Nuclear Waste Management of the Olkiluoto and Loviisa Power Plants

Annual Review 2001

On the front cover: In May, the Finnish Parliament ratified the Decision in Principle concerning the construction of a final disposal facility.

SUMMARY

This report describes the nuclear waste management of the Olkiluoto and Loviisa nuclear power plants. The report includes a description of the status and operations of nuclear waste management of the power companies in 2001, a review of the communication activities pertaining to nuclear waste management, and an account of the provisions made for future waste management costs.

Studies of the final disposal of spent fuel progressed in accordance with the schedule confirmed by the Ministry of Trade and Industry (KTM). The main objective of the operations begun in 2001 is to bring the research, development and design work to the level that is required for the application for a construction licence and, further, to receive the construction licence from the Council of State. In accordance with the Decision in Principle ratified by Parliament on 18 May 2001, the final disposal site will be Olkiluoto in Eurajoki.

Detailed design of the underground rock characterisation facility known as ONKALO began during 2001. The alternative concepts that were considered included access routes based merely on shafts, and those based on an access tunnel and a shaft.

The site characterisation concentrated on determining the undisturbed baseline of the Olkiluoto bedrock before construction of the ONKALO facility is begun. The work mainly consisted of acquiring additional data on the hydrology, hydrogeochemistry and seismicity.

With regard to safety studies, the main emphasis was placed on studies into the performance of engineered barriers. The studies centred on degradation of the fuel matrix and solubility of uranium oxide (UO_2), corrosion of the copper canister, the expansion properties of bentonite and potential effects of cement.

The next interim target of the repository design is to draw up a preliminary plan that has been adapted to the conditions at Olkiluoto. The design must take account of the integration of the repository and the ONKALO facility.

Jointly with SKB, Posiva launched development work on the MLH concept, or the KBS-3H concept, which is based on the horizontal positioning of the canisters. Development work linked with the manufacturing, sealing and inspection of the copper canisters continued.

The location of the encapsulation plant, either as part of the KPA Store, the interim store for spent fuel, or directly above the repository, was considered from the point of view of utilising the infrastructure on the island as effectively as possible.

The co-operation agreements signed with SKB in June 2001, particularly in the fields of encapsulation and final disposal technologies, substantially increased the resources and investment in research, development and design work.

With regard to operating waste, the established monitoring and long-term investigations and practical measures continued.

By the end of 2001, 4 102 m^3 of operating waste had accumulated at the Olkiluoto Power Plant, and 2 427 m^3 at Loviisa. 3 671 m^3 of the Olkiluoto waste has been finally disposed of in the VLJ Repository. 1 031 m^3 of the Loviisa waste has been disposed of in the low- and intermediate-level waste repository at Hästholmen.

The overall costs of the research programme for nuclear waste management of the Loviisa and Olkiluoto Power Plants amounted to EUR 10.5 million. On the whole, the research programme was implemented according to plan; the most significant difference with respect to the plans involved the drilling of two deep investigation boreholes at Olkiluoto.

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INTRODUCTION

In Finland, two companies utilise nuclear energy to generate electrical power – Teollisuuden Voima Oy (TVO) and Fortum Power and Heat Oy (hereafter referred to as Fortum). In compliance with the Nuclear Energy Act, TVO and Fortum are liable for all activities associated with management of the nuclear waste they produce, for the appropriate preparation of these activities and for all related costs incurred.

In accordance with the Nuclear Energy Act, the Ministry of Trade and Industry (KTM) makes decisions on the principles that must be applied to nuclear waste management. KTM formulated these principles in its decisions of 19 March 1991 and 26 September 1995. The decisions provide a basis for both the practical implementation of nuclear waste management and the research and development related to future measures.

Each company is separately responsible for all measures necessary for the treatment and final disposal of low- and intermediate-level operating waste, and for the decommissioning of the power plants. Posiva Oy, a company jointly owned by TVO and Fortum, is in charge of the research and development regarding the final disposal of spent nuclear fuel and, ultimately, of the construction and operation of the final repository itself.

Posiva is also in charge of compiling the operating plan for and report on nuclear waste management of the Olkiluoto and Loviisa nuclear power plants, both of which are to be prepared annually. As prescribed by the Nuclear Energy Act and Decree, this Annual Review 2001 describes the status and operations of nuclear waste management in 2001. The report also reviews communication activities pertaining to nuclear waste management and the provisions made for future nuclear waste management costs.

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At its Olkiluoto Power Plant in Eurajoki, Teollisuuden Voima Oy operates two boiling water reactors with a nominal output of 840 MWe (net) each. Olkiluoto 1 (OL1) was connected to the Finnish grid in September 1978, and Olkiluoto 2 (OL2) in February 1980. In 2001, the load factors of OL1 and OL2 were 97.6% and 95.1%, respectively. The operating licences for plant units OL1 and OL2, the storage facility for low-level waste (MAJ Store), the storage facility for intermediate-level waste (KAJ Store) and the interim store for spent fuel (KPA Store) will be valid until the end of 2018. The operating licence for the repository for operating waste (VLJ Repository) will be valid until the end of 2051.

Fortum Power and Heat Oy's Loviisa Power Plant has two pressurised water reactors with a nominal output of 488 MWe (net) each. Commercial operation of Loviisa 1 (Lo1) began in May 1977, and that of Loviisa 2 (Lo2) in January 1981. In 2001, the load factors of Lo1 and Lo2 were 92.1% and 89.0%, respectively. The operating licences for plant units Lo1 and Lo2, and the related nuclear fuel and nuclear waste management facilities will be valid until the end of 2007. With respect to the repository for operating waste (VLJ Repository), the operating licence will be valid until the end of 2055.

SPENT FUEL MANAGEMENT

PRINCIPLES AND SCHEDULE

In compliance with the Nuclear Energy Act and the KTM decisions, preparations are underway for the final disposal in Finland's bedrock of all spent fuel from the Olkiluoto power plant and the spent fuel stored to date at the Loviisa power plant, as well as that which will accumulate hereafter. The preparations are made according to the schedule requiring that the companies must be prepared to begin the final disposal of spent fuel in 2020. In the meantime, spent fuel is stored temporarily at the power plant sites.

In December 2000, the Council of State took a Decision in Principle concerning the final disposal of spent nuclear fuel at Olkiluoto in Eurajoki. Parliament ratified the decision nearly unanimously in May 2001. The final disposal facility, consisting of an encapsulation plant and a repository, will be built in the 2010s. In accordance with the Decision in Principle, an application for a construction licence must be submitted in 2016 at the latest.

CURRENT STATUS OF STORAGE

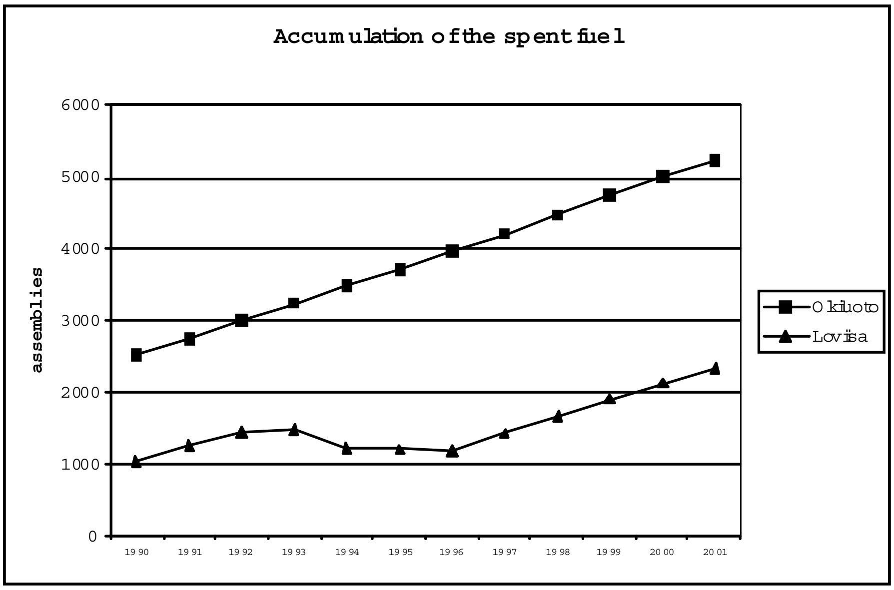
Spent fuel from the Olkiluoto plant is stored temporarily at the plant units and in the interim store for spent fuel (KPA Store). The twenty-second refuelling of Olkiluoto 1 and the twentieth refuelling of Olkiluoto 2 were carried out during the year under review. At the end of 2001, a total of 5 274 assemblies of spent fuel, equivalent to 923 tonnes of fresh uranium (estimated on the basis of the amount of uranium contained in the spent fuel, about 897 tonnes), were stored at the Olkiluoto plant. The KPA Store housed 4 264 assemblies; the pools of OL1 stored 487 assemblies and those of OL2 stored 523 assemblies. The KPA Store has sufficient capacity for the spent fuel accumulated during about 30 years' operation of the plant units, and can be enlarged if necessary. To date, fuel racks have been installed in two of the three storage pools of the KPA Store.

Return transports of spent fuel from the Loviisa plant to Russia terminated at the end of 1996 owing to an amendment to the Nuclear Energy Act. After this, the storage capacity of spent fuel has been increased in such a way that, using racks of the current type, the capacity is sufficient until 2008. In the future, it will be possible to substantially increase the capacity through the use of dense racks. At the end of 2001, a total of 2 335 spent fuel assemblies, equivalent to about 279 tonnes of fresh uranium (estimated on the basis of the amount of uranium contained in the spent fuel, about 268 tonnes), were stored in the Loviisa plant's storage facilities. Lo1 housed 174 assemblies and Lo2 housed 223. The spent fuel storage facilities 1 and 2 held 390 and 1 548 assemblies, respectively.

ONKALO

Before a decision to construct a repository is taken, supplementary bedrock investigations will be carried out at Olkiluoto for the implementation design of the facilities. An underground rock characterisation facility, known as ONKALO, will be constructed to allow the investigations and design. In addition, the purpose of ONKALO is to provide Posiva with experience in the investigation, design, construction and operation of deep rock facilities for the actual implementation of final disposal. The construction is scheduled to begin during 2004.

A detailed design and impact assessment of the ONKALO facility was launched in 2001. The matters to be investigated included, for instance, location of the facility in the Olkiluoto bedrock and depth positions of the characterisation levels, access routes, linking to the future repository, effects and reduction of water seepages, rock grouting and use of cement, and backfilling and sealing. The studies conducted in 2001–2002 are aimed at verifying that the technical plans for the repository and the ONKALO facility are compatible with each other. In designing ONKALO, provision is being made for later linking the facility to the repository so as to form a part of it.



SITE CHARACTERISATION

Characterisation of the Olkiluoto bedrock continued in 2001 to acquire increasingly detailed information. Investigations were carried out to build up information reserves and, in particular, to support the design of underground characterisation facilities.

Characterisation of the Olkiluoto area and its neighbourhood from the ground surface and with the aid of surveys, geophysical methods and drilling investigations has provided deeper insight into the bedrock model and given additional information on the general properties of the fracture zones and the bedrock. A report was drawn up on the updating. The interpretation of the fracture zones in the Olkiluoto area was updated on the basis of the results from the new sounding performed in the sea area.

The structure and history of evolution of the bedrock throughout the southern part of the Satakunta province has been studied to increase understanding of the geological background at Olkiluoto. This work has sharpened the picture of the rock types occurring in the bedrock and their mutual age ratios, and of the different deformation phases that have affected the bedrock structure.

Detailed drilling investigations were performed in the planned location of the potential access route to the underground characterisation facilities. Four medium-deep (125-233 m) boreholes were drilled towards the end of 2001, and some of the basic measurements were already taken in them. The purpose of the investigations is to characterise a small area in minute detail.

Investigations at Olkiluoto

Acquisition of information on the bedrock structure and baseline

Two deep and four shallower boreholes have been drilled at Olkiluoto to determine the point of access to the ONKALO facility – part of a total of 18 investigation boreholes (120–1000 m) that have been drilled in the area. They have provided detailed information on the area in which the repository is planned to be located. Geophysical and hydrogeological measurements have been carried out, and water samples have been taken and analysed in all the boreholes. Measurements conducted in the old investigation boreholes have been completed by borehole TV imaging and vertical seismic profiling (VSP). Gravitational measurements were carried out to specify the occurrence of rapakivi massifs in the Olkiluoto area. Acoustic and seismic soundings were performed to examine the occurrence of fracture zones in the sea area that surrounds Olkiluoto. These investigations also provided information on the thicknesses and quality of the sediments in the sea bottom.

Before construction of the ONKALO facility, what is called the baseline, or the undisturbed status, of the area is defined to be able to discover any subsequent disturbances caused by the construction. Collection of the existing data has already begun to describe the baseline at Olkiluoto, and the need for complementary data has been identified. Investigations with a view to acquiring mainly hydrological and hydrogeochemical supplementary information were launched during 2001.

A regional microseismic station network was planned, equipment was acquired and measuring points were established during 2001 in order to define the undisturbed baseline with regard to seismic measurements. The equipment will be installed and put into use in 2002. The recording of seismic incidents may be continued concurrently with the construction underground.

To carry out hydrological monitoring measurements, the sets of equipment have been repaired and replaced in 2001 with a view to observing the pressure head of the groundwater. In 2001, a long-term pumping test was underway in borehole KR6 to establish the interrelationships between the different groundwater environments, such as deep saline groundwater, sea water and infiltrating meteoric water. Monitoring the groundwater levels of the boreholes in the neighbourhood of borehole KR6 also helps assess the evolution and intensity of any hydraulic disturbance. The hydraulic and chemical results show preliminarily that the behaviour of the groundwater system is stable. Up to now, a slight increase has been detected in the salinity of the water seeping into the pumping hole.

Hydrogeochemical investigations

The water sampling performed in 2001 helped specify the regional distribution of the salinity and the baseline of the groundwater chemistry in the investigation area before construction of the underground facilities begins. This helped acquire additional data on the oxygen and redox parameters, and on the salinity of waters occurring at the final disposal depth. The data material necessary to establish the paleohydrogeological courses of evolution and the chemistry of deep groundwaters was complemented. A total of 13 water samples and six gas samples were taken from deep boreholes.

Samples were taken extensively from the shallow boreholes drilled in the bedrock of the Olkiluoto investigation site and from the standpipes installed in the earth to determine the geochemical processes occurring near the ground surface and to understand the factors essential with respect to the baseline. Most of the analyses were completed in 2001 and the interpretation will be performed in early 2002. Water samples were taken from 11 standpipes installed in the earth and from eight shallow boreholes drilled in the rock.

The work concerning definition of the temperature correction coefficients of the electrical conductivity measurements of saline groundwaters and calculation of the TDS values was completed in 2001, and will be reported in early 2002.

Geological descriptions

The results of the bedrock investigations were gathered together and interpreted to meet the needs of design

A total of 16 standpipes were installed in eight locations at Olkiluoto in autumn 2001 in order to examine the hydrological and chemical phenomena linked with the soil cover.

of the underground characterisation facilities and detailed characterisation of the planned repository area. The modelling methods and ways of reporting the results were improved. The properties of the measuring methods, such as the capability of a radar to measure rock features under the Olkiluoto conditions, were investigated.

Development of the groundwater flow modelling was underway in 2001. The objective of this work is to realistically describe the hydrology of the investigation site in different situations. These situations include, for instance, the behaviour of the groundwater table during the pumping test that simulates the effects of a shaft, and the occurrence and effects of the seepages in the underground facilities. Studies conducted in 2001 concerned true integration of the modelling concepts of porous and fissured medium into the same model. The experience gained up to now shows the benefits of the modelling method and the needs for further development.

The geophysical measurement data accumulated during the investigations were analysed further and the interpretations were compared with the existing structural models. Procedures of the collection, processing and modelling of geological data were studied with the help of internationally acclaimed experts. Selected parts of the drill core data were reviewed to verify the interpretations. A need arose to increase overall knowledge about the occurrence of and variation in the different features and properties of the bedrock. An ever-better final result may be achieved using as wide a range of examination methods as possible simultaneously, for example, interpreted borehole images and drill cores.

Investigations in Loviisa

Field investigations at Hästholmen ended practically in 2000. Reporting on the last borehole investigations (water sampling and analysis, and flow measurements) was completed in early 2001. The final report on the geochemical modelling of the groundwater at Hästholmen was also published.

The readiness for water sampling was retained in investigation borehole KR1 with the aid of the multi-packer equipment left in the borehole, mainly with a view to obtaining reference samples for studies into the saline Olkiluoto groundwater.

Equipment and method development

Upgrading of the measurement software of the hydraulic testing unit (HTU), begun in 2000, to a 32-bit Windows 95 version was completed. The new electronics cards to be used in the measuring probes were also completed. Development of the Single Point Resistance measurement property to be added to the unit began during the year under review. This measurement can replace the detailed flow logging of individual known fractures performed for depth correction. In practice, the point (fracture) to be measured can be located by means of the Single Point Resistance measurement.

A new measuring computer was acquired for the unit and the software modification work required by the modernisation was carried out. The construction of a new thermal pulse flowmeter began. The purpose of the redesign and reconstruction of the thermal pulse flowmeter is to improve the sensitivity and range of measurement. The development work will continue in 2002.

During the year under review, the development work on the equipment aimed at measuring the thermal properties of the bedrock *in situ* centred on the upgrading of the interpretation and modelling methods and the calibration method. Theoretical examinations supported the design of the new transducer. Furthermore, optional materials and ways of locating the heating resistor were studied. Great precision of the calibration is of primary importance, particularly for the definition of thermal diffusivity. Construction of a new prototype transducer may begin in 2002 on the basis of the results.

The construction of a new differential flow measurement unit began. The unit consists of the differential flow measuring equipment with a winch, a cable and necessary tools. Two pieces of the measuring probes and other components to be installed in the borehole were made, suitable for both the 56-mm hole and the 76-mm hole. The electronics of the measuring tool was modified in the new unit, and the lower limit of the unit's measuring range was improved. The latter was implemented by combining the measurements of the thermal dilution method and the thermal pulse method. The constant heating effect of the thermal dilution method is used as the pulse of the thermal pulse method. Thanks to this arrangement, the measurement is speeded up, the total heating energy consumed is reduced, the definition of the direction of flow is improved, and the thermal dilution method becomes considerably more sensitive than previously. The improvement work also resulted in modifications to the software. It is probable that new electronics cards will be installed even in the old measuring transducers, and as a result the measuring program of the new unit can be directly used in the old units as well.

Modifications to the valves of the pressurised water sampling equipment (PAVE) and the groundwater sampling equipment, which were launched in 2000, continued during 2001. These valves were replaced by three ball valves connected in series, which function more reliably than the valve types used previously. Together with this work, development aimed at helping install the pressure vessels of the PAVE equipment (attachment of the pressure vessels to the actual equipment) was launched. The threaded joints of valves used previously were replaced by push-pull couplings. This modification standardises the components and enables the vessels to be used at any PAVE unit. During 2001, four vessels with a smaller volume were also manufactured to help extract gas samples.

A motorised hose winch is used to install the PAVE equipment in the borehole; the cable that supports the equipment, the working-pressure hose of the membrane pump, the pressure hose of the packers and the sample hose are on the winch. Another similar hose winch was constructed towards the end of 2001.

In the pumping of groundwater samples, the water is conducted above ground to a flow-through cell, in which the pH, electrical conductivity, redox and oxygen electrodes have been placed. Two measuring cells of this type have been in use, which has limited the volume of sampling. The construction of a third cell began by component acquisitions. The cell will be assembled in 2002.

During water sampling, equipment was tested for the purpose of gas sampling from the groundwater pumped onto the ground. In preliminary tests, the pressure vessel of the PAVE equipment, in which a vacuum is created, was used as the vessel. After sampling, gases are analysed in the vessel in the same way as in the pressure vessels filled in the borehole. Tests will be continued, and separate equipment will possibly be developed for the sampling.

Linked with the rock stress measurements, Posiva and SKB jointly launched development work concerning quality assurance methods of the overcoring method and the manner of conducting the actual measurement.

The project aimed at developing capillary electrophoresis equipment progressed according to plan. The purpose of the project is to upgrade the analysis method of the cations and anions of groundwater samples. The objective of this three-year project is to construct the prototype for on-line equipment. This method is characterised by the very small amount of sample required, which also enables, for instance, better investigation of the bentonite or rock pore waters.

Development projects of the flow measurement equipment were underway mainly to improve electronics of the differential flow measurement units and to widen their measuring range, particularly to enable the measurement of ever-smaller flows. The figure shows the borehole transducers that are being used in the flow measurement units.

ASSESSMENT OF LONG-TERM SAFETY

Studies on the performance of engineered barriers

The objective of performance analyses is to study the functioning of engineered barriers and to adapt the details of the final disposal concept to the conditions at Olkiluoto. These analyses also provide background material and basic data for future safety assessments and design of the final disposal system. In addition to spent fuel, the canister and bentonite, the studies pertained to the requirements that must be fulfilled in designing the repository and tunnels, shafts and backfilling materials, and sealing structures. The studies are conducted to a great extent under international co-operation programmes. A project to examine processes inside the canister and several experimental and modelling projects to study the behaviour of bentonite and other buffer and backfilling materials have been launched under the EU's research programme. Posiva's own studies and the bilateral studies with SKB pertained, in particular, to the effects of saline groundwater on copper corrosion and on the functioning of compacted bentonite and optional tunnel backfilling materials. Studies on the performance of engineered barriers are also discussed in the sections entitled "Final disposal technology" and "The Äspö Hard Rock Laboratory".

The EU's project named "Rates and mechanisms of radioactive release and retention inside a waste disposal canister (IN CAN PROCESSES)" investigates canister-internal processes during the potential release of radionuclides from spent fuel. Studies are conducted to establish the degradation rate of the fuel matrix both under oxidising conditions and under reducing conditions buffered by iron. The tests launched in Finland examine, in particular, the effect of iron on the reduction of U(VI). Posiva and SKB jointly studied the dissolution mechanism of UO_2 oxidised to the $UO_{2,4}$ state under controlled conditions. The studies also concerned the oxidation of uranium from the surface inwards. The modelling of the dissolution mechanisms of UO_2 under reducing conditions performed by Posiva in 1996–1998 was supplemented by the modelling of oxidising conditions in 2001.

In September, Posiva arranged a working meeting of the international "Spent fuel workshop", which discussed the solubility studies and modelling projects of spent fuel and UO_2 that are underway and being planned. About 50 experts participated in the working meeting.

Experimental solubility measurements of radionuclides have been launched under the conditions that correspond to Finnish final disposal conditions to specify the solubility values so as to be more realistic. The study was launched with thorium and nickel. In 2001, the studies concentrated on the solubility of thorium in various simulated groundwaters and in Olkiluoto groundwaters with different salinities. The tests are modelled by the EQ3/6 model. Posiva was also involved in the NEA's TDB-II project (Thermochemical Database Project).

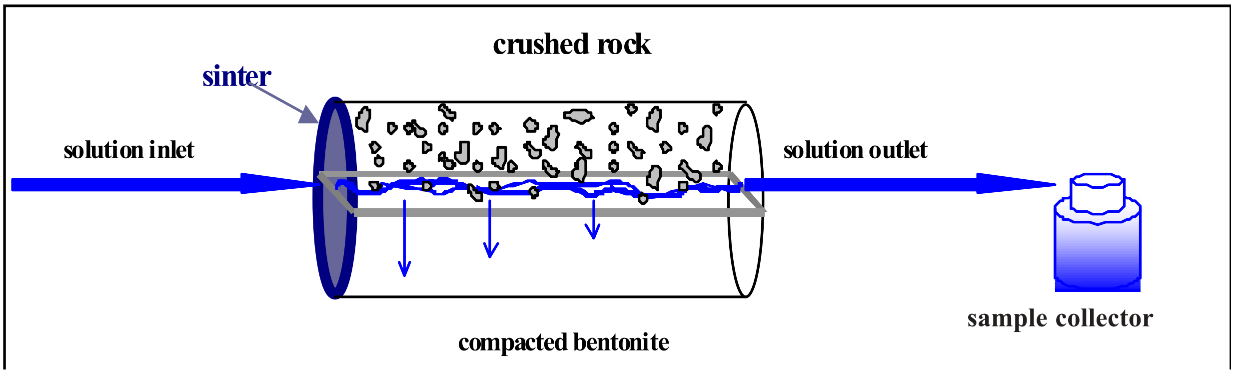
Jointly with SKB, Posiva compiled a report on the current knowledge of the corrosion of copper under final disposal conditions. The summary also assessed the needs for further investigations. A research plan was worked out towards the end of the year to study the effect of saline groundwater on the corrosion of copper.

It is characteristic of bentonite that in saline water its swelling pressure and expansion capacity are reduced. To ensure a sufficient swelling pressure, the bentonite must be initially compacted to a sufficient density. In 2000–2001, Posiva and SKB jointly studied the ability of existing models to theoretically explain the swelling pressures of bentonite measured in the tests. The studies pertained to measurements of the swelling pressures in Na bentonite as a function of the density and ionic strength of the NaCl solution, and the interpretation of the results on the basis of a thermodynamic model. The Finnish contribution consisted of studies into the pore-water chemistry, which plays a part in the formation of swelling pressure. A report on the tests will be completed in 2002. The need to continue the studies will be assessed on this basis.

Posiva arranged a Crystalline Group Workshop, which dealt with the use of cement in underground facilities and its potential short-term and long-term effects on the bedrock, groundwater and backfilling materials. Development work on low-alkaline cement types was launched as a co-operation project of Posiva and SKB. The objective of the project is to verify that the pH of the groundwater will not rise above 11 through the effect of the use of cement. A summary of the potential effect of cement on the groundwater chemistry was also drawn on the basis of the experience obtained at a Canadian underground research laboratory (URL, AECL).

In 2000-2003, Posiva is taking part in the EU project named "Effects of cement on clay barrier performance – Phase II (ECOCLAY)". The project investigates interaction processes of bentonite and cement in clay formations and in the environment of crystalline rock, particularly geochemical reactions, effects on the sorption of radionuclides, and coupled geochemical and migration phenomena. In 2001, tests were launched to examine the reactions and phenomena linked with the system formed by bentonite, cement and crystalline rock.

The EU's Nuclear Fission Safety programme (1994-1998) included the FEBEX project (Full-Scale Engineered Barriers Experiment), which demonstrated construction of the repository and investigated the thermohydromechanical and thermohydrogeochemical processes that occur in bentonite. The project included a full-scale test at the Grimsel Hard Rock Laboratory in Switzerland (an *in-situ* test), a large-scale laboratory test in Spain (a mock-up test), and laboratory investigations that supported these tests. Studies were being continued under the EU's framework programme for 2000-2003. The follow-up project includes partial completion of the in-situ test in summer 2002 and its continuation on a smaller scale, continuation of the mock-up test, and the laboratory investigations and the modelling that support them. Posiva is taking part in the new FEBEX II project by examining, from the samples of the *in-situ* test, the chemical effects caused by concrete on bentonite near the interface of these materials. During 2001, a plan was drawn up for sampling and analyses of the *in-situ* test. Completion of the *in-situ* test was postponed by one year, and consequently, the analysis of the samples will be performed in 2002. The Spanish Ca-Mg-Na bentonite employed in the research differs in composition from the Na bentonite most commonly investigated in Finland, and thus extends the knowledge about the opportunities of using alternative bentonite types.



A diagram of a cylindrical sample in which the alkaline solution flows through the sample parallel to the interface of bentonite and crushed rock. The test is carried out to examine alterations caused by saline concrete water in bentonite and crushed rock, and in the interface between them, and to monitor the progress of the alkaline flow front.

The three-year EU project named "Bentonite barriers in integrated performance assessment (BENIPA)" was launched in 2000. Posiva's contribution concentrates, in particular, on the features, events and processes (the FEPs) that affect buffer and backfilling materials based on bentonite, and on the collection of a scientific and experimental database concerning bentonite to provide a basis for the modelling studies to be conducted within the project. In order to collect the database, Posiva will review, for example, the studies published in the report series of Posiva, STUK, SKB and SKI in 1996–2001 (and even earlier, if necessary).

The treatment of thermohydromechanical and chemical (THM(C)) phenomena in a safety case was demonstrated in the joint working meeting of the DECOVALEX III and the BENCHPAR projects arranged by STUK Radiation and Nuclear Safety Authority in Naantali, Finland. Posiva was also involved in the work of the Finnish monitoring group of these projects.

Development of the model that describes the migration of gas through compacted bentonite continued in the co-operation group named "GAMBIT Club". The second phase of the project consisted of the development and assessment of the model according to which gas is assumed to migrate through the microfracturing formed in bentonite in such a way that the gas pressure has on effect on the aperture of flow paths. Furthermore, an alternative model was studied in which the migration of gas is averaged in the reference volume without describing the separate flow paths. The development and testing of the alternative models will continue in the third phase of the project.

Functioning of the bedrock as a barrier

The EU project named RET-ROCK, launched in 2001, studies the modelling methods and concepts of migration and retention in the bedrock. The project examines the models and concepts employed in safety analyses, and their scientific background. The objective is to get a uniform idea about the suitability of the models and concepts for the description of migration in assessing long-term safety.

Studies into the migration phenomena with the aid of experimental tests continued jointly with other waste management organisations at the Äspö Hard Rock Laboratory. The work done in Finland concerned the modelling and interpretation of the results. These co-operation projects are discussed in the section entitled "The Äspö Hard Rock Laboratory".

In addition to sorption tests, work continued with a view to increasing the mechanistic and theoretical understanding of sorption. On this basis, it is possible to assess the dependence of the sorption behaviour of radionuclides on the prevailing conditions. The research aimed at defining the measured parameter values for kaolinite continued in 2001. Europium and americium are used as radionuclides in this research. Posiva was also involved in the NEA's "Sorption Forum II" project.

In 2001, a joint project of several waste management organisations was launched under the direction of the Geological Survey of Finland (GTK) to establish the potential effect of permafrost on final disposal. The initial phase of the project concentrates on studies into the opportunities to use the mine named "Lupin-Mine", located in the permafrost area in Canada, for understanding the hydrogeological and hydrogeochemical effects and processes of permafrost. A summary of the occurrence and physico-chemical processes of permafrost was drawn up in 2001.

Work was started to generate a hydrogeochemical 3D model of the Olkiluoto investigation site. Other studies launched included the work aimed to describe the hydrogeochemical baseline of the Olkiluoto site and studies aimed at assessing the hydrogeochemical disturbance caused by the future underground characterisation phase.

Biosphere studies

Research was conducted within the scope of Posiva's safety studies to establish the migration of radionuclides in the bog environment and to determine the properties of the Olkiluodonjärvi wetland area on the basis of soil and water samples. Soil logging was also performed in the wetland area to establish the thickness of the soil layers.

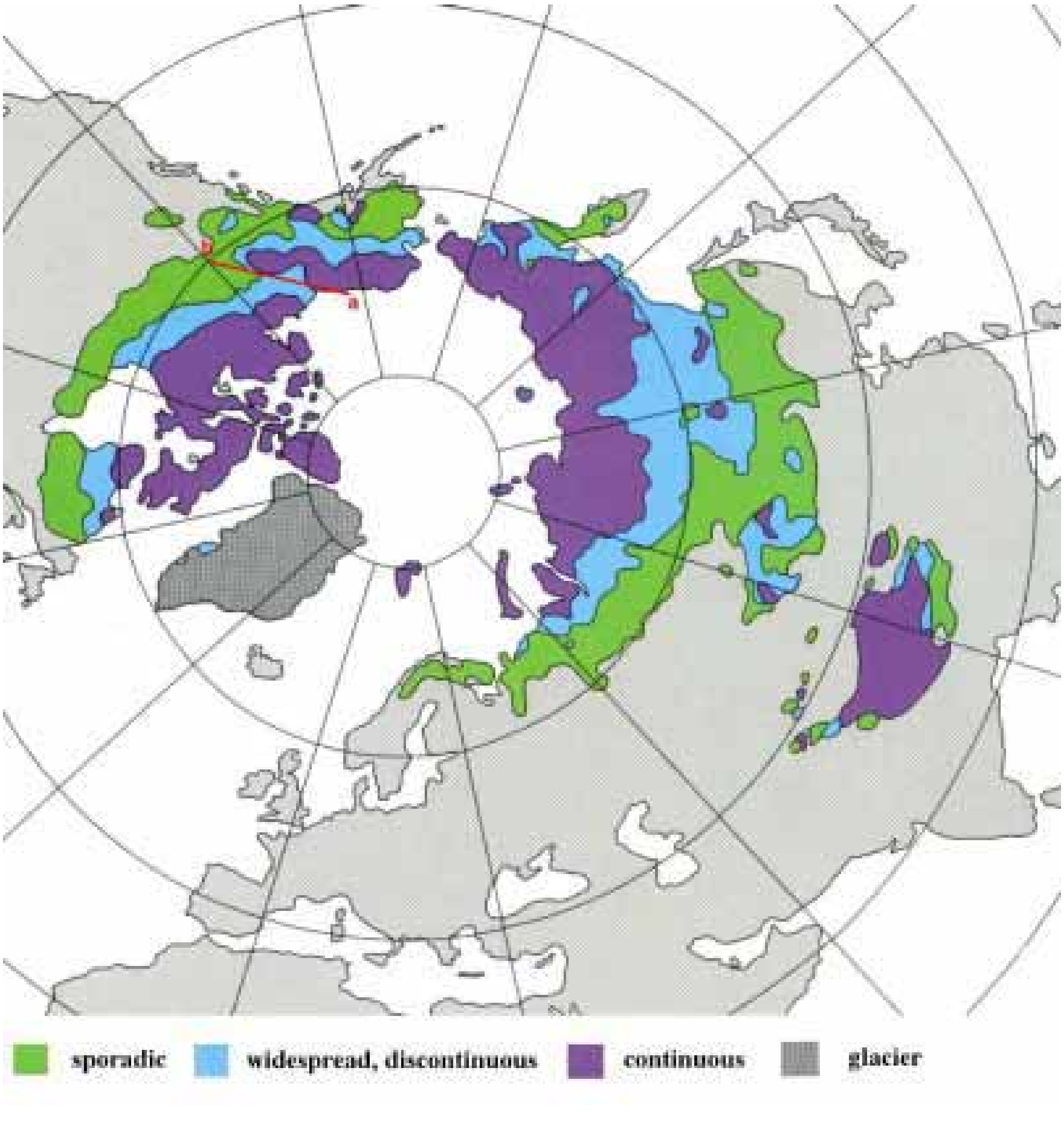
Water sampling was launched to examine the hydrological and chemical properties of groundwater occurring in the soil cover and the chemical properties of the upper part of the rock, and to study the seasonal variation. The samples were taken from the new and previously made groundwater pipes and from shallow rock holes.

Posiva supports Studsvik Eco & Safety AB's participation in the EU's project entitled "Biosphere Models for Safety Assessment of radioactive waste disposal based on the application of the Reference Biosphere Methodology (BioMoSA)". In addition, Posiva monitored progress of the projects linked with international biosphere modelling (BIOMASS, FASSET, BIOCLIM).

Towards the end of 2001, Posiva ordered from the Finnish Forest Research Institute a plan for a basic inventory of the vegetation, tree stand and soil at Olkiluoto, and for intensive monitoring of the forest ecosystems. Implementation of the plan will begin in stages from the spring of 2002 in order to establish the current situation of the Olkiluoto biosphere in detail and to examine the flow of materials.

Assessment of long-term safety

Posiva is supporting the participation of VTT Energy in the EU project entitled "Testing of safety and performance indicators (SPIN)", which is carried out in 2000–2002, with a view to studying optional performance and safety indicators of final disposal. VTT's contribution consists of visualisation of the provisional and final results of the TILA-99 safety analysis (for instance, activity flows and radiation toxicity of radionuclides in the different parts of the final disposal system). In 2001, two joint reports were drawn up on the project, includ-



The occurrence of permafrost in the northern hemisphere (IPA 1995, POSIVA 2001-05).

ing a literature review of the subject and an introduction of the indicators selected for testing, and the safety analysis models and calculation cases. As one test case, all participants compare the release rates calculated by them with the long-term release limits imposed by YVL Guide 8.4 concerning releases from the bedrock to the biosphere. The SPIN project is implemented in co-operation with the research project entitled "The use of selected safety indicators (concentrations; fluxes) in the assessment of radioactive waste disposal", which is co-ordinated by the IAEA. A working meeting for the SPIN project was arranged in Helsinki.

Detailed design and impact assessment of the ONKALO facility was launched. The impacts with respect to the long-term safety will be assessed in close connection with the final disposal technology. The research is discussed more closely in the section entitled "Final disposal technology".

Posiva and VTT are taking part in the three-year EU project named GASNET (A thematic network on gas issues in safety assessment of deep repositories for nuclear waste), which was launched in autumn 2001. The project assesses gas generation, the migration of gases and their treatment in safety analyses.

Co-operation and the exchange of information continued, for instance, within the OECD/NEA and in the international Crystalline Group. Within the OECD/NEA, Posiva was involved in the work of, for instance, the "Integration Group for Safety Case (IGSC), and in the FEP database, the "Thermodynamic Database (II)" and the "Sorption Forum II" projects. Plans for Posiva's biosphere studies were demonstrated in the "Topical Session" of the IGSC.

FINAL DISPOSAL TECHNOLOGY

Design of the repository

The next interim target of the repository design is to draw up a preliminary plan that has been adapted to the conditions at Olkiluoto. The technical design of the repository of the KBS-3 type was launched concerning the facilities and systems located in the uncontrolled area. The design was based on the working shaft alternative, and consisted of the facilities located on one floor and on two floors. In the design of the systems, the main emphasis was placed on the design of heating, water supply, ventilation, fire prevention and transportation systems. In the first design phase, the studies of the one-storey and two-storey concepts concerned location of the auxiliary facilities and functions that have an effect on the design of ONKALO. In the second phase, alternative layout plans were devised during the autumn of 2001. The plan selected among them also provided a basis for the draft designs of the ONKALO facility. Alternative systems were designed for access connections to the repository; in these systems, exiting from the repository in the event of a fire, for instance, would be mainly based on the use of passenger and rescue lifts. The plans have served as basic data for the different alternative concepts for ONKALO, and they will provide a basis for future rescue studies.

Posiva launched development work on the MLH concept, or the KBS-3H concept jointly with SKB. The objective is to develop the MLH concept in such a manner that it can be described in the preliminary plan and that a choice between the KBS-3 and the MLH concepts can be made, if necessary, before submitting an application for a building permit.

During the year under review, thermal dimensioning of the repository was carried out on the basis of the thermal properties of rock based on measurements of the Olkiluoto bedrock; the work was reported in early 2002. The work consisted of assessing the necessary distances between the canisters in accordance with the KBS-3-type concept and, in the two-storey concept, the distance between the two storeys with different assumptions of the amount of spent fuel and the after-cooling period. At the same time, assessment was also concerned with the thermal effect of potential disturbances and alterations resulting from the final disposal operations, and provision for them in the operation and dimensioning of the repository.

Canister structure and manufacturing technology

Mechanisms of the damage sustained to the nuclear waste canister in handling and transportation accidents were studied by means of energy calculations and dynamic FE analyses; the findings of the studies were reported during 2001. The significance of thinning of the copper canister wall with respect to the other factors was examined. These examinations showed that the thinning of the wall of the copper canister would bring mainly technical benefits but indirectly also cost benefits. On the other hand, the thinning may make the manufacture of the copper canister more difficult. Long-term safety is the crucial factor, however, and assessment of the effects of the thinning will continue as the studies linked with long-term safety progress.

A gap of about 1 mm is left between the copper canister and the insert made of cast iron to help install the components one within the other. Owing to the hydrostatic pressure of groundwater, the pressure caused by swelling of the bentonite that surrounds the canister and the relatively high temperature of the canister, creep occurs in the copper canister. As a result, the gap is reduced until it is completely closed. Studies conducted in 2001 concentrated on this phenomenon and, particularly, on creep of the copper canister welds during the first decades of final disposal.

Posiva and Outokumpu Poricopper Oy jointly continued development linked with the manufacturing of the copper canister. Posiva's first seamless copper canister was manufactured in 2000 with the "pierce and draw" pipe-manufacturing method at the pipe factory of Vallourec & Mannesmann Tubes in Germany. In 2001, the copper canister was cut into several pieces for further material investigations. The results were encouraging, and consequently development of the method is being continued. As a result of the co-operation agreement concluded between SKB and Posiva in the spring of 2001, the pierce and draw method, for instance, is being developed jointly with SKB. A preliminary report was drawn up on the technical and economic suitability of the different copper canister manufacturing methods.

Development work on the electron beam welding (EB welding) technique planned for sealing the canister continued during 2001. The purpose was to conduct welding tests in order to apply the previously well-tried parameters to another set of EB welding equipment that is more suitable for the welding of thick copper. In the current equipment, even the starting and ending of the weld, which previously posed problems, and quality of the weld surface achieved through remelting of the welded surface are now flawless.

The literature survey launched in 2000 concerning the suitability of ultrasonic techniques for inspecting the copper canister was completed. During 2001, the suitability and resolution of the ultrasonic method planned for use in inspecting the welded seam of the copper lid was assessed with the aid of inspection tests of the test samples obtained from the EB welding tests.

Design of the encapsulation plant

Alternative locations of the encapsulation plant at Olkiluoto were considered during 2001. In locating the encapsulation plant either as part of the KPA Store or the repository, the purpose has been to utilise the infrastructure on the island as effectively as possible. A plant description was drawn up of both alternatives; the description also assessed performance of the alternatives from different points of view. Cost estimates of the alternatives will be made in the course of 2002.

Final disposal technology

The fracture properties of the Olkiluoto rock was analysed statistically between depths of 300 m and 600 m with respect to the properties affecting the stability of the rock and the groundwater flow. The effect of fracturing on the orientation of the rock facilities was assessed with the aid of calculations made by the Key-Block program.

Breaking of the anisotropic gneissic rock and the development and propagation of fractures during the breaking were modelled three-dimensionally using the particle mechanical PFC3D program. The work consisted of developing a model that simulates anisotropic rock samples used in determining the compressive strength. This model was applied to compare the modelled strengths, microfracturing and deformations with those experimentally detected for rock samples.

At Helsinki University of Technology, a master's thesis linked with rock mechanics of the repository was launched at the Laboratory of Rock Engineering. The thesis mainly concentrates on the use of acoustic emission for monitoring measurements to be taken during excavation of the rock facilities. The thesis will be completed in 2002.

Design and development work aimed at controlling seepage waters in the rock facilities was launched in 2001. For the purpose of designing the grouting methods, studies were concerned with the performance requirements set for the grouting of the repository and the design based on them. Grouting methods necessary for reducing seepage waters were designed preliminarily. The most important methods include location of the rock facilities in as intact a rock block as possible, grouting of the hydraulically conductive fractures and sealing of the hydraulically conductive structures by pressure-proof constructions. Performance requirements, design bases and grouting methods were discussed with Swedish experts in the joint workshop of Posiva and SKB entitled "Grouting to limit water inflow to the deep repository during the preclosure stage", which was conducted at Olkiluoto in October.

Methods for assessing water seepages into the rock facilities and the feasibility for grouting were studied by means of a literature survey. The first phase of the work centred on the mathematical methods and assessment

Draw of the canister being done at the pipe factory of Vallourec & Mannesmann Tubes in Germany.

of their suitability. In the second phase, studies concerned the effect of geological factors on the grouting work and analysis of the methods used for assessing and classifying the feasibility for grouting of the rock, a fracture zone or a fracture. A survey was conducted of the experience gained with grouting in Finland and Sweden for the purpose of designing the grouting work.

A prototype of the equipment that generates a dynamic grouting pressure was manufactured, and its functioning is being tested in early 2002 by a pilot test in the boreholes drilled in the rock tunnel wall.

In 2001, a test programme was planned jointly with KTH (Kungliga Tekniska Högskola) for laboratory tests on cement-based grouting materials. The planning was preceded by a survey of the commercially available grouting materials, on the basis of which the materials to be tested were selected. The laboratory tests will be carried out in the Technical Research Centre of Finland (VTT) in 2002.

Development work on cement-based materials that generate a low pH was launched as a co-operation project of Posiva and SKB. The objective is to verify that the pH of groundwater will not rise above 11 by the action of the use of cement. A feasibility study was conducted in 2001, on the basis of which development work was launched on the manufacturing technology of grouting materials, the grouting mortar for rock bolts and binders. The project will continue until the end of 2002. The work is mainly being done at CBI (Cement och Betong Institutet) and KTH in Sweden.

Preliminary layout studies of the repository were completed in 2001. They consisted of studies into the layout of the repository for spent fuel (4000 tU) in the Olkiluoto bedrock at a depth of 400–500 m using 18 model cases. These cases included one-layer and two-layer concepts of both the KBS-3 and the MLH types. The studied factors that affect location of the repository included conditions on the ground surface, the rock model, feasibility for construction of the rock, groundwater conditions, and the available rock resources. The examined factors that affect orientation of the facilities included direction of the principal stress, schistosity and fracturing.

Integration of the design, research and construction during construction of the rock facilities was designed on the principle of what is called the observational method (OM). The studies conducted during 2001 pertained to the principles of the OM and to the design of reinforcement occurring during shaft sinking.

Optional methods for backfilling the final disposal tunnels were designed and assessed in 2001. These methods included, for example, backfilling with crushed stone and bentonite, compartmental backfilling with crushed stone and backfilling with expansive natural clay. Compaction and spreadability of the Friedland clay were tested jointly with SKB at the Äspö Hard Rock Laboratory. In the test, methods similar to those used for spreading mixtures of crushed stone and bentonite were employed. Towards the end of the year under review, laboratory tests were launched to establish the compressibility of the Friedland clay.

Partly as a joint project and as part of SKB's Äspö Hard Rock Laboratory project, Posiva and SKB further co-operated in 2001 to study the properties of the disturbed zones of rock facilities excavated by the drilling and blasting technique, and by mechanical blasting (TBM = Tunnel Boring Machine). Furthermore, they continued studies into disturbances caused by the drilling of final disposal holes around the full-scale final disposal holes drilled in the Olkiluoto research tunnel, preparation of the summary report on characterisation of the research tunnel, and preparation of the *in-situ* failure test to be performed in the research tunnel aimed at studying the compatibility between the numerical modelling of rock fracturing and the actual fractures produced in the rock.

Posiva arranged an international working meeting of the Crystalline Group, which dealt with the use of cement in underground facilities and the development of low-alkaline cement types. Posiva and SKB arranged a bilateral working meeting concerning the control of seepage waters and the sealing of rock. In addition, Posiva and SKB jointly arranged an international working meeting relating to the backfilling and sealing of the repository. The matters discussed at the meeting will be published in the publication series of the Äspö Hard Rock Laboratory. A group of Posiva's experts visited the URL Hard Rock Laboratory in Canada, where they participated in a working meeting and got acquainted with design and construction of the hard rock laboratory, the research conducted there and the plans made in Canada for the backfilling and sealing of the repository.

The results of the studies concerning the ONKALO facility and the detailed plans will be published in 2002 and 2003. In 2001, working reports were published, for instance, on the foreign hard rock laboratories, on the assessment methods of water seepages and the compaction of rock, on the effects of the anisotropic thermal conductivity properties of rock, and on the properties of bentonite-based backfilling materials and their experimental determination.

Studies on the performance of engineered barriers

Information necessary for the technical design is obtained by being involved in the LOT test, in the investigations of the second phase of the FEBEX project and in the CROP project. Furthermore, the BENIPA project is being carried out to examine the role of engineered barriers made of bentonite in PA (Performance Assessment) studies. Studies on the performance of engineered barriers are discussed in the sections entitled "Assessment of long-term safety" and "The Äspö Hard Rock Laboratory".

Posiva is involved in the EU's project named "Cluster Repository Project – A Basis for Evaluating and Developing Concepts of Final Repositories for High-level Radioactive Waste (CROP)". Besides the EU countries, the parties involved are Japan, Canada and the USA. The purpose of the project is to gather and assess the experience gained with the construction of underground characterisation facilities and with the research and tests conducted in them. In 2001, Posiva drew up reports on the engineered barriers of the repository to be constructed at Olkiluoto and on the tests carried out in the research tunnel of the VLJ Repository.

THE ÄSPÖ HARD ROCK LABORATORY

In June, Posiva signed an extensive co-operation agreement with SKB, which provides a framework for the research and development programme concerning canister and encapsulation technology, final disposal technology and site characterisation, and site evaluation, and for the use of commercial services. The new co-operation agreement will increase the number of bilateral projects between Posiva and SKB. In practice, some of the investigations conducted at the Äspö Hard Rock Laboratory are being continued in the same way as in previous years, but new co-operation projects will no longer be co-ordinated through the Äspö programme. The emphasis of the studies remains unchanged: at Olkiluoto, the Company mainly concentrates on the research into the bedrock conditions and into the assessment of site-specific or site-dependent factors, while at Äspö it performs the general testing and demonstration linked with engineered barriers and final disposal technology. Co-operation within the Äspö Hard Rock Laboratory project included bilateral (Posiva-SKB) studies, such as the "Hydrochemical Stability" project, and international EU projects, such as the "Prototype Repository" test. Within the scope of a separate agreement, Posiva was also involved in the large-scale TRUE (Tracer Retention Understanding Experiment in Block Scale) test jointly with Nirex, ANDRA, ENRESA, JNC and SKB.

The investigations to be carried out at the Äspö Hard Rock Laboratory within the framework of international co-operation have been grouped as follows:

- detailed investigation methods and their application to the modelling of the repository sites;
- testing of models that describe the barrier function of the bedrock;
- demonstration of the technology and performance of important parts of the repository concept.

The "Hydrochemical Stability" project carried out jointly with SKB was completed. The project established, for example, the effect of climate change on the hydrology and chemistry, such as the pH and redox conditions, with the aid of both theoretical studies and modelling. The composition of the hydrogeochemistry was examined for three periods: 1 000 years after the sealing, 1 000 to 10 000 years after the sealing, and 10 000 to 100 000 years after sealing. The final report on the project was published in 2001.

The COLLOID project was launched at the Äspö Hard Rock Laboratory in 2000 to examine the stability and mobility of colloids. The purpose of the project is to establish the role bentonite plays in forming colloids, the amount of colloids in the deep groundwaters at Äspö, and the formation and migration of colloids under the groundwater conditions. Posiva became involved in the project in 2001. It is in Posiva's interests to compare the different sampling and analysis methods with a view to quality control, and to gather experience with the sampling of colloids and deep groundwaters in underground conditions. In addition, studies pertain to comparing the effect of SKB's and Posiva's sampling methods on the analytical data on colloids. A groundwater sampling campaign was organised in the autumn. The results will be assessed in SKB's workshop on colloids to be held in the spring of 2002.

The development of water sampling and the sampling from very poorly hydraulically conductive rock, known as sampling of the rock-matrix pore fluid, were underway at the Äspö Hard Rock Laboratory at a depth of 450 metres. The rock-matrix pore fluid probably affects the geochemistry of deep saline groundwaters, and for this reason it is important to define its origin, age and mode of origin. As part of the rock-matrix pore fluid research in Finland, studies also pertain to fluid inclusions occurring in minerals: their contents, origin and geochemistry.

Posiva was involved in the tasks of the Task Force aimed at studying groundwater flow and migration. During 2001, the Task Force continued modelling and reporting Task 5, the purpose of which was to combine the groundwater flow model and the geochemical model. Three groups from the Technical Research Centre of Finland (VTT) contributed in Finland to the modelling. The purpose of Task 6, which was performed during 2001, was to combine the site evaluation and modelling processes linked with the migration of fluids in fractured rock. From Posiva's point of view, it is highly useful to explore the compatibility of the results of site characterisation with the modelled migration paths.

The objective of the large-scale (10-50 m) TRUE Block Scale test was to provide deeper insight into groundwater flows and the migration of the tracer in the fracture network. Posiva took part in the test by making predictions about the migration for certain parts of the test. The same model was employed to assess the success in the Phase C tracer test. As part of the same project, Posiva also examined the porosity and microfracturing of the rock types occurring at Äspö with the ^{14}C-PMMA method. In addition, Posiva was involved in the drawing up of the final report on the TRUE Block Scale test.

Posiva is involved in the "Prototype Repository" project, which is implemented at SKB's Äspö Hard Rock Laboratory. The project has been accepted into the EU's framework programme for 2000-2003. The KBS-3 final disposal concept is being tested and demonstrated in the project by constructing a full-scale long-term test for a sealed final disposal tunnel. During 2001, canister models fitted with heaters and surrounded by compacted bentonite were placed in four full-scale final disposal holes. In addition, the tunnel was equipped with instrumentation, and a sampling system was also installed. Finally, the tunnel was filled with a mixture of crushed stone and bentonite, and closed by a solid concrete structure. Posiva took part, for instance, in the assessment of the design and installation of the test arrangements and structures, in the preparation of the tunnel groundwater sampling and analysis, and in the assessment of results. The groundwater balance on the interface of the bentonite and bedrock is being modelled in the near-field. A decision on the modelling method was taken and preliminary calculations were made during 2001.

Posiva is involved in the LOT test (Long-Term Test of Buffer Material) to be carried out at the Äspö Hard Rock Laboratory. The test pertains to validating the hypotheses and models of long-term processes occurring in the buffer material, and the closely linked processes concerning microbiology, the migration of radionuclides, copper corrosion and the migration of gas. The tests are performed at a depth of about 500 metres, in boreholes drilled in the tunnel bottom; the boreholes have a diameter of 30 cm and a depth of 4 m. The tests to be performed in five boreholes were begun in summer 1999, and they have been planned to last for 1, 5 and 20 years. On completion of the tests, the purpose is to compare the physical and chemical properties, mineralogy and microstructure of the material subjected to the test with the corresponding properties of reference material. The research conducted in Finland pertains to the chemical processes occurring in bentonite and the chemical conditions produced in pore water and bentonite. The first one-year-old bentonite samples were delivered to Finland for analysis, and preliminary results showed that compression of the pore water had occurred in the sample as the saturation phase had progressed. The results will be reported during 2002.

Posiva and SKB jointly tested the compaction and the feasibility for tunnel backfilling material of the German Friedland clay in a small-scale field test in the Method tunnel at the Äspö Hard Rock Laboratory. The compaction methods and techniques were similar to those used in the “Prototype Repository” project.

MANAGEMENT OF OPERATING WASTE

In addition to high-level spent fuel, the Olkiluoto and Loviisa Power Plants produce intermediate- and low-level nuclear waste, comprising used reactor internals (e.g., control rods and core instruments) and plant operating waste (e.g., ion-exchange resins and miscellaneous maintenance waste). Management of used reactor internals is discussed in the section entitled “Decommissioning investigations”. The management of operating waste is discussed below.

OLKILUOTO POWER PLANT

Principles and schedule

Most of the operating waste is packaged immediately for handling, storage and final disposal. The intermediate-level ion-exchange resins used to clean the process water are solidified into bitumen, and the mixture is cast into steel drums. Some of the low-level waste (compressible miscellaneous maintenance waste) is compacted into the steel drums with a hydraulic press, and some (metal scrap and filter rods) is packed as such into steel containers, concrete boxes and steel drums. Drums containing compressible waste are further compacted so that the final height of the drums is approximately one half of the original (the diameter, however, does not change). Metal scrap can also be compacted before packaging. Miscellaneous liquid waste and sludge are solidified by mixing the waste and a binding agent in a drum that serves as a package for the solidified mixture.

Operating waste is stored temporarily at the plant units, in the storage facility for intermediate-level waste (KAJ Store), in the storage facility for low-level waste (MAJ Store), in the enclosed storage area and, to a minor extent, in the KPA Store, at the Olkiluoto plant site.

Intermediate- and low-level waste produced during power plant operation is disposed of in the present waste silos of the repository for operating waste (VLJ Repository). Very low-level waste is exempted from regulatory control and is either transported to the dump at the Olkiluoto plant site or handed over, for example, to be processed for reuse.

Current status of storage and final disposal

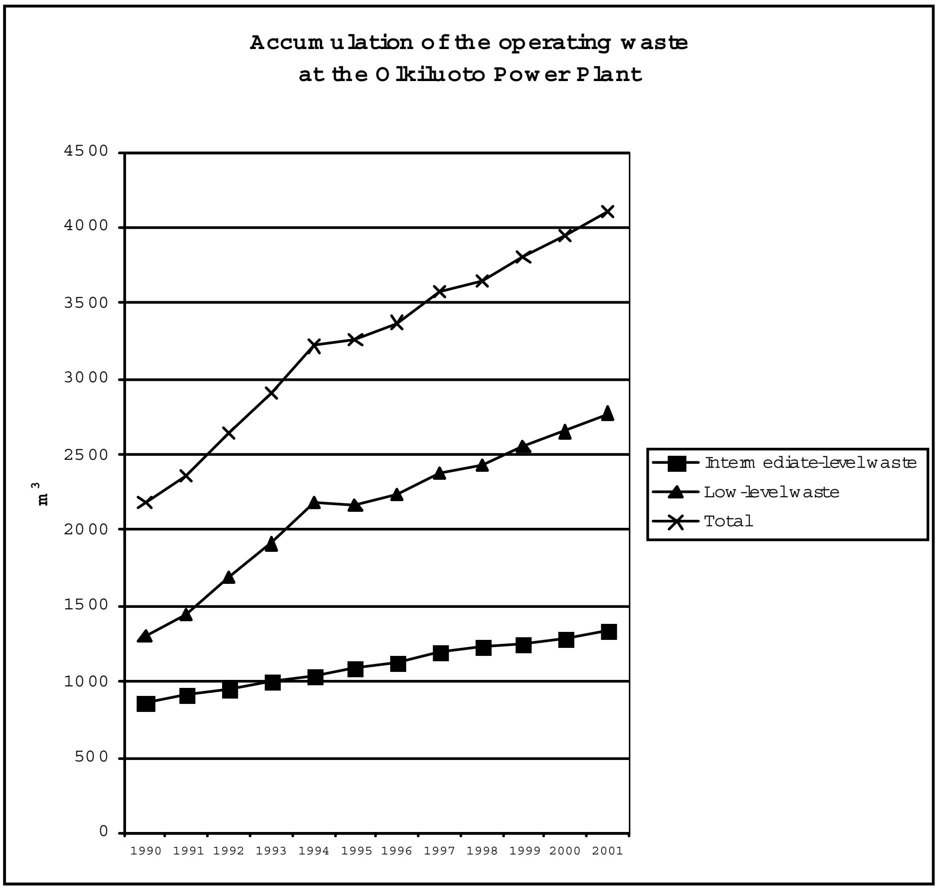
The table below shows the current status of storage and final disposal at the end of 2001. The waste has been packed into drums (200 litres each, or about 100 litres in compacted form), steel containers (1.3 or 1.4 m^3 each) and concrete boxes (net 5.2 m^3 each). In addition, five drums of low-level ash generated in an incineration test were held by Studsvik Energiteknik AB in their storage facility in Studsvik, Sweden. If necessary, the drums and containers are stored in the storage facilities of the plant units and the KAJ Store before final disposal in the VLJ Repository. Before transfer to the VLJ Repository, the drums and steel containers were placed in large (net 5.2 m^3 each) or small (net 3.9 m^3 each) concrete boxes, the large boxes housing 16 drums or 7 drums and 2 steel containers, and the small boxes 12 drums. Correspondingly, the concrete boxes will house twice as many compacted drums.

Bulky contaminated metal components are stored in the KAJ Store and the adjoining enclosed storage area. In addition, used ventilation filters and other unpacked operating waste are stored at the plant units. The unpacked waste also included non-bituminised resins and waste oil. Some of the metal scrap will be disposed of as such in the concrete boxes used in the VLJ Repository. Some of the unpacked waste will later be exempt from regulatory control and will either be reused or transported to a dump. For example, very low-level waste oil may be exempt and reused. At the end of 2001, the amount of such waste oil was 13 m^3.

The waste storage facilities of the power plant units can house some 1 000 drums each. The MAJ Store mainly houses only very low-level maintenance waste bags and scrap, which will be exempt from regulatory control. The KAJ Store can house drums, containers and bulky, contaminated metal components, the total vol-

Operating waste produced at the Olkiluoto Power Plant

	Total volume of waste		**In the VLJ Repository**		
			KAJ Silo	MAJ Silo	Total
	(pcs)	(m^3)	(pcs)	(pcs)	(m^3)
Bituminised waste	6684	1336	6291		1258
Other operating waste					
– in drums	5839	1050		5617	1004
– in steel containers	454	629	2	450	624
– in concrete boxes	157	816		151	785
– unpacked		271			
Total		**4102**			**3671**



ume of which comprises some 6 000 drums. The capacity of the intermediate-level waste silo in the VLJ Repository is 17 360 drums (200 litres each) and that of the low-level waste silo 24 800 drums, i.e. about 8 400 m^3 of operating waste packed in drums, or the equivalent of the waste accumulated during 40 years of operation of the two power plant units at Olkiluoto. Additional repository facilities can be built in the same bedrock area, if necessary.

Radioactive wastes from small producers are stored in the VLJ Repository at Olkiluoto. STUK Radiation and Nuclear Safety Authority has so far been in charge of these wastes, which consist of radioactive material used mainly in hospitals, research institutes and industrial plants. By the end of 2001, 41 m^3 of this waste had accumulated in the VLJ Repository.

Studies on operating waste

A large-scale test of the microbiological degradation of low-level maintenance waste is being conducted in the construction tunnel of the VLJ Repository. The project was part of the PROGRESS project of the EU's nuclear fission safety programme in 1997–1999. These studies are conducted to determine more exact estimates of the volume of gases generated by maintenance waste and in order to gain a better understanding of the entire degradation process after the sealing of the VLJ Repository. This project also involves monitoring the migration of activity from the waste drums to the surrounding water. One concrete box of the VLJ Repository with drums containing compacted waste was placed in a 20 m^3 steel tank. The test began in August 1997. When the air originally found in the drums had been let out, the generation of gas was found to be low compared with the value used in the safety analysis. After the first test year, the average rate of gas generation corresponded to some 70 dm^3/month, whereas the value used in the FSAR safety analysis of the VLJ Repository is some 900 dm^3/month, when proportioned to the scale of the test.

Hydrochemical, microbial and gas analyses show that the test conditions are clearly anaerobic. The amount of anaerobic bacteria is on the increase, the sulphide and iron concentrations have also risen substantially, and methane is a dominant gas. The measured chemical parameters and microbes distinctly prove that the chemical and microbiological conditions prevailing at the bottom of the tank and at the lid level of the drums differ considerably.

The studies are progressing in accordance with the drawn-up research plan. The cell was partly renovated in 2001 by replacing the steel cell with a cell made of glass. The summary report drawn up in 2001 assessed the analysis programme of the monitoring process. On the basis of this assessment, both the parameters to be analysed, and the sampling points with sampling intervals have been verified with respect to the hydrochemistry, gases and microbes.

Studies during the operating period of the VLJ Repository

Operation-time monitoring of the VLJ Repository (rock mechanics, hydrogeology, groundwater chemistry, repository air) continued in 2001 in accordance with the research and monitoring programme drawn up previously.

The groundwater chemistry in the area of the VLJ Repository at Olkiluoto has been monitored since the 1980s. Water samples have been taken for analysis from three groundwater stations of the repository during construction and operation. In accordance with the monitoring programme of the VLJ Repository, the sampling has been preceded by the monitoring of water pH, electrical conductivity, redox potential (Eh), dissolved oxygen and temperature.

In 2001, field measurements were conducted at groundwater station PVA2. The results show that reducing and slightly alkaline conditions prevail at the measurement point.

The objective of the corrosion test of the zinc coating is to obtain information on the corrosion resistance of galvanised reinforcement bolts in the bedrock under the conditions of the VLJ Repository at Olkiluoto, with the hypothesis that the cement mortar that protected the bedrock bolts had completely lost its protective property.

The corrosion behaviour of galvanised steel in a borehole drilled in the VLJ Repository was studied by a test begun in 1998. Samples of the galvanised steel plates were taken in 2001. Previous sampling showed that corrosion of the zinc coating had already occurred during the first test year, and after the second test year the zinc coating had dissolved from nearly all the plates studied. In summer 2000, concrete cylinders were installed in the borehole, thus seeking to regulate the groundwater pH so as to make it more alkaline, thereby simulating the actual environment of the reinforcement bolts in the operating conditions. Zinc plates were installed in the borehole in summer 2000 as well; with the aid of these plates it will probably be possible in the future to determine the corrosion rate of zinc better than with zinc-coated plates under the conditions in question. The samples taken in 2001 showed that corrosion of the zinc plates was minor, and had resulted, for example, from alterations that had taken place in the water chemistry and conditions in the borehole. The aim is to change the test arrangements in 2002.

The investigation and monitoring programme concerning the bedrock of the VLJ Repository at Olkiluoto drawn up in 1999 defined the need to carry out more exact and supplementary hydraulic conductivity measurements and groundwater flow measurements in the area of the VLJ Repository. The measurements launched in 1999 were completed during the year under review. The hydraulic conductivity profile of the bedrock was measured by Posiva's differential flow measurement equipment in investigation boreholes YD5-YD7 and YD13. Transverse flow measurements were conducted in boreholes YD6 and YD7. On the basis of the measurements, plugging plans were drawn up for boreholes YD5-YD7 with a view to reinstalling multi-packer equipment in the holes. The installation work was carried out in 2001.

The multi-packer equipment contains automatic measuring and data collection systems of the hydraulic head of the groundwater. The data provided by the pressure transmitters that measure the hydraulic head are gathered in the GWMS 2001 data collection equipment, from which they are forwarded through a GSM modem to Posiva's measuring computer. The measurement data are gathered in files and delivered to the consultant that is responsible for reporting the results.

LOVIISA POWER PLANT

Principles and schedule

Intermediate- and low-level operating waste is conditioned and stored at the plant site. Spent ion-exchange resins and evaporator concentrates are stored temporarily without solidification in a tank storage facility. As the storage capacity is still sufficient, a solidification plant has not yet been built.

Compilation of the preliminary safety analysis report (PSAR) of a cementation-based solidification plant began towards the end of 1997. According to the plan, construction of the solidification plant can commence after STUK has approved the preliminary safety analysis report. The preliminary safety analysis report was submitted for approval on 3 January 2000 and it was approved on 30 March 2001.

Fortum has invested heavily in the development of new waste-treatment methods. These efforts have resulted in a waste-treatment method that separates caesium from the evaporator concentrate and reduces the waste to a very small volume. The evaporator concentrate is then so clean that a larger volume than previously can be exempt from regulatory control without increasing the annual activity release.

Dry maintenance waste from power plant service and repair work is packed in steel drums of 200 litres each. Compressible waste is compacted into drums with a hydraulic press, thereby reducing the volume by a factor of 3 to 4.

Intermediate- and low-level operating waste from the Loviisa Power Plant will be disposed of in an underground repository built in the bedrock at the power plant site. The repository was put into operation as an interim store in the spring of 1997. The repository received an operating licence in the spring of 1998, and the repository has been used for the final disposal of maintenance waste since the summer of 1999.

Current status of storage

The table below shows the current status of storage and final disposal at the end of 2001.

The final disposal facility

Intermediate- and low-level operating waste produced at the Loviisa Power Plant will be disposed of in a repository constructed in the bedrock of Hästholmen Island. The repository was put into operation as an interim store in spring 1997, and as a final disposal facility in summer 1999.

The final repository comprises a transport tunnel of about 1 100 metres in length, tunnel and hall spaces built at a depth of about 110 metres, and stair and ventilation shafts. The construction of the repository is implemented in two stages. During the first construction stage, all repository spaces and access routes were excavated. These included two final disposal tunnels for maintenance waste and a final disposal hall for solidified waste. Only one maintenance waste tunnel and the systems serving the entire repository were completed during this stage. During the second stage, construction and installation work relating to the second maintenance waste tunnel and to the room for solidified waste will be carried out. The implementation time of the second stage is determined by the building schedule of the solidification plant. On the basis of the current estimate, it is scheduled for 2003-2005.

Separate research programmes have been planned for the study of the transport tunnel and hall areas during operation.

Caesium separation facility

By the end of 2001, a total volume of over 900 m^3 of evaporator concentrates was treated at the caesium separation facility with 14 ion-exchanger columns, each with a volume of 8 litres. The efficient separation of caesium from evaporator concentrates is a normal operating procedure at the power plant.

Studies on solidification methods

Solidification with cement has been selected as the basic conditioning method for Loviisa's wet operating waste. Verification of the solidification recipes for bottom deposits with new building cements and corresponding tests on the solidification product of ion-exchange resins continued during the year under review. With regard to the latter test, tap water contained in the solidification recipe of the solidification product of ion-exchange resins was replaced by evaporator concentrates. In addition, test data was obtained from final disposal containers and from solidification product samples in long-term storage, the oldest of which are now more than 18 years old.

Owing to the entry into force of the European cement standard and, at the same time, to the modification of the burning process, grinding and raw-material base of cement clinker made by the only Finnish cement manufacturer, Finnish building cement types have changed considerably. Studies on the suitability of these new cement types for solidification recipes developed for evaporator concentrates and bottom deposits of the overflow tank were completed in 2000. As a result of the development work, which comprised materials tests, preliminary tests and actual solidification tests, the solidification formulations of the above waste have been verified in such a way that the properties of the fresh and hardened end product fulfil the requirements set. During the year under review, corresponding studies continued concerning the solidification formulations of ion-exchange resins, in which tap water used for adjusting the consistency of the mixture was replaced by evaporator concentrates, and the testing of the new solidification recipes for bottom deposits required by the safety analysis also continued.

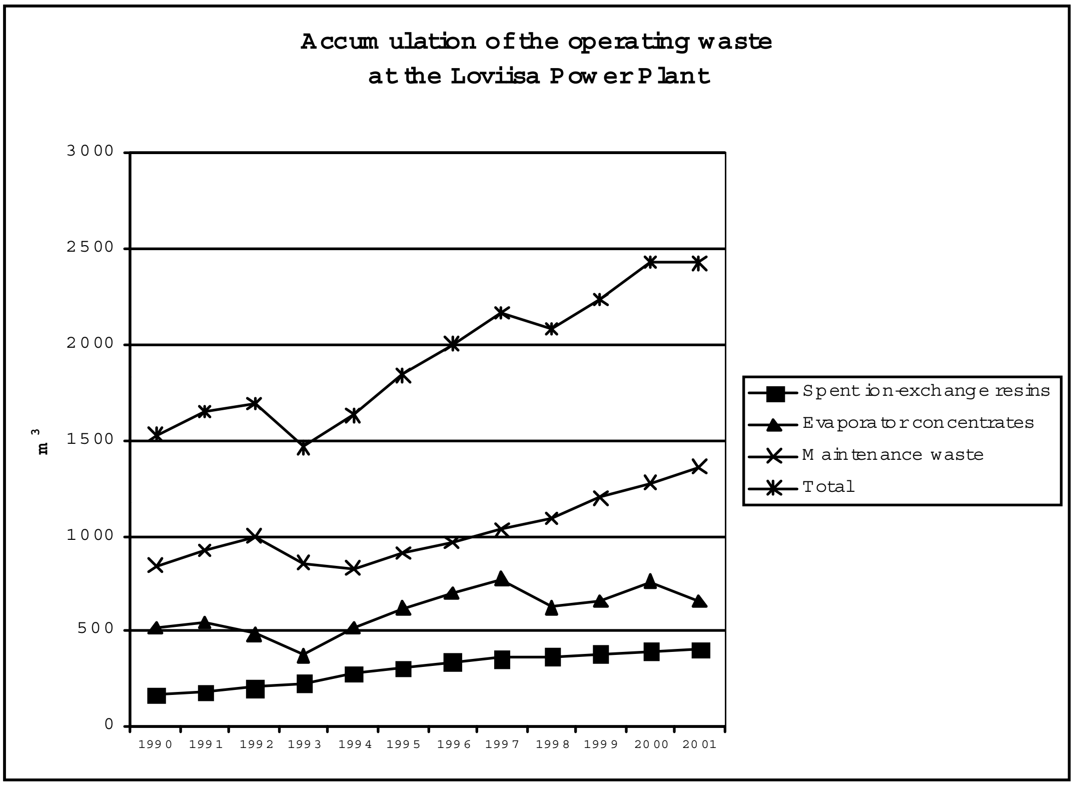
The durability test on ion-exchange resins solidified in half-scale containers in 1987 continued. For 14 years now, the waste containers have been immersed in tanks filled with groundwater at the Loviisa Power Plant; as expected, they are still in good condition. No damage to the concrete walls of the containers has been detected, and the composition of the groundwater has remained relatively stable. Activity measurements for the groundwater have not indicated any signs of nuclide release from the solidification products in the concrete containers.

Studies during the operating period of the VLJ Repository

Operation-time studies on the repository for operating waste (VLJ Repository) continued in 2001 in accordance with the monitoring programme. The objective of the programme is to study and monitor long-term changes in the properties and the behaviour of the groundwater and bedrock in the repository and in its immediate vicinity.

Operating waste produced at the Loviisa Power Plant

	Total volume of waste		Share of the storage capacity	Activity
	At the plant/ in the storage building (m^3)	In the repository (m^3)	(%)	(GBq)
Spent ion-exchange resins	409		48	17070
Evaporator concentrates	655		63	495
Maintenance waste	332	1031		230
Total	**1396**	**1031**		**17795**



The monitoring programme included monitoring the groundwater table in the investigation holes above ground once a month. The location of fresh and saline groundwater in the holes was measured four times during 2001. In the repository, the conductivity and pressure of groundwater, and the amount of seepage water were measured once a month, with the measurement of pressure and the amount of seepage water being partly continuous. The measurements concentrated on seepage water pools and on five groundwater stations built especially for this purpose. Towards the end of the year, water samples were taken at the groundwater stations for chemical analyses. The stability of the bedrock was mainly monitored by an automatic rock mechanical measurement system. The excavated and reinforced rock surfaces were also checked for maintenance purposes in 2001.

According to the findings of 2001, the groundwater table follows variations in the sea-water level fairly closely. During construction, the groundwater table lowered a few metres in the immediate vicinity of the repository, but a distinct rise was observed after completion of the repository, which continued in 2001. Correspondingly, the interface between fresh and saline groundwater is becoming slightly lower, between the levels of about -5 and -80 m in the repository area, in other words, distinctly above the repository.

The electrical conductivity measurements of seepage water show that the seepage water is slightly fresher than in the previous year, with the conductivity varying between 700 and 1 500 mS/m in the different parts of the repository.

The pressure values of the groundwater clearly reflect the effect of variations in the sea-water level. At the five groundwater stations, the pressure varies between 1 and 11 bar.

The amounts of seepage water were measured at seven points on different sides of the repository. After completion of the excavation in 1996, the total amount of seepage water was about 300 l/min at its highest, from which it has steadily reduced, and would now seem to be stabilised at the level of 131 to 141 l/min. About half of the seepage water comes from the transport tunnel and the rest from other facilities. The measurement results show that the maintenance waste rooms are practically dry.

The waters of the groundwater stations are so-called saline Na-Cl and Na-Ca-Cl waters or partly fresher, so-called Na-Ca-Cl/Na-Cl waters of the transition layer. The waters are slightly reducing and alkaline.

The preliminary results of rock mechanical measurements suggest very stable conditions. As in the previous years, displacements that have taken place in the repository ceilings and walls are very small, distinctly of the order of less than 0.1 mm.

The survey carried out shows that the repository is in good condition. The performance of the subsurface drains was improved by washing out the precipitate gathered in the drains in the course of years.

Safety of final disposal of operating waste

During the year under review, a feasibility study was performed into the suitability of the currently used FLUENT flow calculation code for the groundwater and safety analysis of the repository, primarily for the modelling of the near-field.

JOINT STUDIES

The long-term durability of concrete under final disposal conditions is being studied as a joint project by TVO and Fortum in the VLJ Repository at Olkiluoto and at the Materials and Concrete Laboratory of Contesta Oy (formerly owned by Fortum Technology). The research project pertains to both the operating waste and decommissioning waste management. The studies are discussed in the section entitled “Decommissioning investigations” (Page 25).

DECOMMISSIONING INVESTIGATIONS

OLKILUOTO POWER PLANT

The operation of the Olkiluoto Power Plant results in the accumulation of intermediate- and low-level nuclear waste consisting of used reactor internals (e.g., control rods, core instruments, core grids, moderator tank lids and steam separators). Given that these items will be disposed of during the decommissioning of the plant, the matter is discussed in this section.

By the end of 2001, 230 control rods, 204 core instruments, two core grids and two moderator tank lids with their steam separators had accumulated at the Olkiluoto Power Plant. Used reactor internals are stored in the pools of the plant units.

The decommissioning plan for the Olkiluoto Power Plant is to be updated every five years. The latest updated plan was presented in 1998. According to the decommissioning plans, the reactor pressure vessels of the power plant units will be cut into pieces during decommissioning. The plans also include an alternative, according to which the reactor pressure vessels are removed and disposed of in one piece. The plans are based on a power plant unit operating period of about 40 years and on controlled storage of about 30 years before decommissioning. The final decommissioning plan will be drawn up well before the power plant units cease energy generation. According to the present plan, the intermediate- and low-level waste from the decommissioning and the used reactor internals from power plant operation will be disposed of in an extension of the VLJ Repository.

During 2001, studies were conducted concerning the filling of the reactor pressure vessels with concrete before their decommissioning in one piece.

Activity measurements of various systems within the plant were continued as a means of further developing the activity inventory of the power plant's decommissioning waste. Calculation of the activity inventories and radiation levels of the activated decommissioning waste began.

The exemption limits of a nuclear power plant's decommissioning waste were studied, and a report was drawn up on the matter, paying particular attention to the conditions of the reactors at Olkiluoto. Preparations were made with a view to verifying the amounts of waste for the next update of the decommissioning plan.

Long-term corrosion tests of carbon steel began towards the end of 1998 in the construction tunnel of the VLJ Repository. The tests are performed jointly with the concrete research in such a way that some of the pieces of carbon steel have been placed in the same borehole as the test samples of concrete. Laboratory tests in the concrete-water and bedrock-groundwater environments were launched in spring 1998. The corrosion rate of the carbon steel samples is determined by the loss in weight and by the volumetric measurement of hydrogen gas. In 2001, new test samples of carbon steel were placed in a new borehole.

The solubility of nickel (Ni-59) in the concrete-water and bedrock-groundwater environments, important for the safety analysis of decommissioning waste metals, was studied in 1998-2001 by considering the effect of the main parameters on the solubility, such as iron and sulphide, in the concrete-water and bedrock-groundwater environments. The findings of the study were reported in 2001.

LOVIISA POWER PLANT

Operation of the Loviisa Power Plant results in the accumulation of intermediate- and low-level nuclear waste that will not be disposed of until during the decommissioning of the plant. This waste includes, e.g., used shielding elements, absorbers, neutron flux transducers, intermediate rods of control rods and fission chambers.

By the end of 2001, 146 used shielding elements, 185 absorbers, 165 neutron flux transducers, 128 intermediate rods and nine fission chambers had accumulated at the Loviisa Power Plant. Of these items, the shielding elements have been placed in the plant pools in the spent fuel store, and the absorbers and fission chambers have been stored in specially built channels in the spent fuel store. The neutron flux transducers and intermediate rods have been stored in corresponding channels located in the reactor halls. In addition, 31 containers of materials sample chains and other similar materials have been stored in the reactor hall channels.

In 1987, Fortum drew up a plan and cost estimate for the decommissioning of the Loviisa Power Plant. The decommissioning plans were updated in 1993. The plan was based on 30 years of commercial power plant operation, which is equivalent to the designed technical life of the power plant. However, technical measures may be undertaken to extend the operational life of a nuclear power plant. New studies were completed at the end of 1998, which focused on the effects of revised spent fuel management and the power plant modernisation project on the decommissioning plans and schedules. The operational life of the power plant has also been planned to be extended to 45 years, and this was considered in the studies. According to the updated decommissioning plan, all the radioactive systems not necessary for the remaining nuclear operation (i.e. storage of the spent fuel, solidification of the wet waste and final disposal of low- and intermediate-level waste) at Hästholmen will be dismantled immediately after the shutdown of the power plant.

In the future, the plans will be revised every five years. During the year under review, provision continued for updating the decommissioning plan, which is scheduled to be made in 2003. The work conducted in 2001 specified the location of the waste in the decommissioning plan in the repository, and determined more exact cost estimates of the cranes planned for the repository and defined the crane rails. More exact estimates of the activation of the biological shield were determined, and some uncertainties about the input data for the activation calculation were analysed. Furthermore, the Company monitored the experience gained in decommissioning projects that are underway abroad (e.g. Greifswald) and was involved in the studies co-ordinated by the IAEA about the decommissioning costs of VVER-440 plants. As a final result of these studies, the IAEA will publish the TECDOC report in 2002.

It is not expedient, however, to make any decisions regarding decommissioning or continued operation until towards the end of the designed technical operational life. It is also advisable to take a final stand on whether the plant will be decommissioned immediately or after a certain delay, just upon termination of the power plant operation, before the beginning of the decommissioning.

JOINT STUDIES

The long-term durability of concrete under final disposal conditions is being studied as a joint project by TVO and Fortum in the VLJ Repository at Olkiluoto and at the Materials and Concrete Laboratory of Contesta Oy (formerly owned by Fortum Technology). The research project co-ordinated by Posiva concerns both operating waste and decommissioning waste management. The results will be used for the performance assessments of the final disposal of operating and decommissioning waste. The purpose of the studies is to realistically assess the long-term behaviour and degradation of concrete in the bedrock-groundwater environment that corresponds to operating conditions. The objective is to establish, using modern concrete technology, the durability and lifespan of the planned concrete types with different compositions under the real final disposal conditions and under the accelerated laboratory conditions. Special emphasis will be placed on establishing the most durable concrete compositions under the prevailing conditions that will meet the requirements set for the lifespan.

The field and laboratory tests were begun in 1998. During 1999-2001, the research included periodic water chemistry analyses of storage solutions of the test samples and groundwater in the boreholes. Periodic analyses of the test samples with respect to the penetration depth of corrosive components were also carried out. In 2001, the concrete test samples were washed during the field test sampling owing to their black deposits. The black deposits contained, for instance, sulphate-reducing bacteria (SRB). Interaction between the laboratory tests and the storage solutions, and the penetration of corrosive components into the concrete samples were modelled in 2001. The tests will continue in accordance with Posiva's R&D Report published in 2000.

REPORTING, COMMUNICATIONS AND CONTACTS

A total of six reports were published in the Posiva series of reports in 2001. A list of these reports is appended. In addition, company-specific reports dealing with the research results were published.

In Finland, close co-operation continued with the research institutes, universities and consulting firms engaged in studies on nuclear waste management. During the year under review, the Ministry of Trade and Industry and STUK Radiation and Nuclear Safety Authority, as regulatory authorities, were kept informed of measures taken in nuclear waste management and of the progress made in research.

Lectures were held in Finland at meetings intended for both experts and the general public. Representatives from the power companies and from Posiva participated as experts in the work conducted by the leading and joint groups of the publicly financed nuclear waste management research programme.

On its own and jointly with its co-operation partners, Posiva has produced material that is intended to disseminate information, provoke social debate and react to the issues raised in the media concerning nuclear waste management. The objective has been to offer the public and decision-makers such information that would provide a basis for the formation of opinions and for decision-making.

Co-operation between Posiva and the municipality of Eurajoki continued.

During the year under review, 65 groups visited Olkiluoto to become acquainted with nuclear waste management and Posiva's investigations. More than half the visitors were foreigners.

Close co-operation with other Nordic organisations involved in nuclear waste research continued both through direct contacts and within the framework of various joint groups.

The progress made in international research projects related to nuclear waste management was monitored by participating in conferences and joint projects. Close co-operation in the Äspö Hard Rock Laboratory project continued.

The progress of research programmes in various countries was followed closely. Presentations have been given on Finland's nuclear waste management programme and research results in international conferences regarding nuclear waste. Participation in the OECD/NEA expert working groups involved, for example, discussion and assessment concerning site characterisation and safety studies.

A group of Brazilians visited Olkiluoto in May 2001.

LIST OF RESEARCH INSTITUTES, UNIVERSITIES AND CONSULTANTS ENGAGED IN NUCLEAR WASTE MANAGEMENT OPERATIONS IN 2001

AEA Technology (United Kingdom)
AECL (Canada)
Alan Auld Associates (United Kingdom)
ALARA Engineering AB (Sweden)
Astrock Oy
Australian National University (Australia)
Ayotte Consulting and Management Services (Canada)
Cando Contracting Ltd (Canada)
Clay Technology Lund HB (Sweden)
Computer-aided Fluid Engineering AB (Sweden)
Consulting Engineers Esko Hämäläinen
Consulting Engineers Paavo Ristola Ltd
Conterra AB (Sweden)
Contesta Oy
Diskurssi Oy
Duke Engineering & Services Inc. (Canada)
Electrowatt Ekono Oy
EnvirosQuantiSci (Spain, United Kingdom)
Evata Finland Oy
Finnish Forest Research Institute
Parkano Research Station
Finnish Geodetic Institute
Fintact Oy
Fortum Nuclear Services Oy
Fortum Power and Heat Oy
Fortum Energy Solutions
Fortum Engineering Oy
Gascoyne Geoprojects Inc. (Canada)
GEA Consulting (Sweden)
Geodevelopment AB (Sweden)
Geokema AB (Sweden)
Geological Survey of Finland (GTK)
Geoservice Centre/Marine Geology
Nuclear Waste Disposal Research
Regional Office for Mid-Finland
Regional Office for Southern Finland
Geopoint AB (Sweden)
Geopros Oy
Golder Associates Inc. (USA)
Gridpoint Finland Oy
G.R. Simmons & Associates Consulting Services Ltd (Canada)
Helsinki University of Technology
Laboratory of Materials Technology
Laboratory of Rock Engineering
Inspecta Testing Oy
Integrity Corrosion Consulting Ltd (Canada)
Kaisaniemen Dynamo Oy
Kivitieto Oy
Kungliga Tekniska Högskolan (Sweden)
Laine & Fire Safety Office Ltd
Lapela Oy
Libenter Oy
Monitor Scientific (USA)
Outokumpu Mining Oy
Outokumpu Poricopper Oy
PRG-Tec Oy
Research Center Vinco Ltd
Robertson Geologging Ltd (United Kingdom)
Rock Engineering Consultants (United Kingdom)
Rollcon Oy
Saanio & Riekkola Consulting Engineers
Safety Assessment Management SAM (United Kingdom)
Safety Technology Authority
Safram Oy
Serco Assurance (United Kingdom)
Sidney Whitaker (Canada)
Streamflow AB (Sweden)
Studsvik Eco & Safety AB (Sweden)
Suomen Malmi Oy
Svensk Kärnbränslehantering AB (SKB) (Sweden)
Swedish Corrosion Institute (Sweden)
SwedPower AB (Sweden)
Tauno Nissinen Consulting Engineers Ltd
Technical Research Centre of Finland (VTT)
Automation
Biotechnology and Food Research
Communities and Infrastructure
Chemical Technology
Energy
Manufacturing Technology
Terralogica AB (Sweden)
TVO Nuclear Services Oy
University of Helsinki
Department of Chemistry
Department of Pharmacy
University of Jyväskylä
Department of Physics
University of Waterloo (Canada)
VBB Viak (Sweden)
Vibrometric Oy
Viestintä-Paprico Oy

QUALITY MANAGEMENT AND ENVIRONMENTAL MANAGEMENT

Posiva's operations are aimed at the safe implementation of nuclear waste management in accordance with the needs of its owners and other clients, while protecting the environment and fulfilling the requirements set by society. Posiva has been upgrading the quality management of nuclear waste management ever since the Company was established. The purpose of the quality system is to verify the systematisation of Posiva's operations, and that the quality system complies with the principles of the international ISO 9001 standard.

In 2001, the key area in development work was the upgrading of the operating system in the direction of the ISO 9001:2000 standard, also taking the requirements of the environmental standard into account. Furthermore, studies were concerned with the significance of and opportunities for a safety culture in Posiva's operations.

During the year under review, the efficiency and reliability of the system in relation to the set targets were assessed by Posiva's internal audits, in which the entire personnel were involved. One of the bases used for the assessment also included the European criteria for the quality award (EFQM).

The capability of several subsuppliers to fulfil the technical, economic, quality and environmental requirements was assessed during 2001. The operating systems that are being applied and their development potential were surveyed. In addition, the functioning of some organisations was assessed by means of an inspection visit.

Instructions with a view to assuring the quality of research, development and design work were specified. The planning of an instruction manual for construction of the ONKALO facility began. The requirements established by the IAEA concerning nuclear safety were reviewed, and their effect on Posiva's operations was evaluated.

To enhance expertise, the know-how and training needs of the personnel were studied with respect to both the task units within final disposal and Posiva's operating system. Besides professional training, the personnel were given common training in operating systems and languages. Induction training was given to new Posiva employees. Annual development discussions were held.

To upgrade the safety culture, the requirements set by the nature of the operations on the safety of the operations, and the opportunities to meet these requirements at Posiva were studied. Procedures relevant to a good safety culture will be reinforced in the future on the basis of these studies.

COSTS

RESEARCH

The total cost of the nuclear waste management research programme was some EUR 10.5 million. Cost estimates for the research programme in 2001 were about EUR 8.7 million. The research programme was mostly implemented as planned. Compared with the plans, the most significant difference was the drilling of two deep investigation boreholes at Olkiluoto.

The above-mentioned costs do not include Posiva’s research assignments sponsored by Tekes, the National Technology Agency of Finland.

SUMMARY OF THE RESEARCH COSTS IN 2001

Research area	Costs (EUR million)
Planning, co-ordination, information activities and general studies	0.7
Management of spent fuel and high-level waste	9.3
Management of intermediate-level and low-level waste	0.3
Decommissioning and decommissioning waste	0.2
Total	10.5

FINANCIAL PROVISION FOR NUCLEAR WASTE MANAGEMENT

Funds for the future costs of nuclear waste management are collected by the State Nuclear Waste Management Fund. The fund target is determined according to the liability of nuclear waste management to be confirmed each year. The liability comprises the future costs of the management of all wastes accumulated by the end of the year in question. The difference between the liability and the fund target is covered by securities.

EUR 656.2 million was assessed as the fund target for TVO in 2001, the corresponding amount for Fortum being EUR 485.6 million.

A liability amount of EUR 693.2 million was confirmed for TVO's nuclear waste management at the end of 2001 and, based on this amount, a fund target of EUR 693.2 million was confirmed for 2002. For Fortum, a liability amount of EUR 515.2 million was confirmed and, accordingly, a fund target of EUR 515.2 million for 2002. This means that the fund targets rose for the first time to the level of the liability amounts.

LIST OF REPORTS 2001

POSIVA 2001-01
Geochemical modelling of groundwater evolution and residence time at the Hästholmen site
Petteri Pitkänen, Ari Luukkonen
VTT Communities and Infrastructure
Paula Ruotsalainen
Fintact Oy
Hilkka Leino-Forsman, Ulla Vuorinen
VTT Chemical Technology
January 2001
ISBN 951-652-102-9

POSIVA 2001-02
Modelling gas migration in compacted bentonite: GAMBIT Club Phase 2 Final report - A report produced for the members of the GAMBIT Club
B.T. Swift, A.R. Hoch, W.R. Rodwell
AEA Technology, United Kingdom
January 2001
ISBN 951-652-103-7

POSIVA 2001-03
Modelling of the UO_2 dissolution mechanisms in synthetic groundwater solutions – Dissolution experiments carried out under oxic conditions
Esther Cera, Mireia Grivé, Jordi Bruno
EnvirosQuantiSci, Spain
Kaija Ollila
VTT Chemical Technology
February 2001
ISBN 951-652-104-5

POSIVA 2001-04
Experimental study of Ni solubility in sulphidic groundwater and cement water under anoxic conditions
Torbjörn Carlsson, Ulla Vuorinen, Tommi Kekki, Hannu Aalto
VTT Chemical Technology
June 2001
ISBN 951-652-105-3

POSIVA 2001-05
Permafrost: occurrence and physicochemical processes
Lasse Ahonen
Geological Survey of Finland
October 2001
ISBN 951-652-106-1

POSIVA 2001-06
Hydrochemical stability of groundwaters surrounding a spent nuclear fuel repository in a 100,000 year perspective
Ignasi Puigdomenech (Editor), KTH, Stockholm, Sweden
Ioana Gurban, DE&S, Ottawa, Canada
Marcus Laaksoharju, Geopoint AB, Stockholm, Sweden
Ari Luukkonen, VTT Communities and Infrastructure
Jari Löfman, VTT Energy
Petteri Pitkänen, VTT Communities and Infrastructure
Ingvar Rhén, VBB Viak, Göteborg, Sweden
Paula Ruotsalainen, TUKES: Safety Technology Authority, Helsinki
John Smellie, Conterra AB, Uppsala, Sweden
Margit Snellman, Posiva Oy
Urban Svensson, Computer-aided Fluid Engineering AB, Norrköping, Sweden
Eva-Lena Tullborg, Terralogica AB, Gråbo, Sweden
Bill Wallin, Geokema AB, Lidingö, Sweden
Ulla Vuorinen, VTT Chemical Technology
Peter Wikberg, SKB, Stockholm, Sweden
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