New directions in nuclear energy with emphasis
on fuel cycles "What to do with spent fuel?"
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The back end of the nuclear fuel cycle - Radio-
active waste management plan, Plan 82: parts 1 and 2
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Berlin, 7-10 June, 1982.

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G Andersson, A Rasmuson, I Neretnieks (KTH, Stockholm)
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A comparison of in-situ radionuclide migration studies in the Studsvik area and laboratory measurements
O Landström (Studsvik Energiteknik AB),
C E Klockars, O Persson, S A Larsson, E Tullborg (Swedish Geological Survey), K Andersson,
B Torstenfelt, B Allard (Chalmers University of Technology, Gothenburg)
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J A T Smellie (SGAB, Luleå)
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G Schultz (SKBF)
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H Carlsson (SKBF)
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H Forsström, (SKBF)
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Seattle, Washington, USA, October 10-14, 1982.