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FINNISH REPORT ON NUCLEAR SAFETY

Finnish 2nd national report as referred to in Article 5 of the Convention on Nuclear Safety

STUK • SÄTEILYTURVAKESKUS • STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

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EXECUTIVE SUMMARY

Finland signed on 20 September 1994 the Convention on Nuclear Safety which was adopted on 17 June 1994 in the Vienna Diplomatic Conference. The Convention was ratified on 5 January 1996, and it came into force in Finland on 24 October 1996.

In the first report, the implementation of each of the Articles 4 and 6 to 19 of the Convention was separately evaluated. Based on the evaluation it was concluded that

- the Finnish nuclear and radiation regulations fulfil the obligations of the Convention
- the Finnish regulatory infrastructure is in compliance with the Convention obligations
- the regulatory and licensee practices comply with the Convention obligations.

It was concluded in the first report that Finland had implemented the obligations of the Convention. Also the objectives of the Convention were complied with.

The principle in Finland has been a continuous fulfilment of the criteria presented in the Articles of the Convention and further enhancement of nuclear safety and regulatory activities. Issues that required measures to further enhance nuclear safety in Finland were discussed in the first report. In addition, some new issues requiring measures were identified during the First Review Meeting.

A full scope IRRT mission was conducted by IAEA in Finland in March 2000. It resulted in recommendations that will improve regulatory activities when implemented according to a prepared action plan.

The second report focuses especially on the changes related to the regulatory control infrastructure under the scope of the Convention Articles. The report includes also issues identified in the First Review Meeting and during the IRRT mission and subsequent measures and development activities. Based on the evaluation done during the preparation of the second report, it can be concluded that Finnish regulations and practices continue to be in compliance with the obligations of the Convention.

Finnish 1st and 2nd national reports to the Convention as well as Finnish legislation and other regulations are available on STUK's Internet site at http://www.stuk.fi.

CONTENTS

1 INTRODUCTION

The fulfilment of the obligations of the Convention was evaluated in the first report. It was concluded that Finland had implemented the obligations of the Convention. The objectives of the Convention are also complied with.

The second report focuses on the changes related to the regulatory control infrastructure and nuclear safety under the scope of the Convention Articles. The report also includes matters that were identified during the first evaluation and review meeting to require further measures to enhance safety in Finland and also the results of international missions and self-assessments conducted after the First Review Meeting. These issues and their consequent measures in Finland are discussed in this report under each Article.

In Finland, there are two nuclear power plants: the Loviisa and Olkiluoto plants. The Loviisa plant has two VVER units, operated by Fortum Power and Heat Oy (former Imatran Voima Oy), and the Olkiluoto plant two BWR units, operated by Teollisuuden Voima Oy (TVO). The Loviisa units were connected to the electrical grid in 1977 (unit 1) and 1980 (unit 2) and the Olkiluoto units 1 and 2 in 1978 and 1980, respectively. The nominal thermal power of both Loviisa units is 1500 MW. The Operating Licenses of the Loviisa units are valid until the end of 2007. The nominal thermal power of both Olkiluoto units is 2500 MW. The Operating Licenses of the Olkiluoto units are valid until the end of 2018. According to the conditions of the Olkiluoto license, the licensee shall carry out an intermediate safety assessment by the end of 2008. This assessment will be reviewed by STUK. At both sites there are fresh and spent fuel storage facilities, and facilities for the storage and final disposal of low and medium level radioactive wastes.

Teollisuuden Voima Oy applied at the end of 2000 for a Decision in Principle for a fifth reactor unit in Finland. The licensing process is going on. In preparation for the Decision in Principle by the Council of State in this matter, statements were collected from all stakeholder groups by the end of March 2001. The Decision in Principle by the Council of State needs to be confirmed by simple majority of the Parliament according to the Finnish licensing process.

In the Vienna Diplomatic Conference in 1994 Finland informed that it observes the principles of the Convention, when applicable, also in uses of nuclear energy other than nuclear power plants, e.g. research reactors and facilities for nuclear wastes. In Finland, such facilities are the TRIGA Mark II research reactor (250 kW) in Espoo and the final disposal facilities for low and medium level radioactive waste at the Olkiluoto and Loviisa plant sites. The TRIGA Mark II reactor was taken into operation in 1962 and the disposal facilities at Olkiluoto in 1992 and at Loviisa in 1998. The Operating License of the TRIGA reactor was renewed in 1999 and it is valid until the end of 2011. The new license was issued after a comprehensive safety review.

Spent fuel from the Olkiluoto plant has been stored in the intermediate storage facility at the plant site. Earlier, at the Loviisa plant, spent fuel was stored in the storage of the plant for some years, after which it was transported to Russia. Due to the changes made in the Nuclear Energy Act in 1994, the spent fuel generated in Finland has nowadays to be treated, stored and disposed of in Finland. Accordingly, spent fuel shipments to Russia were terminated at the end of 1996 and Fortum Power and Heat Oy constructed additional spent fuel storage capacity at the Loviisa site.

The research into development and planning of spent fuel disposal as well as its later implementation is carried out by Posiva Oy, a company owned by the Finnish nuclear power plant utilities. In this final disposal programme, the first licensing step has recently been completed. Posiva's application for the Decision in Principle was approved, after STUK's safety review, by the proposed host municipality in January 2000, by the Council of State in December 2000 and by the Parliament in May 2001. The next step will be the construction of an underground research facility at the Olkiluoto site and further research and development work prior to the submittal of a construction license application.

In Chapter 2 of this report, the changes made and ongoing or planned development activities under the areas of Articles 6 to 19 of the Convention are reported. If there are no relevant changes made after the First Review Meeting or ongoing or planned development under the scope of the Article, reference to the first report is given.

In the First Review Meeting, the following recommendations on the second Finnish national report were given:

- information on methods used at Finnish nuclear power plants, regulatory body and other related organisations to enhance safety culture (see Annex IV),
- continued reporting on how the regulatory body and operators benefit from the exchange of experience with other countries operating similar plants (see Article 19 and Annexes II and III),
- evaluation of the possible prescriptive features of the regulatory system and assessment of their impact on the development on safety (see Article 7 and Annex I),
- presentation on plant modernisation programmes (see Annexes II and III).

These issues are discussed in this report as indicated in the brackets above.

Taking into account the discussions and observations in the First Review Meeting, a list of items requiring further actions in Finland was prepared (see Chapter 4). These items are also discussed in this report.

An IRRT team of the International Atomic Energy Agency (IAEA) evaluated in spring 2000 STUK's effectiveness as an authority in ensuring nuclear and radiation safety. The results of the mission are presented in the IRRT report, which is available on STUK's Internet site. In the report, STUK's expertise was fully recognised. In addition, developed legislation, STUK's comprehensive quality assurance programme, nuclear and radiation safety research and emergency preparedness were reported as good practices. Some valuable recommendations and suggestions for the further enhancement of regulatory activities related to nuclear safety were also given. For example, attention was paid to the adequacy of internal procedures for enforcement activities and possible prescriptive features of the Finnish safety regulations. However, none of the issues were found to be serious enough for immediate corrective measures in Finland. A special action plan was prepared to take care of the identified deficiencies.

2 COMPLIANCE WITH ARTICLES 4 AND 6 TO 19

2.1 Article-by-article review

Article 4. Implementing measures

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

The legislative, regulatory and other measures to fulfil the obligations of the Convention were discussed in detail in the first report. It was concluded that the Finnish regulatory framework fulfils the obligations of the Convention, and also the objectives of the Convention are complied with. The approach in Finland is a continuous fulfilment of the criteria presented in the Articles of the Convention. This approach of a continuous improvement of safety is also manifested in the Finnish nuclear legislation.

During the First Review Meeting some issues were identified to require measures to further enhance safety in Finland. Also international missions and self-assessments conducted after the First Review Meeting have resulted in recommendations that will improve safety in Finland when implemented according to specific action plans. These issues and the subsequent measures in Finland are discussed in this report under Articles 6 to19.

Article 6. Existing nuclear installations

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shutdown may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

The safety of both Finnish nuclear power plants was extensively reviewed during 1997 and 1998, when operating licenses were renewed as described in the first report. The next comprehensive safety evaluations will be done in 2006–2009. Meanwhile, the enhancement of safety of the Finnish nuclear power plants is based on the results of continuous safety assessments. This comprises the results of deterministic and probabilistic safety assessments, safety research, periodic inspection programmes, analyses of operating experience and topical inspections. The continuous safety assessment and enhancement approach is based on the Finnish nuclear legislation (Council of State Decision (395/1991), Section 27) where it is stated that *operating experience from nuclear power plants as well as results of safety research shall be systematically followed and assessed. For further safety enhancement, actions shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.* The implementation of safety improvements has been a continuing process at both Finnish nuclear power plants since their commissioning and there exists no urgent need to upgrade the safety of these plants in the context of the Convention. Recently implemented and ongoing safety upgrading measures, mostly related to the mitigation of severe accidents at the nuclear power plants, are described in more detail in Annexes II and III.

In addition to the continuous regulatory safety assessment, there have been independent safety reviews conducted by WANO at both Finnish nuclear power plants after the First Review Meeting (Olkiluoto nuclear power plant at the end of 1999 and Loviisa nuclear power plant at the beginning of 2001).

The safety of the Finnish research reactor (TRIGA Mark II 250 kW pool reactor) was reviewed before its operating license was renewed in 1999. The new license is valid until the end of 2011. Until that time, the safety of the TRIGA reactor is continuously reviewed according to STUK's periodic inspection programme.

Article 7. Legislative and regulatory framework

Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.

The legislative and regulatory framework shall provide for:

- ***the establishment of applicable national safety requirements and regulations;***
- ***a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;***
- ***a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;***
- ***the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.***

The legislative and regulatory framework in Finland was described in detail in the first report. There have been no major changes. However, the following minor changes are reported in the context of Convention Article 7.

Legislative and regulatory framework

The nuclear energy legislation has been amended to take into account the changes made in the national pressure equipment legislation (1999). Earlier the legislation for pressure equipment in conventional facilities was used as the basis, as far it was applicable, for the regulatory control of pressure equipment in nuclear facilities. However, after implementing the European Council Directive 97/23/EC of 29 May 1997, on the approximation of the laws of the Member States concerning pressure equipment, there was a need to provide a basis for the control of pressure equipment of nuclear facilities directly in the nuclear legislation. This was due to the fact, that the above Directive explicitly excludes nuclear related pressure equipment from its scope. These amendments to nuclear energy legislation (the Nuclear Energy Act and the Nuclear Energy Decree) did not have any essential effect on the scope or procedures of the regulatory control of nuclear safety related pressure equipment.

The Nuclear Energy Act has been amended (2000) to implement the new additional protocols of the IAEA Safeguards Agreements under the International Treaty on the Non-Proliferation of Nuclear Weapons (NPT) for expanding the safeguards control. This amendment will be set into force after all procedural requirements concerning notifications by EURATOM have been met.

The radiation protection legislation (the Radiation Act and the Radiation Decree) has been amended (1999) to implement the European Council Directives 96/29 EURATOM of 13 May 1996, laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation, and 97/43/Euratom of 30 June 1997, on the protection of the health of individuals against the dangers of ionising radiation in relation to medical exposure.

The Council of State has issued a new decision for the general regulations on the safety of the disposal of spent fuel (1999). Finland has accepted the International Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

The Act on Rescue Services and the subsequent Decree have been totally revised in 1999. The earlier rescue service legislation was combined with the civil defence legislation. The roles and duties of authorities in the area of emergency preparedness of nuclear facilities were not changed.

In the area of administrative legislation the new Publicity Act was issued in 1999. The new act supports the principles of transparency and openness in regulatory actions and, furthermore, realises the constitutional right of citizens to participate in decision making on environmental matters. In practice, the new law provides the citizens with a better access to regulatory documents in the preparation phase, and also requires, that the authorities actively inform the citizens on matters under preparation.

The regulatory guides prepared and issued by STUK are being continuously re-evaluated for updating. The general rule stemming from the Quality System of STUK requires that a guide shall first be re-evaluated after five years from its issuance. This re-evaluation does not always lead to a revision of the guide. However, 10 years of age is considered a limit that automatically launches the revision of a guide. Since 1999 safety-related requirements have not experienced major changes in the sense of technical content, but e.g. the document system internal consistency in sense of terminology and structure has been approved. In addition, the procedures of applying new guides to existing nuclear facilities have been focused.

As one specific development effort, a limited self-assessment was carried out to evaluate the consistency of requirements that apply to the submitting of documents to STUK. The requirements within operational safety area were reviewed identifying documents to be sent to STUK for approval or for information only. The study concluded that the existing requirements are still valid and well in balance with the needs of an effective regulatory control system. A further assessment covering documents in all technical and administrative areas will be carried out in connection with a development project for Information Management. In this project opportunities provided through modern Intranet and especially Extranet applications are being studied for use in correspondence and document submittance between STUK and the licensees. An Extranet application provides several possibilities to limit the amount of paper documentation submitted to authorities. Also the continuous updating of plant documentation (e.g. FSAR) could easily be taken care of. Discussions with the Finnish licensees on the matter continue.

Activities to further develop and enhance the internal consistency of the regulatory guide system as well as to ensure the catch-all coverage of the regulations are discussed in detail in Annex I.

Licensing procedure

The licensing procedure of nuclear facilities in Finland is described in the nuclear legislation and has not been changed after the First Review Meeting. The so-called periodic safety reviews have been built into the relicensing procedure. In Finland the legislation allows only fixed term licenses, and in general a license has been issued for 10 years at a time. If the license is granted for a longer period, an equivalent safety review will be required as a separate license condition.

Regulatory inspections

STUK's periodic inspection programme for nuclear power plants was renewed during 1998 and inspections in 1999 were conducted according to the new programme consisting of altogether 30 inspections. This programme replaced the former programme that had been in place for about 10 years. The new programme is focused more on licensee main working processes instead of specific technically oriented areas, and is considered to cover the most relevant areas of nuclear power plant safety. The new programme has three levels: safety management, main working processes and propriety of the activities in different organisational and technical areas. The objective of the inspection process is to assess the safety level at the plants as well as the safety management. Possible problems at the plants and in procedures of the operating organisations are to be recognised as soon as possible. Special emphasis has been put on the improved management of the entire inspection programme, including the timely conduct and accurate reporting of results. The results of the new programme have been good. Some development areas (conduct of unannounced inspections, more specific inspection procedures) were identified during the IRRT mission and by self-assessment. At the moment, STUK is developing Risk Informed Regulation practices. These include among others use of PSA for planning regulatory inspections to focus inspections on risk significant areas. It also includes assessment of inspection findings by PSA.

In addition to the periodic inspection programme, STUK conducts ad-hoc inspections if seen necessary. In the past, these have mainly related to operating event investigations (both domestic and international events), but also on the consequences of the development of science and technology. These inspections are usually conducted by an investigation team including 3-5 experts from STUK.

Enforcement

The enforcement tools and procedures of regulators have not been changed and are considered to fully meet the needs. The repertoire of these tools will be issued in an internal policy document as part of STUK's Quality System to serve for training.

Article 8. Regulatory body

Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.

Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilisation of nuclear energy.

The regulatory system in Finland was described in detail in the first report. The structure of the regulatory system in Finland has not been changed. However, some minor changes have taken place after the First Review Meeting and these are reported below.

In the area of regulatory control, the strategy of financing the work has been reconsidered. The earlier financing model to get the resources from the State budget, was changed to so called net-budgeting model. This means that the licensees pay the regulatory control fees directly to STUK. This approach to finance governmental regulatory activities became a common practice in Finland in the 1990's. The change was carefully analysed and discussed among the parties involved. The conclusion was that considering the long traditions and stability of the amount of regulatory control no concern of loosing the required objectivity was foreseen. Also it was clearly recognised that the amounts charged would continuously be under the control of the Ministry of Social Affairs and Health. The change in the financing procedure has not changed the actual costs of regulatory control activities.

The organisation of the Department of Nuclear Reactor Regulation of STUK has undergone some changes: a new office, that of Human and Organisational Factors (3 persons), has been established to develop appropriate functional methods to oversee the licensees' organisation and personnel activities. The office also co-ordinates research activities on the effects of organisational and human factors as well as event investigation, and develops methods to assess safety culture. The office also gives recommendations to improve regulatory control methods based on research results. The other change was made to clarify and highlight STUK's role in the co-ordination of national and international co-operation in nuclear safety research: a new organisational unit, "Research Management" (2 persons), was established within the Department of Nuclear Reactor Regulation.

The independence of STUK's technical support has been evaluated in 2000. The evaluation included quality audits to the five research units of the Technical Research Centre of Finland, VTT, the main technical support organisation of STUK. The audits were performed by Qualitas Fennica Ltd. The audits concentrated on activities and work processes that are essential to nuclear safety and safety related research. Independence problems were not discovered in these audits. On the other hand, one essential element in this respect is STUK's in-house expertise providing independence when drawing conclusions from research results. However, based on the audit results, the quality systems of these research units have been further improved taking into account STUK's point of view concerning the required independence from utility driven research projects. Two follow-up audits will be conducted in October

2001. A similar quality audit will be carried out at the Geological Survey of Finland, GTK, at the end of 2001. This means that all main support organisations of STUK have then been evaluated.

Article 9. Responsibility of the licence holder

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

The responsibility for the safety rests with the licensee as manifested in the Nuclear Energy Act. STUK verifies that the licensee meets its responsibility as described in the first review report. These principles have not changed after the First Review Meeting.

The existence and further maturing of this responsibility originate from the safety culture of the licensee organisation. The regulatory activities to support the safety culture among the Finnish nuclear community are discussed in Annex IV.

The financial provisions to cover the possible harms of a nuclear accident have been arranged according to the Paris and Brussels Conventions. Finland has supported the international efforts to revise the Paris and Brussels Conventions for Nuclear Third Party Liability in order to raise the funds made available by the Contract Parties in case of accidents.

Article 10. Priority to safety

Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

Safety is emphasised in the general principles of the Nuclear Energy Act and an advanced safety culture is required to be maintained when designing, constructing and operating nuclear power plants. These principles and priorities have not changed after the First Review Meeting. However, special emphasis has been put on the following areas after the First Review Meeting.

Attention has been paid to safety culture in the operation and maintenance of Finnish nuclear power plants. STUK has taken an active role in this area and both developed its own culture and taken the initiative in the assessment and development of the culture of the utility organisations. This work is described in more detail in Annex IV. At the Loviisa and Olkiluoto nuclear power plants, actions have been taken to emphasise a high level of safety culture, and to further develop it. The licensees have established written quality and safety policies.

Both utilities have organisational units for safety. They are independent of those units, which are directly responsible for the operation of the plants. In addition to the safety units, both utilities have independent safety committees with external expert members.

Attention has also been paid to the impact of the deregulation of energy markets to the priority to safety. In spite of the limited expected impact of market deregulation, there is a development project within STUK aiming to make sure that the periodic inspection programme continues to provide relevant information also in the deregulated market. The project reviews the effects, which market deregulation has had so far in Finland and also in other countries, and how these effects should or could have been manifested by the inspection programme. If some areas are identified where a significant reduction in the utilities' capability to sustain a high safety level could occur, modifications in the inspection programme will be made accordingly. In addition, STUK has some indicators in its indicator system to detect the possible impact of market deregulation on plant safety. One is the rate of annual investment (Figures 1 and 2). The costs of large modernisation programmes at both nuclear power plants during 1996–2000 can be seen in these figures. These figures are only used to trend changes over time. Other indicators are related to trending of the quality of maintenance activities.

STUK has updated its own Quality Policy in 1999. The Quality Policy includes also STUK's values that are engaged to every day work giving the highest priority to the prevention and mitigation of the harmful effects of radiation.

Article 11. Financial and human resources

Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.
Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

Adequate financial and human recourses are a condition for the granting of a construction and operating license according to the Nuclear Energy Act. This shall be complied with throughout the operation of the facility. These principles have not changed after the First Review Meeting. However, effects of the deregulation of the energy markets need to be carefully followed in Finland to ensure that adequate financial recourses are available to support safety. STUK has a development project for this issue as described under Article 10.

In spring 2000, the Ministry of Trade and Industry set up a working group to analyse the contents and scope of the know-how required to continue the safe operation of nuclear power plants. The task of the group was to identify the measures needed during a period of five to ten years to maintain the high level of expertise despite changes in the operating environment

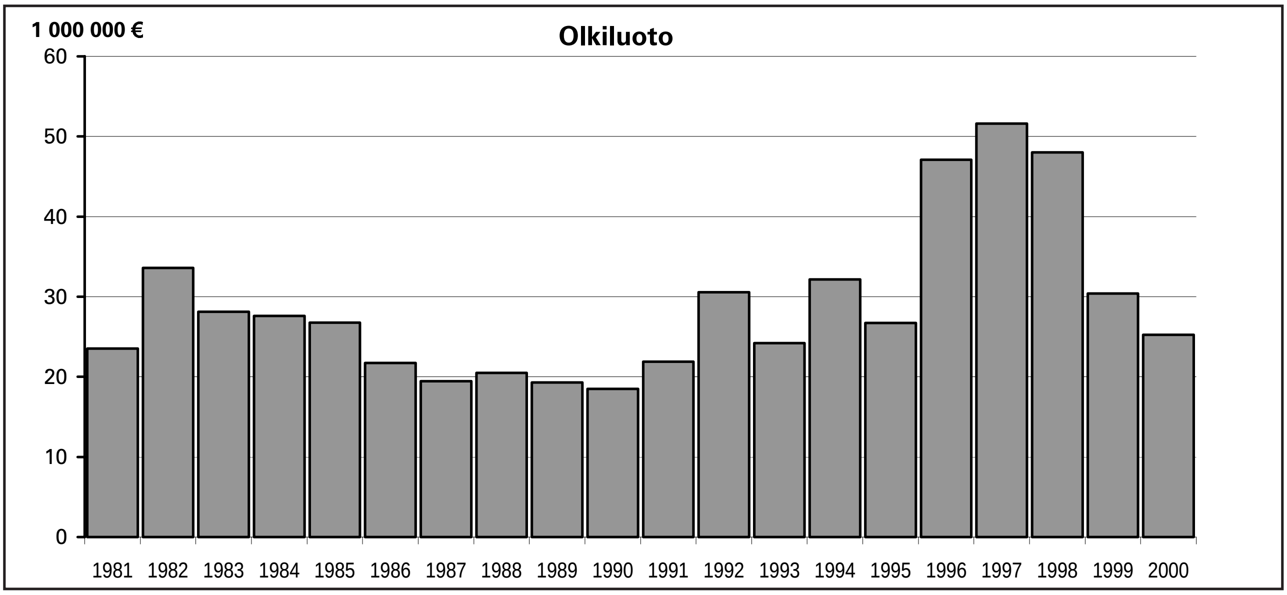

Figure 1. *The annual rate of investments at Olkiluoto.*

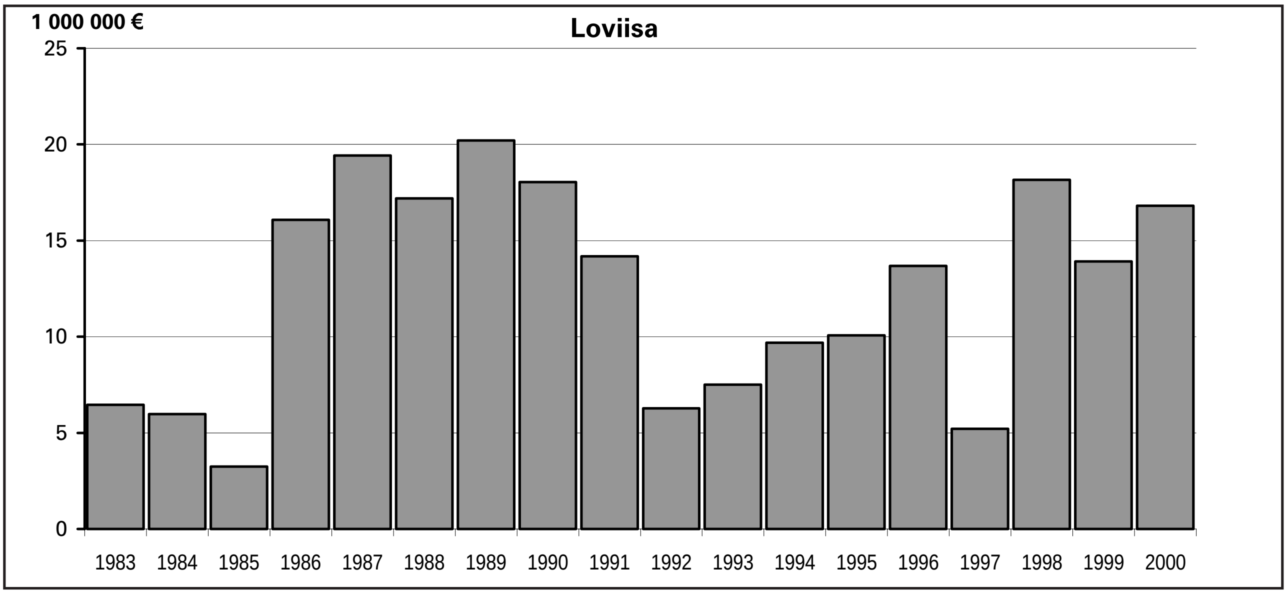

Figure 2. *The annual rate of investments at Loviisa.*

such as deregulation of the energy market and the growing turnover of personnel due to the retirement of many experts. The group also assessed which of the services required could be provided through international co-operation. Another task of the group was to estimate the need to train new experts and to propose measures ensuring that a sufficient number of highly skilled experts would be trained. The study indicates that in general the availability of the services needed and the level of expertise are sufficient today. However, the resource basis is very narrow in some fields of competence, and in some cases special measures are called for in the next 5 to 10 years. The most critical fields will be reactor physics and dynamics, fires, human and organisational factors and programmable automation. Also areas such as severe accidents and ageing require special attention and financial resources in the future. However, the uncertainties related to the continuation of the public funding of nuclear safety research could have some effect on the attractiveness of the research field to young experts. The age distribution of personnel working in organisations in the nuclear energy sector indicates that the need for new experts will increase two- or even three-fold within the next five to ten years due to retirement. The current training capacity of universities is adequate to meet this need.

STUK has paid special attention to the strategy for personnel development and to ensuring sufficient amount of experts in the utility organisations. Both utilities have a systematic approach to training. However, changes in energy markets and the fast development of technology will bring new challenges to the knowledge, and this requires special emphasis of all parties.

Article 12. Human factors

Each Contracting party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

Section 19 of the Decision of the Council of State (395/1991) requires special attention to be paid to the avoidance, detection and correction of human errors. This applies to the design, construction and operation of the facility. These requirements have not changed after the First Review Meeting. Recently STUK has paid special attention to the assessment of human and organisational factors in abnormal events and transients and working processes in the nuclear power plants. A separate organisational unit has been established and expertise in behavioural science has been recruited as described under Article 8.

Article 13. Quality assurance

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

Based on the Nuclear Energy Decree, a quality assurance programme for the design, construction and operation of the nuclear facility needs to be submitted to STUK when applying for a construction and operating license. According to Section 5 of the Decision of the Council of State (395/1991), a quality assurance programme shall be employed in all activities that affect safety, from design to operation. Quality assurance programmes have to be established also by all other organisations taking part in safety important activities of the use of nuclear energy. These basic requirements have not changed after the First Review Meeting. At the moment, STUK's YVL Guides that set more detailed requirements for quality assurance programmes are being updated. The new guides will closely follow IAEA guidelines. In addition, both licensees are in the process of developing their quality systems. More information on the work carried out by the licensees can be found in Annexes II and III. As described under Article 8, STUK has also paid attention to the quality systems of its support organisations.

STUK's Quality Manual has been prepared and implemented since the First Review Meeting. It includes STUK's quality policy, description of the quality system, organisation and management, main and supporting working processes and personnel policy. Numerous internal audits, self-assessments and international evaluations have revealed development areas that are now being tackled by STUK. In addition to STUK's Quality Manual, all organisational units of STUK have their own more detailed Quality Manuals. The Quality Manual prepared for the regulatory control of the use of nuclear energy has been benchmarked with other regulators under the auspices of OECD/NEA working groups and bilateral agreements.

Article 14. Assessment and verification of safety

Each Contracting Party shall take the appropriate steps to ensure that:

- ***comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;***
- ***verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.***

Safety assessment

Comprehensive and systematic safety assessment is an essential part of the licensing process and license renewal. As a condition for a license, both deterministic and probabilistic safety assessments (PSA) need to be carried out and submitted to STUK for approval. Both assessments are kept up to date throughout the operation of the nuclear facility, reflecting the advancement of science and technology. Any changes to these documents are submitted to STUK for approval. These requirements have not changed after the First Review Meeting.

Since the First Review Meeting, the PSAs have been updated, and their scope has been extended at both nuclear power plants. Plant-specific living PSAs, including internal initiators, fires, flooding, harsh weather conditions, seismic events for operation mode, and internal events for low power mode, have been completed for the plants. These PSA studies are used in support of decision making by the regulatory body and of safety management at the utilities. The risk-informed regulatory scope at STUK is progressing towards Risk Informed In-service Inspection/In-Service Testing, and Risk Informed Technical Specifications activities. A related study has recently been completed by STUK.

Special attention has been paid to seismic events in Finland, although Finland is not in a seismically active area. Training on seismic events (earthquakes, their origin, measurements) in Finland was organised at STUK to increase awareness and consideration of seismic risks at nuclear facilities. The training included the presentation of seismic PSAs for Finnish nuclear power plants and the presentation of a report on seismic hazards in the southern territory of Finland. According to the PSA results, seismic events do not cause major risks in Finland. However, some modifications have been made at Olkiluoto nuclear power plant, where for example the support structures of batteries and switchgear cubicles have been improved. There has been no need to implement any specific measures regarding seismic events at Loviisa nuclear power plant. STUK is also reassessing the regulatory requirements related to seismic events given in Guide YVL 2.6, Provision against earthquakes affecting nuclear facilities, that is currently under revision.

The year 2000 problem at Finnish nuclear power plants and at regulatory body was carefully evaluated before the millennium. Both utilities and STUK created programmes to cope with the problem. These included e.g. updating of some computer programmes both at nuclear power plants and at STUK. Utility programmes were closely followed by STUK. During the millennium, no problems were identified at Finnish power nuclear plants.

Design and documentation of plant modifications

Special attention has been paid to plant modification processes and documentation at Finnish nuclear power plants. Requirements concerning modifications designed by the utility and their independent assessment have been reassessed and included into appropriate YVL Guides that are now being updated. The new requirements mean in practice that all safety significant plant modifications have to be assessed by a unit which is independent of the design and implementation of the modification. The results of these assessments have to be included in the documentation submitted to the regulator.

STUK has also paid attention to the documentation of plant modifications and has established an own plant modification database, including the whole operating history of the Finnish plants. Based on this database, STUK produces reports on ongoing plant modifications biannually. These reports include all safety significant plant modifications and other important modifications. The purpose of this report is to inform STUK's personnel of the cause of each modification, technical implementation, implementation stage, assessment of safety significance and documentation submitted to the regulatory body and possible remarks related to the modification project.

Verification of safety

Several requirements concerning the verification of the physical state of a nuclear power plant are given in the Decision of the Council of State (395/1991). More detailed requirements are given in YVL Guides. These basic requirements have not changed after the First Review Meeting.

As written in the first report, the qualification of non-destructive testing (NDT) systems and procedures requires a high priority in Finland. The implementation of qualified NDT systems has been started in Finland. STUK has decided that the consensus document "Common position of European Regulators on qualification of NDT-systems for pre- and in-service inspection of lightwater reactor components, EUR 16802 EN" is to be followed in Finland. ENIQ documents (European Network for Inspection Qualification) can also be followed. The application of the documents is still under discussion. A national strategy document for NDT qualification has been written. The most important issue is that the qualification body shall be competent and independent. Ad hoc type qualification bodies have been established by the Steering Committee of NDT Qualifications. However, this has not been an easy task due to the shortage of independent and competent personnel in Finland. The work carried out by the Finnish utilities is described in more detail in Annex III.

Article 15. Radiation protection

Each contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

Basic requirements for the safe use of nuclear energy are given in the Nuclear Energy Act. The ALARA principle is included in the Radiation Act. These basic requirements have not changed after the First Review Meeting. As a consequence of the implementation of the new European Basic Safety Standard Directive, medical surveillance of the employees of the nuclear power plants has been performed since 1999 according to a practice based on the new Directive. Otherwise the implementation of the Basic Safety Standard Directive concerned mainly radiation safety regulations in Finland, and caused no major changes to YVL Guides.

Environmental radiation safety

Fuel rods at the Olkiluoto and Loviisa nuclear power plants have had low failure rates (from 0 to 2 leakages during one annual operational period of the reactors between 1998–2001). The plant operators have also paid special attention to water chemistry conditions and the proper selection of materials, when changing primary circuit equipment and components. The activity levels in the primary circuit water have been reasonably low.

Both nuclear power plants have implemented special measures to reduce the releases of radioactive matter into the environment. The Loviisa nuclear power plant has operated a system for efficient Cs removal from liquid waste tanks, where liquid waste is collected before release into the environment. Olkiluoto nuclear power plant has implemented new purification measures and storage tanks which aim to increase water recirculation in the plant processes, thus reducing the liquid waste effluents from the plant.

Sections 7 to 12 of the Decision of the Council of State (395/1991) include regulations for limiting the radiation exposure of the general public and the releases of radioactive materials into the environment. Radioactive releases into the environment of the Finnish nuclear power plants have been well below authorised limits (for important nuclides and pathways, of the order of 0.01 to 1% of set values based on the requirements of Guides YVL 7.2, YVL 7.3 and YVL 7.6). The limit for the dose commitment of an individual of the population, arising from the normal operation of a nuclear power plant in any period of one year, is 0.1 mSv (395/1991, section 9). Calculated radiation exposures to the critical groups in the environment of the nuclear power plants are shown in Figure 3.

Environmental radiation monitoring in the vicinity of nuclear power plants has been comprehensive and has been implemented according to the requirements of Guide YVL 7.7. The experience from the surveillance will be taken into account when the nuclear power utilities propose a new monitoring programme for approval to be implemented 2003–2007.

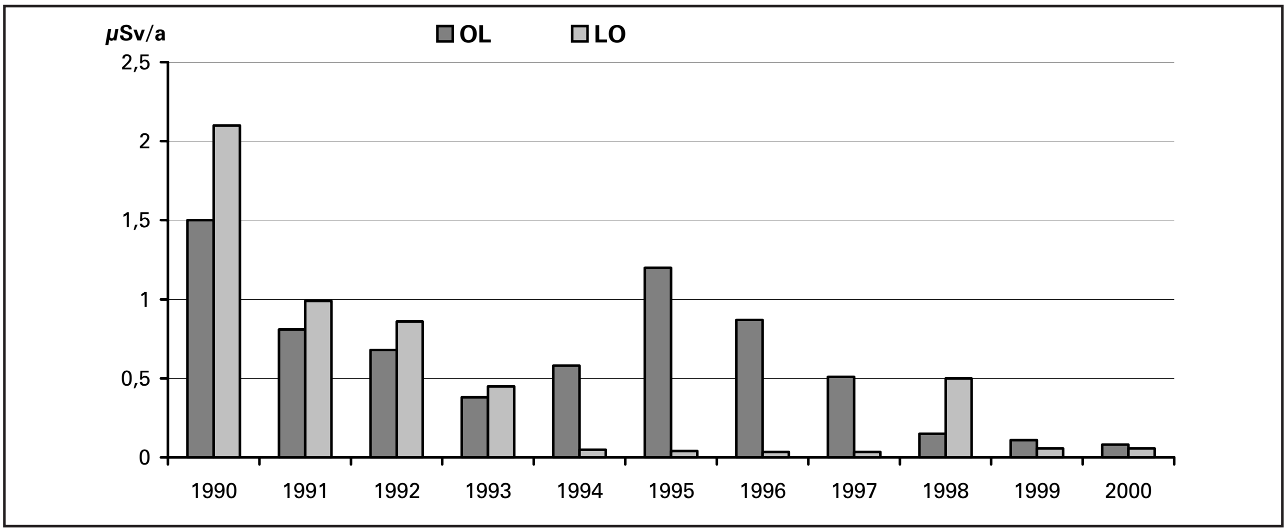

Figure 3. *Calculated annual radiation exposures to the members of critical groups in the environment of the Finnish nuclear power plants.*

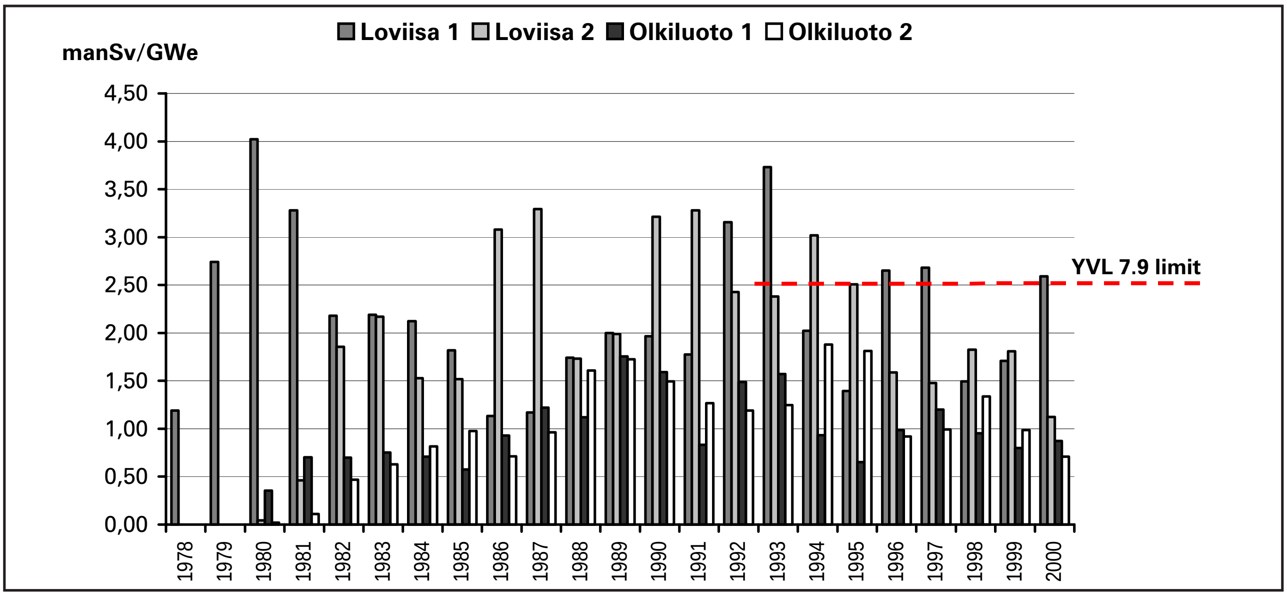

Figure 4. *Two year average of collective radiation doses at Finnish nuclear power plant units.*

Radiation protection of workers

According to Guide YVL 7.9, the collective radiation dose to the personnel should not exceed the value 2.5 manSv per 1 GW of net electrical capacity averaged over two successive years at one plant unit. If the value is exceeded, the cause of the excessive dose and the measures which may be required to improve radiation protection are to be reported to STUK. The two year average of collective radiation doses to Finnish nuclear power plant workers since 1978 is shown in Figure 4. Guide YVL 7.9 has been in force since 1993 and some limit exceeding have occurred as can be seen in the figure. According to Section 3 of the Radiation Decree (1512/1991), the effective dose caused by radiation work to a worker must not exceed 20 millisieverts (mSv) per year as an average over five years, or 50 mSv in any single year. Individual annual worker doses have been below 20 mSv (see Figure 5 for the years 1998–2000) and the maximum dose to a Finnish nuclear power plant worker in the five year period of 1996–2000 was 93.2 mSv.

As specified in the operating strategy of each plant, there has been an extensive annual maintenance outage every second year at each plant unit. These outages have resulted in doses somewhat higher than have shorter outages in between, as can be seen in Figure 4. For example in 1998, large modernisation and power uprating projects were finalised at both nuclear power plants.

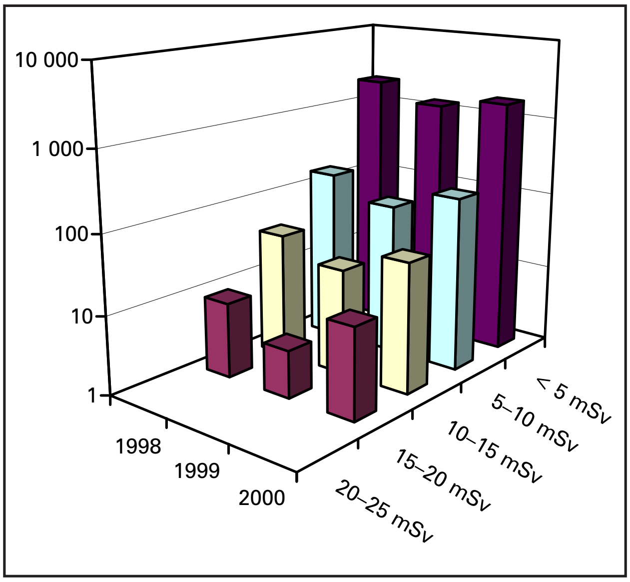

Figure 5. *Distribution of individual annual worker doses.*

Olkiluoto and Loviisa nuclear power plants have agreed on the implementation of plant-specific ALARA programmes.

In addition, Loviisa nuclear power plant has a project for the renewal of the installed radiation monitoring systems (area monitors, air monitors, process monitors and effluent monitors) at the plant during 2001–2002.

Article 16. Emergency preparedness

Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.

Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.

Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

The basic regulations for on-site emergency planning are given in the Nuclear Energy Act and in the Decision of the Council of State (397/1991). Off-site emergency plans required by the Rescue legislation (561/1999) are prepared by the local authorities. These basic requirements have not changed after the First Review Meeting. However, emergency response procedures at Olkiluoto and Loviisa nuclear power plants have been further developed based on the requirements of Guide YVL 7.4. These procedures have been regularly tested in annual emergency exercises that are part of the plants' emergency preparedness training. STUK has approved changes to the emergency plans of nuclear power plants, and carries out an inspection every year to assess the emergency preparedness regime, including emergency training and exercises.

In addition to the domestic nuclear emergency exercises held annually on each nuclear power plant site, STUK has taken part e.g. in international emergency exercises such as INEX 2/Canada in 1999 and INEX 2000/France in 2001. STUK has also participated as a co-player in emergency exercises arranged by the Swedish nuclear power plants and authorities. In September 2000, a national emergency and rescue exercise of the entire Government organisation was carried out in Finland. Part of the exercise scenario was based on a Loviisa nuclear power plant accident scenario and exercise.

As regards emergency preparedness, special attention has been paid by both Finnish nuclear power plants to the classification of emergencies (an emergency-stand-by situation), accident management and the development of the emergency instructions of on-site emergency centres and supporting expert groups, the use of real-time dosimeters by emergency workers on site, and implementation of automatic alerting of plant personnel during emergency situations. Also updated guidelines and information related to emergency situations have been distributed to the public living in the vicinity of the nuclear power plants.

STUK has developed and implemented a new information system (USVA) for the automatic radiation monitoring network in Finland in 1999. In addition, the development of a new transportation and dose calculation model (VALMA) for STUK is underway in Finland.

Article 17. Siting

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

- ***for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;***
- ***for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;***
- ***for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;***
- ***for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.***

Requirements for the siting of a nuclear power plant and for an environmental impact assessment are provided in the Nuclear Energy Decree. These requirements were presented in detail in the first review report and they have not changed after the First Review Meeting. In 2000, STUK issued a new Guide YVL 1.10, Safety criteria for siting a nuclear power plant. It describes generally all requirements concerning the site and surroundings of a nuclear power plant, gives requirements on safety factors affecting site selection as well as covers regulatory control during all licensing phases (Decision in Principle, Construction license, Operating license).

STUK issued to the Ministry of Trade and Industry statements on the environmental impact assessment (EIA) reports of the planned 'Loviisa 3 nuclear power plant project' and 'Olkiluoto nuclear power plant extension project' in 1999. STUK assessed the reports from a radiation and nuclear safety point of view. The following issues, among others, were assessed: how the applicants fulfil current radiation safety requirements, releases of radioactive matters during normal operation and during a severe accident situation. STUK also assessed the estimated environmental impacts of fuel procurement and nuclear waste management. Based on the Espoo-treaty (Convention on Environmental Impact Assessment in a Transboundary Context, Espoo 1991), Finland also received statements on the EIA from neighbouring countries (Estonia, Sweden and Russia; although Russia has not ratified the Espoo-treaty it was given a possibility to give its statement on the EIA).

In the statements, no factors emerged concerning environmental radiation safety that would prevent the construction of a new reactor on the existing sites of Olkiluoto or Loviisa nuclear power plants. Each site is very remote to population and there are no large industrial facilities or transport routes near the sites. The most significant environmental impacts of a possible new reactor would arise from cooling water discharges increasing the temperature of sea water in the vicinity of the nuclear power plant.

STUK has made a safety assessment in early 2001 of the fifth reactor unit, based on the application by Teollisuuden Voima Oy for a Decision in Principle. In this assessment a review of the proposed siting of the new reactor, alternatively to Olkiluoto or Loviisa, was done. Both sites were considered to be appropriate for a new reactor of the proposed size of 1000–1600 MW electric power. A statement in favour of the new nuclear power plant was given also by each candidate site municipality. In addition, based on the Treaty (on guidelines for communication in case of near border siting of nuclear facilities, 1977) between the Nordic Countries, also Sweden gave its favourable statement on the application for a Decision in Principle.

Article 18. Design and construction

Each Contracting Party shall take the appropriate steps to ensure that:

- ***the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defense in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;***
- ***the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;***
- ***the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.***

Defense in depth

According to the Decision of the Council of State (395/1991), several levels of protection have to be provided in the design of a nuclear power plant. The design of the nuclear facility and the technology used is assessed by STUK when reviewing the application for a Decision in Principle, Construction License and Operating License. Design is reassessed against the advancement of science and technology, when the Operating License is renewed. Requirements related to the defence in depth and its application were presented in detail in the first review report. These have not changed after the First Review Meeting. However, as it was written in the first report, severe accidents still need further attention in Finland. Improvements have been implemented to enhance the safety of the plants and to mitigate the consequences of severe accidents. Some of the work is going on and is described in more detail in Annexes II and III.

Proven technology

The requirement to use proven or otherwise qualified technology is stated in the Decision of the Council of State (395/1991). Detailed requirements are provided in several YVL Guides. Digital instrumentation and control technology has already been implemented in some modernised systems. The development of detailed safety requirements and procedures to ensure adequate reliability of such systems is still underway.

Reliable, stable and easily manageable operation

Requirements for control rooms, equipment and automation and the avoidance, detection and correction of human errors are provided in the Decision of the Council of State (395/1991). These requirements have not changed after the First Review Meeting. Both plants are planning to modernise their control rooms. At the Loviisa nuclear power plant this is included into a large automation modernisation project. At the Olkiluoto nuclear power plant changes in the control room are made gradually.

Article 19. Operation

Each Contracting Party shall take the appropriate steps to ensure that:

- ***the initial authorisation to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;***

- ***operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;***
- ***operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;***
- ***procedures are established for responding to anticipated operational occurrences and to accidents;***
- ***necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;***
- ***incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;***
- ***programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organisations and regulatory bodies;***
- ***the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.***

Requirements presented in the Finnish legislation related to operation were presented in detail in the first report. These requirements have not changed after the First Review Meeting. However, some further progress has been made in the following areas.

Anticipated operational occurrences and accidents

As part of its severe accident management project, Loviisa nuclear power plant is developing new symptom based emergency operating procedures. The new procedures will be taken into operation in 2005.

Engineering and technical support

Some concern was related to the adequacy of engineering and technical support available to Teollisuuden Voima Oy when its Operating License was renewed in 1998. This was due to the fact that, recently, Teollisuuden Voima Oy has quite independently designed and implemented some safety modifications at the plant, and the tendency is expected to continue. This issue was raised again in a preliminary safety assessment by STUK related to the Decision in Principle for the fifth reactor in Finland. It was stated that if the Decision in Principle is approved by the Parliament, Teollisuuden Voima Oy should in a very early phase start to develop its organisation and expertise to ensure the safety of the plant in case there is no comprehensive design service available in the market.

There has also been some concern about how to sustain the expertise of nuclear safety personnel in a deregulated environment. This concern has especially touched Fortum Engineering that has recently exposed to divestment. However, a new company, Fortum Nuclear Services Ltd, has been founded and nuclear safety engineering has been transferred to this company so that the possible divestment of Fortum Engineering will not reduce the nuclear safety expertise of the company.

Incident reports

STUK is updating reporting requirements to meet today's challenges taking into account for example energy market deregulation. However, no major changes are foreseen in the requirements.

Incident evaluation and international co-operation

Special attention was paid to incident evaluation methods and operating experience in Finland in 1999. A study was conducted by the Technical Research Centre of Finland, VTT, to evaluate operating experience feedback systems and incident evaluation methods in the Finnish nuclear industry. Several development areas were identified to enhance incident evaluation and to close the operating experience loop in order to avoid recurrence of events. Implementation of these measures is under way.

Both plants co-operate with WANO and countries having similar reactor types. This co-operation is more closely described in Annexes II and III. STUK has also participated in co-operation between international organisations such as the IAEA, the OECD/NEA and the EU, who exchange information on safety issues and operating events. Other forums that STUK uses to obtain information are WENRA, the VVER Forum and the NERS Forum as well as some bilateral agreements. A special exchange of information between Gosatomnadzor and STUK on the operation of the Kola and Leningrad nuclear power plants and of Finnish nuclear power plants has taken place quarterly.

Radioactive wastes

Interim storage facilities for spent fuel are available at the Loviisa and Olkiluoto sites. Both are wet-type storages. At both sites, additional storage capacity needs to be constructed by early 2010. Research, development and planning work for spent fuel disposal is in progress and the disposal facility is envisaged to be operational in early 2020. In spring 2001, the Parliament approved a Decision in Principle on the final disposal of spent fuel at the Olkiluoto site.

At the Loviisa site a solidification facility for low and medium level waste will be commissioned in the year 2004.

At both nuclear power plant sites, rock cavern facilities for the ultimate disposal of low and medium level waste are in operation.

2.2 Concluding summary on the fulfilment of the obligations

The changes made and the ongoing or planned development under the areas of the Articles 4 and 6 to 19 of the Convention are reported above. Based on the evaluation, it can be concluded that Finnish regulations and practices continue to be in compliance with the obligations of the Convention, and further progress is underway.

Safety improvements have been annually implemented at Loviisa and Olkiluoto plants since their commissioning. There exists no urgent need for additional improvements to upgrade the safety of these plants in the context of the Convention. However, there are issues requiring further measures to enhance safety. The main issues are discussed in Chapter 3.

3 PLANNED ACTIVITIES TO IMPROVE SAFETY

The Finnish regulatory control system includes both periodic safety review and continuous safety review processes. Actions for safety enhancement are to be taken whenever they can be regarded as justified, considering operating experience, the results of safety research and the advancement of science and technology. In the following some specific issues and challenges for future work in Finland are presented.

Safety and organisational culture

An understanding of organisational issues and safety culture will be strengthened in Finland. STUK has both developed its own culture and made initiatives to assess and develop the culture of the utilities. These assessments are under planning at the moment and, based on the results of the studies, attention will be paid on the implementation and improvement of safety culture at utility organisations. Studies will also strengthen STUK's and the utilities' competence to assess organisational issues and personnel behaviour.

Changing environment

Deregulation of the electricity markets took place in steps since the new Act on Electrical Power Markets came into force in Finland in 1995. From 1998 on, free competition has existed in all sectors of the market, except transmission in the national grid and local distribution of power. During the past five years, many changes have taken place in the ownership of the utilities, including some changes in the ownership of the nuclear power plants, in Finland. So far, no negative impacts have been seen to the nuclear safety. However, due to competition some savings are in sight in the maintenance costs for example in the use of contractors and possibly by risk informed and optimised approach to maintenance. Possible negative impacts to nuclear safety need to be carefully observed by the regulator.

Human resources in the nuclear field

Based on the evaluation of human resources in Finland in the nuclear field, there is a narrow resource basis in some fields of core competencies such as reactor physics and dynamics, fires, human and organisational factors and programmable automation. Further measures are required in these areas during the next 5 to 10 years in order to avoid loosing competence. In practice it means educating and hiring new people on these areas.

Qualification of non-destructive testing

The reliability of NDT systems taking into account also the small amount of independent and competent personnel resources requires special attention in Finland. International activities and co-operation will be closely followed.

Reliability of digital automation

Detailed safety requirements and procedures to ensure adequate reliability of digital instrumentation and control systems need to be defined in Finland. International activities and co-operation in this area will be closely followed in Finland.

Operating experience feedback

There is still room for enhancement of operating experience feedback activities in order to avoid recurrence of operating events. Implementation of recommendations based on the research carried out on operating experience activities in the Finnish nuclear industry is most essential.

Provision for plant ageing

Ageing issues in Finnish nuclear power plants have already been addressed. However, recent operating experience has shown that this area requires further attention. It is also recognised that ageing effects will reveal technical challenges in the future for which there need to be expertise available to cope with potential problems. The issue of ageing has also been included into the national Finnish research programme on nuclear power plant safety (FINNUS).

4 CONCLUSIONS ON BENEFITS FROM THE FIRST REVIEW MEETING

The Convention on Nuclear Safety is the first legally binding international instrument for nuclear safety in countries that have ratified it. The content of the Convention is consistent and covers well the safety concerns connected to the use of nuclear energy. The Convention calls for regular reporting on how its various articles have been implemented in the participating countries and communities.

In Finland the Convention was cordially welcomed, and Finland was also among the first signatories of it. Based on the experience gained during and after the First Review Meeting in 1999, it can be said that this international legal instrument can be—and it is foreseen to be case also in future—a very powerful tool for enhancing the safety of the nuclear community.

In Finland the Convention and the review mechanism included in it are considered fruitful i.a. for the following reasons:

- The preparation of the national reports requires a certain amount of self-evaluation. Some shortages and development needs of the own regulatory framework are fixed and managed before reporting the situation to the international community.
- The preparation of the review report - if prepared in co-operation with national regulators, the nuclear industry and licensees, and the technical support organisations - contributes to the establishment of a common national understanding on prioritising the important safety issues.
- The reports, as such, form a comprehensive database of nuclear programmes not only in the own country but also in the sense of providing information on other countries' frameworks and programmes. Many Contracting Parties have made their reports available through the Internet, but also others could be encouraged to do the same. In this also the IAEA could provide assistance as needed.
- The publication of reports provides for transparency, which is in today's world one of the basic requirements for gaining general acceptability for using nuclear power. Furthermore, the openness in reporting can be considered to be one expression of a well-developed safety culture.
- Confidentiality of discussions during the review meetings is essential for providing an effective and direct atmosphere for the experts to change views on the prioritisation of safety issues and regulatory policies. Also the way of public reporting of the results of review meetings without making comparisons between contracting parties and without pointing out any countries together with some country-specific needs to enhance the safety level of their nuclear facilities is a necessity for an effective review process.

In the Introduction, the recommendations of the First Review Meeting to Finland are listed. These items are discussed in this report. In addition, taking into account the discussions and observations in the First Review Meeting, the following list of items requiring further actions was prepared. The list was also published on the Internet after the First Review Meeting.

- Reassessment of the requirements for modifications planned by the power company and their independent verification (see Article 14).
- Reassessment of the procedures and requirements for the submission of documents to authorities for approval and information (see Article 7).
- Assessment of the degree of detail and control of the regulatory guides and other regulations (see Annex I).

- Incorporation of safety culture related know-how into a uniform national programme (see Annex IV).
- Development of the methods for evaluating the appropriateness and functionality of the oversight of licensee organisations and strengthening the control and resources in this sector (see Articles 8 and 12).
- Enhancement of the plant modification database with adequate technical data (see Article 14).
- Training to increase awareness and consideration of seismic risks at the nuclear facilities and updating of the requirements related to the control (see Article 14).
- Development and maintenance of STUK's Quality System and benchmarking with other regulators (see Article 13)
- Evaluation of the independence of the technical support to STUK (see Article 8).

These item are also discussed in this report under Articles 6–19 and Annexes, as indicated in brackets.

As a conclusion, in Finland the First Review Meeting was considered very fruitful and it is believed that the second review meeting will also follow the same lines.

ANNEX I

Prescriptivity and consistency of Finnish nuclear regulations and guides

Based on the comments received during the previous Nuclear Safety Convention Review Meeting in 1999 STUK launched a two part study on the general coverage, consistency and prescriptivity of the Finnish nuclear regulatory guide system. The first part was focusing on coverage and internal consistency and it was carried out as a self-assessment within STUK. The second part was an independent study made by the Technical Research Centre of Finland, which was mainly concentrating on surveying the opinions of the licensee representatives about the prescriptivity of the regulations.

The internal study was conducted in such a way that nominated STUK senior experts compared the contents of the Finnish nuclear related regulations (five governmental decisions) and about 70 regulatory guides with the existing IAEA Safety Fundamentals and Safety Requirements (some earlier Safety Codes were included) documents. The task was to identify gaps in the coverage of the Finnish regulations or, gaps in the IAEA guidance. The consistency of Finnish regulations was assessed i.a. in sense of consistent terminology and structure as well as in sense of consistency between the various levels of regulatory documents' hierarchy.

The main findings of the internal self-assessment were as follows:

- The consistency of regulations was considered good and no major structural or terminological problems were identified. It was concluded that since the 1990's the consistency of the regulatory guide system has been paid attention to. Considering the terminology used in the regulations it was however recommended to establish a glossary of used terms to avoid any misunderstandings also in future.
- The IAEA guidance is in most areas more detailed than the Finnish regulatory guides are. This is understandable considering the number of target groups (member states) and the legio of different cultures. In Finnish society many of the detailed requirements of IAEA guidance are considered explicitly for granted.
- Technical areas for which more detailed guidance could be developed are as follows: operational safety, decommissioning, periodic safety review, containment systems and external factors (other than earthquakes).
- The regulatory control methods and procedures should be addressed more in detail in the regulatory guides. Especially it was recommended to include more detailed and updated descriptions to the regulatory guides of enforcement tools and the periodic safety review procedure and periodic inspection programme of STUK. These additions were found necessary in order to meet the general principles of transparency and predictability in regulatory control.

The findings of the internal self-assessment will be taken into account when developing the revised strategy for rulemaking, which is scheduled to be established before the end of 2001.

The independent assessment of the possible prescriptivity of the Finnish regulations and guides was carried out by VTT. In the following the key recommendations and conclusions of the study are presented as an excerpt. The whole report of VTT can be accessed on STUK's Internet site, at http://www.stuk.fi/english/publications/.

The findings of the independent study will be taken into account when developing the revised strategy for rulemaking, which is scheduled to be established before the end of 2001.

Views on the Finnish nuclear regulatory guides

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VTT Automation
VTT Energy

6 RECOMMENDATIONS

Based on the earlier chapters of the report this chapter develops some recommendations for how to further develop the YVL-guides. There are some obvious improvements to be implemented in the YVL-guides in a short-term perspective, but STUK should also initiate a discussion of a more long-term strategy for the development of the YVL-guides. There is also a need to discuss how the YVL-guides are written and used with the aim of making interpretations less dependent on the inspectors. Safety requirements build on a combination between deterministic and probabilistic considerations, but it sometimes appears to be difficult to find a proper balance between the two principles. This has to do with an interpretation of the residual risk and an agreement when it is small enough. The classification of functions, structures and equipment is an issue, which is under discussion in various standardisation committees and here some rethinking seems to be necessary. Finally, in a long-term perspective, there are obvious needs for harmonised regulatory approaches. STUK may take an active role in an international discussion of future approaches to regulatory oversight.

6.1 Near term development of the YVL-guides

One would have expected that the development of the YVL-guides is guided by a clearly expressed strategy. A tacit strategy has evidently been governing their development over the years, but it is would be recommendable to make that strategy more overt. Further development of the strategy would most certainly benefit of general discussion within the nuclear community in Finland on ends and means of regulatory oversight.

There are also a number of larger and smaller needs for improving present guides. The far most problematic is YVL 5.5 which in the present form may even lead to non-optimal practices. Closely connected is YVL 2.1 of two reasons, firstly connected to efforts to reclassify present nuclear power plants and secondly connected to the application of the requirements of YVL 5.5. The requirements of YVL 1.0 that are connected to severe accidents seem to require modifications to balance the probabilistic and deterministic requirements in a logical way.

The possibility that a new nuclear power plant should be licensed in Finland places a large challenge on the whole regulatory system. The YVL-guides themselves give an eminent platform for the licensing process, but it may be necessary to make an assessment of the practical arrangements to ensure that undue requirements on documentation to be supplied will not introduce unreasonable delays in the design and construction process. Ideally a licensing process should be adapted to assess the solutions of a design and construction process in the order they are produced.

6.2 A harmonisation of interpretations

There seems to be some problems in maintaining a consistent interpretation of the YVL-guides. This is something, which has to be expected with requirements written in a natural language, and it may even be counterproductive to try to formulate the requirements in a way to minimise the room for interpretations. According to the interviews the problems are accentuated when new inspectors are taking charge of some area. The underlying problem seems to be partly connected to the maintaining a pool of knowledge at STUK and partly connected to the decision-making processes applied. If younger inspectors can get advice and support for their own judgement this problem should be possible to combat.

Another problem is that some YVL-guides are interpreted more stringently and others more freely. To some extent this is natural, because different issues have a different weight on nuclear safety, but the same general principles should still apply. This problem may be pre-empted with an increased internal dialogue within STUK to transfer a kind of a meta-interpretation between different areas of regulatory oversight.

Finally, in the light of the interviews, there seems also to be a need for a harmonisation of interpretations between different regulatory systems. A growing globalisation and a diminishing number of vendors makes it increasingly important to reach a better international harmonisation of safety requirements. Such a harmonisation can be achieved only in a dialogue between STUK and other regulators in the world.

6.3 Deterministic and probabilistic requirements

The interactions between deterministic and probabilistic safety requirements are one of the keys to the high safety level reached in the nuclear industry. These concepts seem difficult to integrate in practice and people seem often to be tuned to one or the other. Finding a correct balance between deterministic and probabilistic safety thinking has to do with the fundamental question of what is safe enough. Deterministic requirements are needed for essential nuclear safety related components and phenomena. On the other hand, there should be a cut-off probability, below which deterministic safety requirements are not more asked for.

The relationship between deterministic and probabilistic criteria can be illustrated by a simple example. Consider a certain safety function at a nuclear power plant, which is designed according to applicable deterministic principles and with a certain reliability target in mind. Can the deterministic criteria be relaxed if the reliability of the system can be shown to be very high? Safety functions are typically implemented with systems, which for their function rely on various auxiliary systems. What principles should then be applied for setting deterministic and probabilistic requirements on such auxiliary systems? Deterministic design principles can sometimes be used to eliminate certain failure mechanisms and then it would be fair to credit for that property in a probabilistic analysis. Similarly if some sequence can be shown to be very unlikely in a probabilistic sense, then a corresponding accident analysis should be possible to restrict to a few representative cases.

This issue has also an application on the requirements set for the so-called process initiating events. What kinds of reliability requirements are prudent and reasonable for functions and systems, which are needed to cope with certain disturbances, incidents and accidents? When should the single failure criterion be applied also for sequences that can be considered very unlikely and what kind of credits can be given for diversity in functions. A resolution of these questions has to reflect a view on residual risks. It would be beneficial if STUK could enter a discussion on the relationships between such deterministic and probabilistic criteria and their interpretation in a few selected illustrative cases.

6.4 Classification of functions, structures and equipment

The classification system, by which functions, structures and equipment are graded with respect to their importance for safety, is a key to many other issues. If the classification system and the requirements in different classes cannot be agreed upon, there is little prospect that present disagreements and confusion will disappear. In this connection it is important to note that the concern is not only the classification system itself, but also how it is interpreted and how different functions, structures and equipment actually are allocated to different classes.

A second issue connected to the safety classification has to do with changes introduced in YVL 2.1. The guide has been changed two times and the nuclear power plants made serious attempts to comply with the new requirements. It became soon evident that a total plant reclassification would be counterproductive and it was agreed that only plant modifications would be classified according to the new system. This principle is practical, but it also has a potential of introducing confusion. It was a widespread opinion among the persons interviewed that the work connected to a reclassification actually has created considerable costs without any significant influence on safety.

Experience from incidents as well as PSA results demonstrate that the conventional systems can have an important influence on safety. Classification practices of today do not typically recognise this fact. If the principles for the classification of functions, structures and equipment are reconsidered there might be an opportunity to reconsider also principles for handling presently non-classified systems such as for instance the ultimate heat sink.

YVL 5.5 would also warrant some rethinking on how to carry out the classification. There have been international standardisation efforts aimed at a better approach for classification of instrumentation and control functions and systems important to safety. It is too early to predict in which directions these efforts will lead, but it is clear that STUK should involve itself in the discussions.

6.5 Challenges for the future

Any system of requirements should be updated to reflect the technical development. A reasonable requirement is also that nuclear power plants built today should be better than those built twenty years ago. The way such a general feeling for the need of improved solutions should be converted into safety regulation is a different matter. In this connection there may be a need for opening up a societal discussion on the risks of nuclear power as compared to risks of other sources for primary energy. STUK should probably not be too much involved in such a discussion, but an emerging debate may place a need on STUK to explain the content and the assumptions of nuclear regulation in a language, which can be understood by educated laymen.

Another question is how regulatory oversight will change in the future. STUK has had an outspoken policy to move away from inspecting technical details to inspect and review work processes of the licensees. According to the interviews such a development would be welcome, but signs of such a change have been small so far. Instead many of the interviewed expressed the opinion that the regulatory oversight had been moving further into details.

STUK has selected not to be directly involved in matters concerned with economics. Experience from nuclear power plants in the world demonstrate however, that safety can be achieved only when the economic situation of a nuclear power plant is sound. This observation may have some influence on future regulatory approaches.

One issue to be considered is how modern information technology can be utilised efficiently. It is evident that the technology has many potentials, which will require considerable investments before they are fully realised. Experience from information technology projects call however for realism in the expectations. STUK has in this connection taken a small, but welcome step forward in making the regulatory system easier to access in a new computer based system.

A final question towards the future has to do with how the technical development will continue. The conventional industry has already in many fields surpassed the nuclear industry in its quality requirements. Will this influence the nuclear regulatory systems and if so in what way? The nuclear industry itself is considered too small by the large international vendors to motivate the development of specialised nuclear products. This may lead to a situation where special nuclear grade equipment can not be bought at any price, or the equipment available is inferior as compared with normal industrial grade. It seems however likely that a requirement that the technology used should be proven will stay, but such a requirement should not be allowed to stop a search for better solutions. Again it is important that STUK takes an active role in a discussion of future directions in the development of regulatory oversight.

7 CONCLUSIONS

This chapter gives the general conclusions of the study. The main conclusion must be that the YVL-guides have to be considered as a large asset for the Finnish nuclear community. The guides in general can not be considered too prescriptive. There are however a number of improvements which could be made in the structure of the YVL-guides, in the content of specific YVL-guides, in the way they are interpreted and in the processes for keeping them up to date.

In a general evaluation of the YVL-guides one can conclude that they fulfil earlier described criteria reasonably well. They have a structure, which is logical and covering. They are relatively well balanced with a reasonable level of detail. The requirements put forward in the YVL-guides are reasonable and they are reflecting international practice. The guides are understandable and fairly straightforward to interpret. STUK is putting in a considerable effort to keep the guides up to date.

The main question asked in the assignment was whether or not the YVL-guides could be considered too prescriptive and binding for the nuclear utilities in Finland. Based on the interviews and a general assessment, this question has to be answered with a definitive no. All persons interviewed had a clear positive view of the YVL-guides and they were seen as giving structure to the safety activities at the plant. This positive view has however to be qualified with respect to a few problematic YVL-guides. These guides have been treated more in detail in the earlier chapters of the report.

The YVL-guides can be considered as an asset of the Finnish nuclear regulatory system. It is clear that STUK should continue the work they do in keeping the YVL-guides up to date. The strategy for further development of the guides should however be reconsidered, discussed and documented on a continuing basis. The possibility that a new nuclear power plant will be built in Finland gives a number of new challenges to STUK which have to be reflected.

In a long-term perspective, the position of the YVL-guides as a component of the regulatory oversight in Finland may change. The extent to which there will be an international harmonisation of regulatory guidelines remains to be seen. It is however evident that the nuclear community all over the world would benefit from more harmonised approaches to safety. With the present experience and skills STUK could most certainly play an important role in this development.

Acknowledgement

The open and frank discussions during the interviews are gratefully acknowledged. All persons interviewed showed a deep commitment to nuclear safety. The comments given were by the interviewers seen as sincere attempts by the interviewed persons to improve the present Finnish regulatory system. There were no indications that the views expressed could be interpreted as an unfounded groan on something the utilities have to live with. In a way this can be seen as a reflection of a good safety culture at the organisations visited.

1 General

Loviisa Nuclear Power Plant, two 510 MW_e (gross) VVER-440 units, is owned and operated by Fortum Power and Heat Oy (former Imatran Voima Oy). The company name was changed in 1999 after the merging of Imatran Voima Oy and the petrochemical company Neste Oy into Fortum Corporation.

In 1999 the gross production of Loviisa 1 was 4066 GWh and the capacity factor was 91.0% (gross). The annual refuelling and maintenance outage lasted 19 days. The gross production of Loviisa 2 was 4165 GWh, the capacity factor 93.2% and the length of the refuelling outage was also 19 days. The annual collective radiation doses were 0.80 manSv and 0.56 manSv for Loviisa 1 and Loviisa 2 respectively.

In the year 2000 Loviisa 1 produced 3798 GWh (gross), the capacity factor was 84.8% and the refuelling and maintenance outage lasted 44 days. Loviisa 1 had an inspection outage, which is performed every fourth year. In 2000 the gross production of Loviisa 2 was 4075 GWh, the capacity factor was 91.0%, and the refuelling outage lasted 19 days. The collective radiation doses in 2000 were 1.73 manSv for Loviisa 1 and 0.54 manSv for Loviisa 2.

Eight events in 1999 and seven events in 2000 were classified on the International Nuclear Event Scale (INES). In both years there was one level 1 event and the classification of the other events was 0. The first level 1 event was revealed in a periodic test during the refuelling outage of Loviisa 2. It was noticed that the identification tags of two manually operated valves in the nitrogen blowing (cleaning) lines of the emergency cooling system sump strainers, had been interchanged. In these two-redundant sump systems, the cleaning operations of the strainers, if needed, would in this case have affected the wrong redundancy. The other level 1 event occurred at Loviisa 1 during the refuelling outage in 2000 when recurrent line-up errors (in filling the suction line of the draining pump in the fuel pond cooling system) caused reactor pool water leakages onto the floor of the steam generator compartment.

In the first four months of 2001 three events have been classified on the INES scale. These events have been below the INES scale (level 0).

The first stage of the final repository for medium and low level radioactive waste was licensed in 1999. The first stage includes underground tunnels for solid low active waste. In 2001 STUK approved the Preliminary Safety Analysis Report of the solidification plant and detailed planning of the plant is going on. The civil construction works will be started later in 2001.

The interim storage for spent fuel had to be extended when the returning of spent fuel to Russia was terminated in 1996. The extension part of the storage was completed in 2000.

In 1998 Fortum Power and Heat Oy launched the environmental impact assessment procedure (EIA) of the new nuclear power plant. The planned location is the site of Loviisa 1 and 2. The EIA report was finalised in 1999 and the co-ordination authority, Ministry of Trade and Industry, gave its statement on the procedure in 2000.

2 Modernisation and power upgrading of Loviisa NPP

Introduction

The project for the modernisation and power upgrading of Loviisa NPPs gave an excellent possibility to take advantage of the latest development in the nuclear power plant technology. The key aspects were to verify the plant safety, to improve production capacity and to give a good basis for the extension of the plant's lifetime to at least 45 years.

Feasibility study and project objectives

In the first phase, before starting the project, a feasibility study for uprating of the reactor thermal power was carried out. The main result was in short that no technical or licensing issues could be found which would prevent the raising of the reactor thermal output up to 1500 MW from the original level of 1375 MW.

The carefully prepared feasibility study gave a good picture of the necessary plant modifications as well as essential areas in the analysis work, which was of use in planning the critical works and the time schedule of the project. The feasibility study focused on the following tasks:

- the optimisation of the power level and definition of the new parameters of the main process
- reactor core and fuel studies, including RPV irradiation embrittlement
- safety analyses and licensing
- the main components and systems
- project planning and risk assessment.

The main objectives for the project were based on the feasibility study:

(1) Plant safety level as a whole will be checked and, if needed, improvements will be made.
(2) Plant units will be licensed for 1500 MW reactor thermal output.
(3) Gross electric output of the plant units will be raised to about 500 MW.
(4) Assistance to the life time extension of the plant units.
(5) The long-term availability of the plant is not impaired.
(6) Increase in the expert knowledge of staff.

Time schedule and project organisation

The feasibility study concerning the reactor power upgrading and improvements of the turbine efficiency was started in spring 1994. After good results from the study, the preparation of the project plan began in summer 1995. Critical works in the time schedule, such as the revision of the Final Safety Analysis Report and the preparation of certain plant modifications, were started immediately.

The first step of the trial run by 103% reactor power could be started in January 1997. Test runs continued step by step during the year, and the last transient test by final reactor power was completed successfully in December 1997.

The Council of State awarded a new operating license for Loviisa NPP in April 1998. The license is valid until the end of 2007 for 1500 MW reactor thermal power, which is 9.1% more than the previous power level of 1375 MW. Measures to improve the efficiency of the steam turbines will continue in the annual maintenance outages until the year 2002.

The implementation of the project was carried out in co-operation between Loviisa NPP and Fortum Engineering. In addition, many other organisations such as the Technical Research Centre of Finland (VTT) participated in the work. Special attention was paid to the QA routines in the project as well as to the co-ordination of the work in several organisations. One example of this was the particular subject-specific specialist groups which were established to overview essential sections such as nuclear safety and commissioning.

The work was divided into the following ten sub-projects each having a responsible person from the organisations of both Loviisa NPP and Fortum Engineering:

(1) Operating licenses
(2) Other licenses
(3) Safety analyses and basic data management
(4) FSAR revision and comparison of the plant with regulatory body guidelines
(5) PSA (including level 2 PSA)
(6) Modification of the turbines
(7) Electricity systems
(8) Reactor and fuel
(9) Process systems and automation
(10) Commissioning and revision of instructions.

Technical implementation and experience of the trial operation

Increasing the electrical output by about 50 MW at each unit was part of the Loviisa modernisation programme. After completing the upgrading of the reactor thermal output in April 1998, more than 80% of the total increase in the electrical output was fulfilled. The rest of the power increase is available when the measures to improve the steam turbines are completed in the year 2002.

The reactor power upgrading from 1375 MW to 1500 MW was planned on the basis of optimising the need for heavy plant modifications. In the primary side and the sea water cooling system, the mass flow rates were not affected, but the temperature difference has been increased in proportion to the power upgrading. In the turbine side, the live steam and the feedwater flow rate were increased by about 10%; the live steam pressure was not changed.

The reactor fuel loading was considered on the basis of the previous limits set for the maximum fuel linear power and fuel burn-up. The increase in the reactor thermal output was carried out by optimising the power distribution in the core and the power of any single fuel bundle was not increased above the maximum level before power upgrading. In parallel with this work, more advanced options related to the mixing rate of the cooling water in the fuel subchannels and the increasing of fuel enrichment were investigated. The dummy elements installed on the periphery of the core in Loviisa 1 and 2 were preserved to minimise irradiation embrittlement of the reactor pressure vessel.

The VVER 440 design margins in the primary side are rather large and the hardware modifications needed there were quite limited. Replacement of the pressuriser safety valves was indicated already during the feasibility study as a necessary measure because of the power upgrading. Most of the other substantial measures in the primary side were carried out on the basis of the continuing effort to maintain and raise the safety level of the plant, and they were not directly included in the power upgrading.

It was necessary to carry out more extensive measures in the turbine plant and to the electrical components. Steam turbines were modified to a higher steam flow rate. Because of these measures, also the efficiency and operation reliability has improved. Certain modifications were carried out in the electrical generators and the main transformers to ensure reliability in continuous operation with the upgraded power output.

The last step in the process to upgrade the reactor thermal power was the long-term trial run to verify the main process parameters as well as plant operation in both steady state and transient situations. The trial run was carried out at gradually upgraded reactor power with a power level of 103%, 105%, 107% and finally 109%. Transient tests defined in the test programme were performed with a reactor thermal power of 105% and 109%. The test results correspond very well with all analyses and calculations. All the acceptance criteria for the tests were fulfilled.

Licensing procedure and safety analyses

The modernisation programme as a whole was started from the basis of the positive safety progress. This was applied by taking advantage of the latest development in calculation codes and technology as well as feedback of the operating experience, expertise in the ageing processes and safety reassessment coupled with the evolution of safety standards.

STUK was closely involved at every stage of the project, from the early planning of the concept to the evaluation of the results from the test runs. STUK examined all the modification plans that might be expected to have an impact on plant safety. Individual permits were granted stage by stage, based on the successful implementation of previous work.

The renewal of the operating license for the increased reactor power was carried out in the following steps:

- permission from the Ministry of Trade and Industry to make plant modifications and test runs with upgraded reactor power under the existing operating license and under the control of STUK
- assessment of the environmental impact (EIA-procedure) of the project
- STUK's approval of the Final Safety Analyses Report (FSAR), the safety-related plant modifications, test programmes and results.
- the Ministry of Trade and Industry, the responsible authority for the NPP operating licenses, received a statement from several local and national organisations
- the operating license was prepared by the Ministry of Trade and Industry, and the Council of State awarded the license in their session on 2 April 1998. The license is awarded to 1500 MW nominal reactor thermal power until the end of the year 2007.

The environmental impact has been assessed in the EIA Report, which was completed in December 1996. This was the first time in Finland (parallel with TVO plant having a corresponding modernisation programme) the EIA Procedure has been applied to a nuclear power plant. The law and the decree set certain procedures, including a public hearing for screening, scoping and the EIA statement, which are the stages of this procedure.

The result was that the reactor thermal power upgrading has no other considerable environmental impact than a slight increase in the outlet temperature of the cooling water. This means that the maximum temperature increase of the cooling water in the main condenser, before released back to the sea, is about 1°C higher than the previous temperature increase, which was typically close to 10°C.

An extensive safety review and comparison of the plant with the latest national regulatory body guidelines (YVL guides) have been carried out. This work was performed taking into account many international standards, such as the IAEA standard "A Common Basis for Judging the Safety of Nuclear Power Plants Built to the Earlier Standards INSAG-8". As a result of the work, a particular safety review report has been completed.

A part of the safety review and the licensing process of the reactor power upgrading was the renewal of the Final Safety Analysis Report. New accident analyses have been made concerning the containment pressure, LOCA and MSLB, for example. In addition to the accident analyses, there is a large number of transient situations that have also been analysed. The risk for a radioactive release to the environment was probabilistically considered (PSA level 2) for the first time for Loviisa NPP.

3 Severe Accident Management implementation at Loviisa NPP

The Loviisa severe accident program, which includes plant modifications and severe accident management procedures, was initiated in order to meet the requirements of the Finnish regulatory authority, STUK.

Fortum's approach for severe accident assessment and management for Loviisa is based on four successive levels. The first level of the approach is to ensure that severe accidents can be prevented with high probability. The quantitative targets for the overall core damage frequency (CDF) obtained from PSA level 1, are 10^{-4} /reactor year for existing plants.

The second level is to show a very low fraction of overall CDF for those classes of accident sequences which can be assumed to directly lead to a large release. Such sequences are the ones with an impaired containment system function, high pressure core melt sequences and reactivity accidents leading to core damage. The class called sequences with impaired containment function consists of containment by-pass sequences (especially, primary to secondary leakage accidents), sequences with pre-existing openings, containment isolation failures, containment pressure suppression system by-passes and sequences with induced leakage outside the containment.

On the third level of the approach, the focus is on physical phenomena capable of threatening the containment integrity. The challenge to the containment integrity due to any physical phenomena should be excluded either by excluding the phenomenon itself as physically unreasonable or by showing that the loads caused by the phenomenon are tolerable. The phenomena considered include in-vessel and ex-vessel steam explosions, hydrogen burns, direct containment heating, missiles, slow overpressurization due to steaming and generation of noncondensable gases, core-concrete interaction, recriticality of the degraded core and core debris, and temperature loadings of the containment. It is obvious that plant specific studies are needed for proper treatment of the individual phenomena. Instead of traditional PSA level 2 type of approach, in case of Loviisa, Fortum has treated the main phenomenological, Loviisa-specific questions along the lines of the ROAAM (Risk Oriented Accident Analysis Methodology) approach.

After successful exclusion of the containment system and structural failures, the fourth and final level of the approach is to define the radioactive releases through containment leakages. The releases during the managed accident sequences should stay below the acceptable criteria concerning acute health effects and land contamination.

For Loviisa, the approach translates to ensuring the following top level safety functions:

- depressurization of the primary circuit
- absence of energetic events, i.e. hydrogen burns
- coolability and retention of molten core in the reactor vessel
- long term containment cooling
- ensuring subcriticality
- ensuring containment isolation.

The cornerstone of the SAM strategy proposed for Loviisa is the coolability of corium inside the reactor pressure vessel (RPV) through external cooling of the vessel. Since the RPV is not penetrated, all the ex-vessel phenomena such as ex-vessel steam explosions, direct containment heating and core-concrete interactions can be excluded. The only energetic phenomena remaining which could have potential to threaten the containment integrity are hydrogen burns.

In-vessel retention of corium

Some of the design features of the Loviisa Plant make it most amenable for using the concept in-vessel retention (IVR) of corium by external cooling of the RPV as the principle means of arresting the progress of a core melt accident. Such features include

- the low power density of the core
- large water volumes both in the primary and in the secondary side
- no penetrations in the lower head of the RPV and, finally,
- ice condensers ensure a flooded cavity in most severe accident scenarios.

On the other hand, if in-vessel retention was not attempted, showing resistance to energetic steam generation and coolability of corium in the reactor cavity could be laborious for Loviisa, because of the small, water filled cavity with small floor area and tight venting paths for the steam out of the cavity.

The main focus of the thermal studies for IVR is therefore on finding out 1) the actual heat flux from the molten corium pool and 2) the critical heat fluxes at the corresponding locations on the RPV wall. Because of the relatively thick RPV wall, and because of the crust, which creates isothermal boundary conditions for the molten pool, the in-vessel and ex-vessel heat transfer phenomena can be effectively decoupled from each other.

An extensive research program was carried out by Fortum. The work included both experimental and analytical studies on heat transfer in a molten pool with volumetric heat generation and on heat transfer and flow behaviour at the RPV outer surface.

Based on experiments, the IVR concept for Loviisa was finalised in April 1994. The concept includes plant modifications at four locations. The most laborious one is the modification of the lower neutron and thermal shield such that it can be lowered down in case of an accident to allow free passage of water in contact with the RPV bottom. Other two modifications include slight changes of thermal insulations and ventilation channels in order to ensure effective natural circulation of water in the channel surrounding the RPV. Finally a strainer facility will be constructed in the reactor cavity in order to screen out possible impurities from the coolant flow and thereby prevent clogging of the narrow flow paths around the RPV.

The conceptual design was submitted to STUK for approval and approval in principle was received in December 1995.

Absence of energetic events

Based on plant-specific features, the only real concern regarding potential energetic phenomena is due to hydrogen combustion events. The Loviisa reactors are equipped with ice-conderser containments, which are relatively large in size (comparable to the volume of typical large dry containments) but have a low design pressure of 0.17 MPa. The ultimate failure pressure has been estimated to be well above 0.3 MPa. An intermediate deck divides the containment in the upper (UC) and lower compartments (LC). All the nuclear steam supply system (NSSS) components are located in the lower compartment and, therefore, any release of hydrogen will be directed into the lower compartment. In order to reach the upper compartment, which is significantly larger in volume, the hydrogen and steam have to pass through the ice-condensers.

Because of the relatively low design pressure of the containment, the hydrogen burns that can create a potential threat include not only detonations, but also all large-scale combustion events that are rapid enough to yield an essentially adiabatic behaviour. An additional concern, which is caused by the type of the containment, occurs when the steam and hydrogen mixture passes through the ice-condenser. The steam will be condensed in the ice beds, which could potentially lead to very high local hydrogen concentrations.

In the early 1990's an extensive research program was initiated at Fortum to assess the reliability and adequacy of the existing igniter system. One of the focus areas in the studies was to determine the prerequisites for creating and maintaining a global convective flow loop around the containment for ensuring well mixed conditions. The global flow loop which passes from the lower compartment through an ice-condenser to the upper compartment and back to the LC through the other ice-condenser is necessary in order to bring air into the LC and thus to be able to recombine or burn hydrogen in a controlled way already in the LC. The experiments and the related numerical calculations demonstrated that the global convective loop will be created and maintained reliably provided that the ice-condenser doors will stay open.

The studies have been completed and the new hydrogen management strategy for Loviisa has been formulated. The new hydrogen management scheme concentrates on two functions: ensuring air recirculation flow paths to establish a well-mixed atmosphere (opening of ice condenser doors) and effective recombination and/or controlled ignition of hydrogen. Plant modifications which are necessary include the new hydrogen recombination devices and a dedicated system for opening the ice-condenser doors.

Prevention of long term overpressurization

The studies on prevention of long term overpressurization at Loviisa started by considering the concept of filtered venting, as was done for many European NPPs after the Chernobyl accident. However, the capability of the steel shell containment to resist subatmospheric pressures is poor. If using filtered venting, it is possible that the amount of noncondensable gases after the venting is significantly less than originally, which later—after cooldown of the containment atmosphere—may lead to subatmospheric pressures and possibly collapse of the containment. Therefore, alternative solutions were sought for.

Since the concrete used in the reactor cavity of Loviisa does not contain any CO_2, the amount of noncondensable gases (except for hydrogen) generated during core-concrete interaction would be practically zero. Therefore, the overpressure protection of the containment could be limited to condensing the steam produced. An obvious way of doing this is to spray the exterior of the containment steel shell. Later on, the concept of in-vessel retention was introduced to Loviisa (as discussed above), which excludes core-concrete interactions altogether and thus finally ensures that no noncondensable gases apart from hydrogen need to be considered.

The system is designed to remove the heat from the containment in a severe accident when other means of decay heat removal from the containment are not operable. Due to the ice condenser containment, the time delay from the onset of the accident to the start of the external spray system is long (18–36 hours). Thus the required heat removal capacity is also low, only 3 MW (fraction of decay power is still absorbed by thick concrete walls). The system is started manually when the containment pressure reaches the design pressure 1.7 bar. Autonomous operation of the system independently from plant emergency diesels is ensured with dedicated local diesel generators. The single failure criterion is applied. The active parts of the system are independent from all other containment decay heat removal systems. There are no active parts of the system inside the containment.

The both units Loviisa 1 and 2 have their own external spraying circuits and spray water storage tanks. The cooling circuit of the spraying system and the dedicated diesel generators are common for both units. The ultimate heat sink is sea water.

The design calculations were carried out with

Fortum's own simplified containment thermal-hydraulic code PREDEC. The PREDEC calculations were supported by experiments carried out at the HDR containment (tests E11.2 and E11.4) in Germany. These experiments were aimed at studying the hydrogen distribution during stratified conditions inside the containment. The main result from the HDR experiments was that the PREDEC code could be used for the design calculations of the external spray system.

The influence of the external spray system was further studied experimentally using the VICTORIA facility.

Primary circuit depressurization

The primary depressurization is an interface action between the preventive and mitigative parts of SAM. If the primary feed function is operable, the depressurization may prevent the core melt. If not, it sets in motion the mitigative actions and measures to protect the containment integrity and mitigate large releases.

Manual depressurization capability has been designed and implemented through motor-operated relief valves. Depressurization capacity will be sufficient for bleed&feed operation with high-pressure pumps, and for reducing the primary pressure before the molten corium degrades the reactor vessel strength. Depressurization is to be initiated from indications of superheated temperatures at core exit thermocouples. The depressurization valves were installed at the same time with the replacement of the existing pressurizer safety valves in 1996.

Implementation

The SAM-strategy described in the previous chapters has lead to a number of hardware changes at the plant as well as to new severe accident guidelines and procedures.

The containment external spray was implemented at the two units in 1990 and 1991. Primary system depressurization capability was installed at both units in 1996. The major backfittings related to external coolability of the reactor pressure vessel and to opening the ice-condenser doors are, for the most part, implemented at Loviisa 1 in 2000 and at Loviisa 2 in 2002. Test samples of the new hydrogen recombination devices have been aged and tested in plant conditions and the devices will be installed in 2002. In addition to the mechanical equipment, the implementation includes also a new, dedicated, limited scope instrumentation and control system for the SAM-systems, a dedicated AC-power system and a separate SAM control room which is common to both units.

The severe accidents guidance for the operating crew consists of SAM-procedures for the operators and of a so-called Severe Accident Handbook for the Technical Support Team. The SAM procedures are entered after a prolonged uncovery of the reactor core indicated by highly superheated core exit temperatures. The procedures are symptom oriented and their main objective is the protection of containment integrity through ensuring the top level severe accident safety functions. The most important operator actions after the core uncovery are the ensuring of containment isolation, primary circuit depressurization, opening of ice-condenser doors in order to ensure mixing of hydrogen, lowering of the neutron shield of the lower part of the RPV and, in the long term, starting of the containment external spray. The Severe Accident Handbook contains background material for the procedures and it should facilitate the support team in gaining understanding of the progress of the accident and of potential means of recovery.

4 Qualification system for non-destructive testing

See Annex III, Development of the safety of the Olkiluoto nuclear power plant and Chapter 4. The text in Annex III applies also for Loviisa nuclear power plant. The only difference is that the situation of Fortum's inspection qualifications (last paragraph) is that the qualification of in-service inspections based on ENIQ recommendations was started in 1998.

5 Exchange of operation experience with similar power plants

VVER reactor operating experience is collected, screened and evaluated by a dedicated operating experience feedback group composed of engineers from the plant operation organisation and from Fortum Nuclear Services. The group can give recommendations on further studies and measures to the operating organisation. The main information to be handled comes from WANO Moscow Centre which links all the VVER reactor operators. Additional reports are received from the IAEA, OECD/NEA and NRC, and naturally the activities of the operation experience feedback group are not limited only to VVER reactors.

The plant managers of VVER-440 reactors run a so-called VVER Club with periodic meetings. The plant operation problems, modernisation, back-fitting, lifetime extension and safety questions are handled and experiences are exchanged in these meetings and in further individual contacts.

Loviisa Power Plant participates in the WANO Peer Review Programme by sending peers to other plants including VVER plants. In February - March 2001 WANO Moscow Centre organised a Peer Review at Loviisa Power Plant. Several peers including the team leader came from other VVER plants. This co-operation between plants of the same design serve also the exchange of relevant operation experiences.

Fortum Nuclear Services has been a partner in several international and Finnish safety and quality related support programmes. Loviisa Power Plant has participated in some of these projects and has had a possibility to widen the organisation's experience on current development with other VVER operators. The same applies to a couple of direct commercial consultation projects which have been managed by Loviisa Power Plant.

In the area of radiation protection, Loviisa Power Plant is participating in the IAEA Technical Co-operation Project RER/9/063 "Enhancing Occupational Radiation Protection in Nuclear Power Plants". The workshops organised by the project bring together VVER and RBMK health physicists to exchange information on current issues in radiation protection.

6 Modification management development

An analysis of reported events often reveals that deficiencies of modification management have been a contributing factor. Such deficiencies include late planning, lack of co-ordination with other works, last moment changes, documentation defects, unfinished disassembling works and delayed updating of the documentation.

Proper planning and scheduling are the key factors in modification management. Loviisa Power Plant has completed an extensive project training course in 2000 for those in the operating organisation who will be involved in future modification projects. Successful projects such as the plant modernisation and power upgrading have been used as good examples.

The scheduling of the modification planning for the next outage is fixed in order to get enough time for preparations. Minor modifications are concentrated to every second annual maintenance outage and major works are carried out every fourth year. This is accomplished by starting from a long term investment planning which converts into a long term modification plan.

During the maintenance outage the scheduling office is directing their efforts from the previous control of the overall schedule to controlling the individual work packages including also the modification works. In the main schedule more time is allocated to tests related to start-up. New arrangements for handling the work orders in the main control room have been introduced for the next annual outages. The idea is to even up the work load in the main control room and decrease the disturbance of the operators.

Quality procedures for executing modifications have recently been updated. The authority to make decisions on last moment changes in the scope or schedule of the modification works has been clarified.

7 Development of the quality system

After Fortum Corporation was formed a need for an updated quality policy was obvious. In 1999 a quality statement “Fortum’s Policy Commitment to Quality in the Nuclear Power Operations” was issued by the president of Fortum Power and Heat Oy. The statement has been confirmed in 2001 also by the new management of Fortum Power and Heat Oy.

The recent development of the plant quality management system is based on the principle of continuous improvement in accordance with the observations and remarks made in quality audits and quality assessments.

Loviisa Power Plant adopted in 2001 a newly formulated management procedure which defines an annual planning process from strategic planning to annual reports. A first 10-year strategic plan for the power plant was developed in 2000.

A second important and new procedure describes those review processes (e.g. management reviews, self assessments), which are needed in an effective quality management system.

In the internal quality audits, new efforts are directed to the evaluation of the recurrence of events. These have considerably increased the necessary background work both in the preparation and in the reporting phase of an internal audit.

An evaluation of the plant quality management system against the ISO/DIS 9001, 9004:2000 standards was made in 2000 by Fortum Engineering. The work continues in 2001 and a similar comparison with IAEA Safety Series No. 50-C/SG-Q has already been ordered.

Preparation of the environmental management system according to the ISO 14001 standard is included in the quality management system. Preparations at the procedure level have introduced a new chapter in the Quality Manual and in the updating of numerous quality procedures. A novel environmental aspect shall be considered in internal audits and new part-time auditors have been trained for environmental evaluations. The readiness for certification of the environmental management system should be achieved by the end of 2001.

The present tracking system for quality and safety decisions, obligations and actions has capacity limitations and a new tailored application will be delivered in 2001.

ANNEX III DEVELOPMENT OF THE SAFETY OF THE OLKILUOTO NUCLEAR POWER PLANT

1 General

Production

Teollisuuden Voima Oy (TVO) owns two 840 MWe boiling water reactors Olkiluoto 1 (OL1) and Olkiluoto 2 (OL2) located in Olkiluoto.

In 1999 net production at OL1 was 7112 GWh and the capacity factor 96.9%. The annual outage and refuelling of OL1 was performed in May and lasted 8 days. The net production of OL2 was 7091 GWh and the capacity factor was 96.6%. The annual outage and refuelling of OL2 was in May and lasted 10 days. The total number of manhours of the outages was 147000. At peak, there were 671 outside workers.

In 2000 net production at OL1 was 7043 GWh and the capacity factor was 95.7%. The annual outage and refuelling of OL1 was performed in May–June and lasted 14 days. The net production of OL2 was 7091 GWh and the capacity factor was 95.5%. The annual outage and refuelling of OL2 was in May and lasted 14 days. The total number of manhours of the outages was 253000. At peak, there were 870 outside workers. Inspections made during the annual outages showed that the plant units are in good condition and that any faults or defects were minimal. The company policy is to keep the plant units as good as new.

INES-classified events

During the year 1999 four events occurred that were classified level 1 on the International Nuclear Event Scale (INES). The events were:

- OL1 – Erroneous installation of the valve in the Containment Gas Treatment System,
- OL1 – Defects in the torque settings of the outer isolation valve actuators in the RHR System,
- OL2 – Personnel airlock of the containment left open against the Technical Specifications during outage maintenance work and
- OL2 – Deviating vertical position of fuel elements in the core.

All the events during the year 2000 were classified level 0 or below on the INES scale. In the first quarter of 2001, one deviation was observed and classified level 1. The bakelite pinions of several valve actuators had cracks and two of them were damaged mainly due to fatigue. Due to this observation bakelite pinions were replaced by brass pinions in the outer isolation valves of the core spray system of both units.

Environmental matters

The preparation of the environmental management system based on the ISO 14001 standard was started in 1998 and accomplished at the end of 1999 when TVO was granted an international certificate based on this environmental management system.

The EIA-procedure, the investigation of the environmental impacts of a third reactor unit possibly to be built at Olkiluoto, was finalised in February 2000, when the contact authority, the Ministry of Trade and Industry gave its statement on the EIA report.

Management of operating waste and spent nuclear fuel

By the end of the year 2000, 3942 cubic meters of low and medium level operating waste has accumulated in Olkiluoto. Most of this waste has been disposed in the VLJ-repository in Olkiluoto.

Spent nuclear fuel is stored in an interim store at Olkiluoto. By the end of the year 2000, 853 tons of spent uranium has accumulated at Olkiluoto.

The company's liability for its nuclear waste management was settled by the Ministry of Trade and Industry at EUR 663.0 million at the end of year 2000. The reserve in the Finnish State Nuclear Waste Management Fund, as determined from the liability, is EUR 656.2 million.

In May 1999, Posiva Oy, a company jointly owned by TVO and Fortum Power and Heat Oy, submitted to the Council of State an application for a Decision in Principle for a spent fuel final disposal plant to be constructed at Olkiluoto. In December 2000, the Council of State gave a positive decision. The Finnish Parliament approved the Decision in Principle for the final disposal plant after voting in May 2001.

Provision for a new nuclear power plant unit

In November 2000, TVO submitted to the Ministry of Trade and Industry an application for a Decision in Principle for the fifth nuclear reactor unit to be constructed either in Olkiluoto or in Loviisa. The application has been reviewed by all stakeholders, and the respective statements have been submitted to the Ministry of Trade and Industry that prepares the issue for a Council of State decision.

2 Enhanced safety and improved production through modernisation at Olkiluoto NPP

Introduction

OL1 and OL2 have been in operation for over 20 years. The performance indicators have been favourable. For instance, the average capacity factor for the last ten years is well above 90%.

Already before modernisation the plant design was reasonably modern due to the following advanced features included in the original design:

- internal main circulation pumps
- fine motion control rod drives
- 4 × 50% redundant safety systems
- inerted pre-stressed concrete containment, back fitted against severe accidents.

Numerous design modifications have been implemented since the commissioning of the units. For instance, the containments were back fitted against severe accidents at the end of the 80's. TVO's policy has been to keep the plant continuously up-to-date.

It would be imprudent to take favourable performance for granted. Therefore, TVO started proactively a modernisation program in 1994. It was recognised that there were many modifications to be implemented in the next years and a decision was made to include them in a program called "modernisation".

The operating licences of Olkiluoto 1 and Olkiluoto 2 were renewed in 1998. The time schedule of the modernisation was established so that the outcome of the program could be utilised in the operating licence renewal.

Principles and goals

From the beginning, the following principles were followed in the program:

- technical development was exploited
- new safety requirements
- advanced design solutions
- operational experiences were utilised
- own experiences
- experiences from other plants
- own staff was used as much as possible
- losses in electricity production were avoided
- plant modifications presupposing shutdown were implemented during normal refuelling and maintenance outages
- cost/benefit approach was applied.

The main goals of the modernisation were as follows:

- reviewing safety features and enhancing safety, when feasible
- improving the production related performance,
- finding factors limiting the plant lifetime and eliminating them, when feasible
- enhancing the expertise of the own staff and improving productivity.

The goals supported each other. For instance, it is easier to license the reactor uprating if safety is simultaneously enhanced. On the other hand, the cost of safety improvements can be compensated for by the additional output working for lower production cost.

Safety enhancement

In order to achieve the safety goal, the existing plant design has been reviewed and compared to the present and foreseeable safety requirements. The most important requirements are included in the YVL Guides issued by the Finnish regulatory body (STUK) for new nuclear power plants. Compliance with the European Utility Requirements (EUR) has also been reviewed.

The need to fulfil new requirements set for the new nuclear power plants has been considered case by case. The living PSA model of the plant has been utilised within this context.

The most important safety related modifications included in the modernisation program are listed below:

- Reactor pressure relief system has been diversified by installing two additional relief valves.
- ATWS behaviour has been improved by modifying some trip signals and making boron injection automatic and more effective.
- Additional severe accident mitigation measures have been implemented.
- Earthquake resistance of the plant has been checked and related modifications have been made.
- Partial scram function has been strengthened.
- Generator switching device was replaced with a new one, which is able to switch also short circuit current.
- Protection against frazil ice at the seawater intake has been improved.
- Protection against snowstorms at the air intake of the emergency diesels has been improved.

The modernisation program as a whole reduced the severe core damage frequency estimate by a factor of seven.

The radiation exposure of the population was reduced in accordance with the ALARA principle. Liquid releases have been reduced by a factor of ten by improving the liquid waste handling systems. Also occupational doses have been reduced. In practice, this means minimising the cobalt content in the primary circuit.

Production improvement

Four ways were followed to increase the electricity production:

Reducing the unplanned capacity loss factor

There has not been many operational disturbances until now, but there will be more due to the ageing of equipment and components. Replacement of the components helps in itself. In addition to that, favourable system solutions have been realised that, tolerate more component failures without an adverse impact on the plant operation. For instance the original one out of two turbine protection and control systems have been replaced by a new two out of three system.

Shortening refuelling and maintenance outages

Olkiluoto outages have not been very long in the past. However, there is still room for improvement. For instance, the refuelling machine has been speeded up by modernising its instrumentation.

Improving thermal efficiency

The low pressure turbines have been replaced and in that way about 30 MW_e additional production capacity in each unit has been achieved.

Uprating the reactor thermal power

The following facts made power uprating possible:

- development of the BWR technology
- margins revealed by operational experience
- plant modifications due to other reasons.

The most important development in this respect has taken place in fuel technology. The operation was started with 8×8 bundles and now 10×10 bundles are used. The new bundles are able to produce 40 percent more power than the old ones.

The reactor uprating is a sensitive matter that must be treated with extreme care. The following criteria have been applied:

- safety level after the modernisation program at least the same as before
- no adverse effect on long-term availability,
- no shortening of plant life-time
- additional electricity production economically justified.

The thermal power was uprated from 2160 MW to 2500 MW (15.7 percent). Some design changes implemented due to the uprating are listed below:

- 10×10 fuel bundles are used instead of the original 8×8 bundles.
- Inertia of the main circulation pumps has been increased electrically.
- Steam separators have been replaced.
- High-pressure turbine was modified.

- High-pressure turbine valves were replaced.
- Feed water system has been modified.
- Capacity of the decay heat removal system has been increased.
- Generator has been replaced.
- Main transformers have been replaced.

Enhancing staff expertise

The modernisation program continues TVO's policy to maintain and enhance the expertise of the own staff by having challenging projects always in progress. The most important projects since the plant commissioning have been the previous reactor uprating, severe accident mitigation, training simulator, PSA, interim storage for spent fuel, final repository for reactor waste, investigation program for disposal of spent fuel, preparation of the specifications and evaluation of the bids for a new nuclear power plant in the beginning of the 1990's and again in the beginning of the 2000's. All the drive and expertise focusing on a new plant has been directed to the existing plant units.

Implementation

The modernisation program consisted of about 40 separate projects. The installations were performed during the refuelling outages of the years 1996–1998. In spite of large modifications the refuelling outage times were reasonable, between 15 and 20 days. The test program was quite the same as in the case of a new plant. In addition, the capacity factors of the power plant units have been satisfactory (well above 90%) during and after the modernisation

The total cost of the modernisation program was FIM 800 million.

Licensing

Licensing steps related to the modernisation program were as follows:

- An uprated Safety Analysis Report (PSAR, for example) and an uprated Probabilistic Safety Assessment (level 1 PSA) have been submitted to and reviewed by STUK.
- Design modifications and test runs were accepted by STUK before implementation.
- The Final Safety Analysis Report (FSAR) and the related Topical Reports were rewritten. It means also that almost all transient and accident analyses were redone taking into account the uprated power level and modified plant design. The FSAR and Topical Reports have been submitted to STUK at the end of 1996.
- An operating license renewal application, covering design modifications and the power uprating, was submitted to the Council of State at the end of 1996. The A license was granted in 1998.
- The power uprating has been reviewed also according to the Environmental Impact Legislation.

Summary

The modernisation program of the Olkiluoto plant was started in 1994 and completed in 1998. Some latter installations were realised during outages in 1999. The modernisation consisted of about 40 projects. The total cost of the program was FIM 800 million. The results were

- ensured safety
- additional production capacity (over 260 MW in total)
- extended plant life time
- more competent and motivated staff.

3 Severe Accident Management at OL1 and OL2

The provisions for severe accident management were installed in OL1 and OL2 during the SAM project which was finished in 1989. The measures implemented were

- containment overpressure protection
- containment filtered venting
- lower drywell flooding from wetwell
- containment penetration shieldings in lower drywell
- containment water filling from external source
- containment instrumentation for severe accident control
- Emergency Operating Procedures for severe accidents.

Subsequent accident management activities at Olkiluoto plant comprise both the development of accident management procedures and additional plant modifications. They were initiated mainly during the OL1 and OL2 modernisation project. Some hardware changes have been implemented, others are planned. The necessary analyses are often carried out in co-operation with appropriate research institutions.

Emergency Operating Procedures for Severe Accidents

Emergency Operating Procedures for Severe Accidents have been modified in order to take into account plant modifications and to enhance severe accident management. The containment filtered venting system rupture disk line from the upper drywell will no more be closed in the beginning of an accident. This is a precaution for a possible rapid pressurisation of the containment if the generation of non-condensable gases is large. The previously manual depressurisation of the primary system in severe accidents has been replaced by an automatic actuation of the depressurisation system.

Containment filtered venting system—impact of chlorine in the filter

In a severe accident, a large amount of chlorine could be released, due to irradiation and heating, from the synthetic rubbers used as the insulation material of the electrical cables. In order to maintain the iodine retention capability, the sodium thiosulfate concentration of the filter was increased in 1999. The iodine retention capability and stability of the solution have been experimentally verified by TVO and the Technical Research Centre of Finland, VTT.

Containment pH

A large amount of chlorine, which could be converted to HCl in the containment, could reduce the pH of the water pools and wet surfaces. The chlorine originates from the synthetic rubbers used as insulation in cables. This could lead to a significant amount of elemental as well as organic iodine. Another source of organic iodine could be reactions between boron carbide in control rods, steam and iodine in the degrading core.

TVO has investigated the possibilities to enhance the retention of iodine by a containment pH control system. The solution used would be 50% NaOH, which is already normally used by the water treatment plant. A new NaOH tank has been installed. The required NaOH volume was analysed by VTT. The required volume is about 5 m^3 according to the calculations. The solution is gravity driven into a raw water storage tank near fire water outlet nozzles, from where the solution is delivered into the containment during containment water filling.

The lower drywell will be flooded from the wetwell prior to the NaOH supply and the lower drywell water pool pH will be kept above 7. The system modifications were made in 2001.

Organic iodide

VTT Chemical Technology investigates possibilities to improve the retention of organic iodide. The purpose is to find means to improve the existing containment venting filters so that they are capable of trapping the organic iodine compounds and of preventing iodine from forming organic compounds. Possible means are the oxidation of elemental iodine by modifying the chemical composition of the filter or by using catalytic oxidation. The work started with a literature study followed by experiments. The experiments will be finished in 2001.

Energetic ex-vessel fuel coolant interactions

TVO has investigated the response of concrete structures in the containment to energetic fuel coolant interactions, steam explosions, and the result is that they would withstand large steam explosion loads. Further studies will deal with the impact of possible steam explosions on the pipe penetrations and personnel access hatch in the lower drywell. The key issue is maintaining the containment leaktightness in severe accidents.

TVO has decided to strengthen the lower drywell personnel access lock. The modifications will be made in 2001 and 2002.

Diaphragm floor seal

TVO investigates how the diaphragm floor seal would behave in severe accidents. The leaktightness of the seal is important in order to maintain the pressure suppression function of the containment as long as possible.

Reliability of isolation valves

The piping part inside the lower drywell may be damaged because of contact with core debris. In order to ensure the isolation function in severe accidents, an additional second isolation valve was installed in 1998 in the nitrogen system piping lines from the lower drywell to the reactor building.

Hydrogen combustion phenomena in reactor building

During a severe accident, hydrogen gas leaking from the containment might lead to combustible hydrogen concentration in the reactor building compartments. TVO is investigating possible hydrogen combustion loads in the reactor building, including hydrogen burns and detonations. The investigations have started with the preparation of a CFD model of the reactor building to find out the hydrogen transport routes and hydrogen concentration distribution in the reactor building. Hydrogen detonation studies have been performed. An analysis of structural response will be finished by 2002. The concern is that containment penetrations might be damaged due to hydrogen combustion phenomena outside the containment which could lead to a large leak.

Primary system depressurization in severe accidents

To secure depressurisation of the reactor primary system in severe accident situations and to prevent a new pressurisation of the reactor, two valves of the relief system have been modified. It is now possible to keep the valves open with the help of nitrogen supply or water supply from outside the containment. The modification was finished in 1999.

Recriticality

The SIRM detectors will be drawn in the beginning of the accident half a meter below the active core to detect possible recriticality. Analyses were performed in 1999 to determine how to relate the reading of the SIRM monitors to actual reactor power.

4 Qualification of nondestructive testing

Organisation of qualification in Finland

The two utilities (TVO and Fortum Power and Heat Oy), the major Finnish inspection companies and VTT established a working group (nowadays steering committee) to outline a Finnish qualification system considering national objectives, purposes and situation. The principle was that no new qualification organisation should be established for these activities in Finland. The available resources and organisation should be integrated into the qualification system for inservice inspection in Finnish nuclear power plants. The document “The qualification of inservice inspections” outlines the principles followed in Finland in the qualification of pre- and inservice inspections of nuclear power plant components. The document is a living document and will be updated with experiences gained from first inspection qualifications. The document fulfils the recommendations of European methodology for qualification of non-destructive tests, second issue (ENIQ) 15.1.1997.

Organisation structure of inspection qualification

The utility has an overall responsibility for the performance of the inservice inspections. The steering committee is nominated by the utilities. For each qualification task the steering committee nominates and establishes a qualification body on the initiative of the utility. The steering committee receives an order from the utility for the qualification of an inspection, or a part of it.

Steering committee

The steering committee has an important role in inspection qualification. The main tasks of the steering committee are:

- nominate the members of the qualification body for each qualification after assessing their technical competence
- approve the level of qualification based on the safety relevance of the inspection item
- assure that the qualifications follow established practices
- improve and develop the qualification practices for nuclear power plant components in Finland
- organise and specify additional annual training arrangements for the inspectors.

Qualification body

The members of the qualification body are level 3 experts on a specific inspection technique. One is a representative of the Finnish National Qualification Body and, if needed, the others are experts from utilities or research institutes. The level 3 members or the expert members of the qualification body, usually from Finnish inspection vendors or utilities, must be independent in relation to the organisation that is taking part in the qualification.

The representative of the Finnish National Qualification Body, who is completely independent, informs and reports directly to STUK about the work of the qualification body. The main activities of the qualification body are:

- produce the qualification procedure based on the level of qualification approved by the steering committee
- assess the technical justification and the inspection procedure used in the qualification
- prepare and supervise the qualification
- issue qualification certificates
- issue a report summarising the implementation of the qualification and the invigilations and the checks performed during the qualification
- approval of test blocks.

Utility

The utility has the overall responsibility for the performance of the inservice inspections and also for the verification of the efficiency of inspections. The utility is also responsible for applying for the acceptance of different tasks from STUK. The inspection items for which qualification will be carried out are proposed by the utility. All input data necessary for the qualification will be submitted to the qualification body and to the inspection vendor by the utility.

The utility is also responsible for the preparation of the inspection procedure and the technical justification used in qualification. Normally these documents are prepared by the inspection vendor.

The utility is responsible for the procurement of the test specimen needed in the practical tests as well as for the reservation of the facilities and resources necessary for the performance of qualification.

Situation of TVO's inspection qualifications

The first totally qualified inservice inspection documents have been submitted to STUK for approval as a pilot project.

5 Sharing of experience

TVO's operating experience feedback group consists of 6 members and 3 advisors. This onsite group gives recommendations to the line organisation that makes decisions on eventual corrective actions. The industry operating experience from similar reactor types is followed by several means. The main sources of information are ERFATOM, KSU, WANO and Forsmark. These are explained in more detail below. Information is also coming directly from several sources (IAEA and OECD/NEA (IRS), Loviisa power plant (e.g. operating experience meetings and reports), vendors (Westinhouse Atom, Alstom Power Sweden AB), component manufacturers, the WANO Network, BWROG (BWR Owners Group).

ERFATOM was founded by the Swedish utilities and TVO as a consequence of the so called Barsebäck incident (July 1992). Activities started on January 1st, 1994 in the premises of former ABB Atom (Västerås, Sweden). Nowadays ERFATOM is part of the NOG (Nordic Owners Group) and issues reports every two weeks and topical reports when needed. ERFATOM also gives recommendations. ERFATOM co-operates very closely with KSU (Swedish nuclear training and safety center). KSU concentrates on operational safety issues and they have the responsibility to screen out external (international) operating events. ERFATOM screens out internal events from Swedish Nuclear Power Plants and from Olkiluoto.

TVO is a member of WANO (World Association of Nuclear Operators). Although KSU screens out important events reported through the WANO Network, TVO reviews independently all the SOERs (Significant Operating Experience Reports) and SERs (Significant Event Reports) reported by WANO. Forsmark units 1 and 2 in Sweden can be called as "sister units" of OL1 and OL2. Reports from Forsmark 1 and 2 (e.g. licensee event reports) and minutes of the meetings of the Forsmark safety committee are reviewed regularly.

In addition to the above, TVO participates actively in WANO programs and in several international technical groups (such as valve group, reactor group and turbine group) which have regular meetings about twice a year.

6 Development of the handling of modification procedures in Olkiluoto

The modification handling procedure in Olkiluoto has been under continuous development since the early 1980's.

After the modernisation program and several reviews of TVO's working methods, experiences have been collected in a separate development project. The project was realised during the years 1997–1999 and it had participants from operation, maintenance, quality assurance, safety, modification planning and refuelling planning. Special attention was placed also on the new modern automation and on modifications during the field installation phase.

The project started with exploring

1. The working procedure at present state.
2. Comments relevant to the modification procedure collected from the audit results of TVO's working methods:
   - TVO's internal audit 1997
   - modification procedures; a comparison between FKA (Forsmark) and TVO, done by VTT Automation
   - assessment of the QA-system of a nuclear power plant, done by SFS Sertifiointi
   - human errors related to maintenance and modifications, done by VTT
   - STUK's inspection A2, handling of safety questions
   - study on the control of modification work, done by VTT
   - time scheduling of modification work by TVO
   - development of modification process from year 1996, done by TVO
   - international benchmark on safety review practices at nuclear power plants, done by VTT.
3. Experiences from the modernisation program of OL1 and OL2.

On the basis of the results of the above mentioned studies and other experiences, about 60 remarks on the state of the modification process were collected to be taken into account in the development work. The target state was defined and it was also checked that all remarks had been taken into account. In addition, many new ideas were found by the project group itself.

In the development work, detailed procedures were defined making the decision process more exact and taking into account the opinions of all parties in TVO´s organisation. Some of the most significant modifications made included:

- enhanced information flow on modifications within TVO
- procedure for surveys to use the knowledge of the whole TVO-organisation and to enable also safety organisation to analyse the safety significance already in the early stage of the project
- better commitment of personnel responsible for the work
- consideration for independent review on modifications
- establishment of a basic plan for system modifications and more exact specification for system level pre inspection material

- enable comments for the modification process in early stage
- more exact content for the modification plan pointing out environmental matters, training, commissioning, spare parts
- principle of continuous improvement
- better follow up for modification process progress
- consideration of changes to the plant documentation in an early stage.

The practice has shown that there is still need for continuous improvement to keep the personnel motivated and to take into account all aspects to guarantee safe and reliable long term operation of the power plant.

General training, discussion and development seminars have been arranged to continue the modification process development and to get the working organisation committed to the new procedure.

7 Quality assurance program

TVO has developed and re-structured the quality assurance program for operation during the past three years.

The main objectives for the development of the quality assurance program have been:

- to enlarge the scope of the quality management system in practice to all processes
- to describe and manage operational functions and the interactions on the basis of the process-approach
- to make the documentation easier to find and use
- to establish and implement the procedure for the continual improvement
- to increase the level of nuclear safety.

During the development work on the quality management system, the requirements from the following documents have been taken into account:

- YVL 1.4 Quality assurance of nuclear power plants, 20 Sep. 1991
- YVL 1.9 Quality assurance during operation of nuclear power plants, 13 Nov. 1991
- International Atomic Energy Agency, Safety Series No. 50-C/SG-Q, Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations and
- ISO 9001:2000, Quality management systems.

As a result of the development work, TVO has established a new quality management system the description of which has been published as a quality management manual, internally called Performance Manual (Toimintakäsikirja).

The present Quality Assurance Manual of operation has been the Quality assurance program of the licensee accepted by STUK on the basis of Guide YVL 1.9 Quality Assurance during Operation of Nuclear Power Plants. TVO has published the internally accepted quality management system at the beginning of the year 2001. The requirements of the present Quality Assurance Manual of operation are still valid.

TVO has delivered to STUK for approval a plan for the replacement of the present Quality Assurance Manual with a new Quality management system.

TVO has delivered to STUK for approval a general description of the new quality management documents needed on the bases of Guide YVL 1.9 Quality Assurance during Operation of Nuclear Power Plants. After approval by STUK the new quality management system will replace the present Quality Assurance Manual as the operational Quality assurance program of the licensee.

ANNEX IV

Background

The term “Safety culture” was first introduced after the Chernobyl accident by the International Nuclear Safety Advisory Group (INSAG). Experts from Finland were involved in drafting the report of Safety culture (INSAG-4, 1991), and it was possible to develop the national regulations on this topic concurrently.

The nuclear legislation in Finland was totally renewed in late 1980’s. The revised Nuclear Energy Act (1987) and Nuclear Energy Decree (1988) include i.a. the basic safety prerequisites, the licensing procedures and requirements for nuclear waste management. Safety culture was formally included in the Finnish nuclear safety regulations in the Decision of the Council of State on the “General Regulations for the Safety of Nuclear Power Plants”, valid since 1st of March 1991. According to Section 4 of the Decision:

> *“When designing, constructing and operating a nuclear power plant an advanced safety culture shall be maintained which is based on the safety oriented attitude of the topmost management of the organisations in question and on motivation of the personnel for responsible work. This presupposes well organised working conditions and an open working atmosphere as well as the encouragement of alertness and initiative in order to detect and eliminate factors which endanger safety.”*

The essential cornerstones of nuclear safety culture in Finland are the commitment of the Government, the Regulatory Organisation, and the Users of Nuclear Energy (utilities).

Government

Safety culture cannot be established in an atmosphere of uncertainty. Therefore the Government has to ensure a predictable and smooth evolution of the national nuclear energy programme. In Finland this has been achieved by:

- specific nuclear energy legislation including clear duties, responsibilities and rights of various organisations
- provision of information to the public
- clear commitment to the safe disposal of nuclear waste
- clear liability for nuclear accidents
- basic nuclear training in technical universities
- national research programme covering all relevant aspects of nuclear safety
- adequate resources for the regulatory organisation
- participation in international co-operation to gain access to state-of-the-art knowledge.

Regulatory organisation

The regulatory organisations are often seen as “watch dogs” that control their “customers” on behalf of the general public. This is certainly one of their roles, but an important duty of the regulator is to support and foster the good safety performance and safety culture of the Users. In the work of the regulatory body (STUK) it is strongly emphasised that the Users of Nuclear Energy bear full responsibility for safety, and that true respect should be given to their views and proposals. Also, STUK strives to develop and maintain an exemplary safety culture in its own organisation. This aim is realised e.g. in the following principles of the quality system:

- clear organisational and personal commitment to the priority of safety
- logical and predictable regulations and behaviour in general
- frank and balanced relationship with the Users of Nuclear Energy
- questioning attitude towards one’s own work and the influences of separate actions on the culture of the power plants and
- knowledge of the state-of-the-art in the nuclear safety field.

Users of Nuclear Energy

An ultimate responsibility for safety and a strive for excellence, rather than the fulfilment of written rules, should be reflected in all arrangements of the User organisation. Following this line the Users in Finland have a steady investment programme with the aim to keep the plant status and operation at least at the level of the first start-up, and to improve reliability and safety. The Users have mainly set their own performance standards for activities they find most important to reliable and safe operation. The investments made in the training of the personnel have been at a high level and cultural aspects have been covered beside technical and operational themes.

The detection and removal of safety problems can only be done in an open atmosphere where all technical problems and human errors can be reported without a fear of negative consequences to individuals or the User organisation in general. Continuous attention requires the question, how to maintain the spirit of private initiative and the sense of personal responsibility beyond the statutory tasks of each individual among the Users' staff. An observation from the Finnish Users is that all arrangements fostering professional pride among the individual workers are important contributors to addressing this issue.

Introduction and assessment of safety culture by the regulatory body

Practical work for the systematic introduction and fostering of safety culture was started immediately after the Council of State had issued the new safety regulations in early 1991. Training was organised to all engineering and supervisory staff of both power plants as well as to the personnel of the regulatory body, with the experts of STUK giving the lectures.

After the Decision of the Council of the State on the "General Regulations for the Safety of Nuclear Power Plants" had entered into force, STUK made an assessment on how it was received at the operating nuclear power plants. A Safety Evaluation Memorandum on the safety culture at the Loviisa nuclear power plant was issued on May 3, 1991, and a corresponding memorandum on the situation at Olkiluoto nuclear power plant was issued on January 14, 1992. These memorandums discussed 13 concrete topics of safety culture.

An evaluation of the level of safety culture of the licensees was included in the renewal of operating licenses in 1998. The evaluation was based on the licensees' reports on their safety culture and also on STUK's observations in this area. In conclusion, a safety culture complying with the provisions of section 4 of the Decision of the Council of State of 1991 (cited above) was maintained by both licensees.

The essential characteristics of a good safety culture have gradually been incorporated in the Finnish regulatory guide system (YVL Guides). Especially guides concerning Quality Assurance, Operating Experience Feedback and the Qualification of Plant Personnel provide requirements related to a good safety culture. It is foreseen that during the process of updating the YVL guide system, the issue will be further addressed and emphasised to provide more practical guidance.

Safety culture has also been an essential topic in STUK's continuous interaction with the power plants. The top level inspection of the periodic inspection programme, called "Safety Management", includes an assessment of safety culture issues and quality management. In addition, STUK has emphasised that the strengths and shortcomings of safety culture are determined in quality assurance audits and root cause and other event analyses. Findings related to safety culture from different inspections, audits and event analyses are analysed in STUK and discussed in a yearly meeting between the senior managers of the nuclear power plant and the regulatory body. STUK in 1999 increased the resources allocated for this task by founding a new organisational unit, called "Human and organisational factors", in the Department of Nuclear Reactor Regulation. Presently, STUK is explicating the goals and actions relating to safety culture into a coherent national safety culture policy.

STUK has striven to develop and maintain an exemplary safety culture and to concretise the concept in everyday action. In the 80's and early 90's this aim was related to the development of quality manuals. After the most recent organisational change in spring 1997, the systematic development of a uniform quality system was started. Today, the quality manuals of STUK and specifically those of the Department of Nuclear Reactor Regulation document both managerial guidance and memory of the organisation by describing the operational practices that are experienced as good and recommendable. A good quality manual

- ensures a consistent approach to all activities
- reduces the need to "re-invent the wheel" by describing approved practices in handy forms
- facilitates orientation of the new staff members by describing principles, meanings and policies in a comprehensible way, and
- is easily updated when better practices are proposed and approved.

As a means for the further development of operation and safety culture, STUK has initiated several internal audits, self-assessments and independent assessments of its activities. The management system and work processes have been internally assessed with criteria of Quality Award twice (1996 and 2001). The methods used in event analysis were externally evaluated in 1999. The general coverage, consistency and prescriptivity of the regulatory guide system (YVL Guides) were studied in 2001 (see Annex I of the report). Experiences and opinions related to regulatory practices were collected in systematic interviews during 1998. A full-scope IRRT mission was conducted by the IAEA in March 2000. Questionnaires concerning job satisfaction and management practices are used regularly. Lately, the safety culture as a whole has been the subject of conscious assessment and development within the scope of a study carried out within the FINNUS research programme (2000; see below). As a result of these projects, development projects have been introduced some of which have already been implemented.

Manifestation of safety culture at Finnish nuclear power plants

Experience has shown that a safety culture can not be implemented in a separate action or only by written instructions. The roots of safety culture are in the national culture and in the values of organisations and individuals. Evidence of a strong safety culture should be visible in the daily activities of the plant and it's supporting organisations. In the following, a few examples of topics are mentioned, which manifest safety cultural elements at the Finnish nuclear power plants.

- Recognition by the top management of the fact that the atmosphere in all organisations is essentially created by their attitudes and practical examples and that it is manifested in their direct involvement and keen interest in matters concerning safety as well as quality assurance.
- Implementation of a number of projects to maintain and improve the knowledge and skills of the organisation and individuals, needed for the reliable and safe operation of the plants, the modifications and modernisation of technical equipment and changes ongoing in the nuclear field.
- Continuous and well tailored re-training programmes for all personnel levels to maintain staff motivation, and also to give forum to promote new ideas.
- Continuous assessment, development and updating of quality assurance manuals and procedures is important in preserving the credibility of the QA-system.
- Establishment of systematic methods to utilise operating experience from own plants as well as from other relevant sources through participation in relevant international organisations.
- Importance of housekeeping issues in all Finnish plants as of the start of operation.
- Measures to promote a positive atmosphere and the motivation of the personnel.
- Exchange of information and especially communication of planned plant activities within the organisation.
- Direct contacts between the technical personnel of the utilities and STUK are frequent, and the importance of frank relations is emphasised by the management.
- Detailed self-assessment of safety culture, discussion of the results in the management group, and implementation of the necessary improvements; discussion and improvements also on the basis of inspections made by the regulatory body as well as findings and recommendations gathered from assessments of corresponding units abroad.

Research on safety culture in Finland

The Finnish Research Programme on Nuclear Power Plant Safety FINNUS (1999–2002) aims to enhance the safe operation and maintenance of nuclear power plants The programme consists of research areas including ageing, accidents, and risks. Research related to human and organisational factors within FINNUS is called WOPS (Working practices and safety culture in nuclear power plant operation). The co-ordination group of WOPS represents relevant safety critical organisations and researchers in Finland, as well as the utilities and STUK, in order to strengthen the exchange of information. The research work is conducted by the Technical Research Centre of Finland, VTT.

Since 1999, VTT has been developing a methodology for characterising, assessing and developing organisational culture in safety critical organisations. When used together with an integrated conceptual modelling of the task and analysis of actual performance, safety culture can be described. A case study was conducted at STUK in 1999. The analysis consisted of a document analysis, interviews, a survey and a workshop for the whole staff of a department. A further assessment of the used method was carried out after the case study was concluded.

The results of the case study indicated a strong need for the clear understanding of one's own tasks in relation to the whole and a need for communication and feedback at both individual and organisational level. The perceived future threats were related to bureaucratisation and a loss of meaning felt in one's work. The regulatory culture is composed of three occasionally conflicting roles, the authority role, the expert role and the public role. The roles set conflicting demands to both the organisation and individuals, such as flexibility and creativity versus control and rigid obedience to rules. The employees of STUK valued professional knowledge, openness, courage, fairness, efficiency, a questioning attitude, teamwork and independence. The results and conclusions of the case study were broadly considered in discussions organised within the Department of Nuclear Reactor Regulation and developmental actions were carried out.

The organisational culture research methodology, although still under development and discussion, is considered suitable for use by both regulatory agencies and nuclear power plants. For further development of the methodology, a new case study is underway (2001-2002), focusing on maintenance at Finnish nuclear power plants. In addition to national projects, there has been international co-operation as part of Nordic Nuclear Safety Research (NKS), in which a safety culture interview study was conducted at Finnish and Swedish power plants. The results of the 1999 study were presented at a NKS-seminar.