REPUBLIC OF HUNGARY

NATIONAL REPORT

Document prepared in the framework of the
Convention on Nuclear Safety

2nd Report, 2001

CONTENTS

SUMMARY

The Republic of Hungary was one of the first nations to sign the Convention on Nuclear Safety (hereafter referred to as Convention) concluded in Vienna on 20th of September 1994 within the framework of the International Atomic Energy Agency. This resulted from Hungary's awareness of the fact that the main guarantee of maintaining and increasing nuclear safety lies in the collective knowledge, openness and co-operation of the international community. The Convention was promulgated in Hungary by Act I. of 1997.

By promulgating the Convention and introducing the related measures, the Republic of Hungary has fulfilled all the conditions in Article 4 of the Convention.

This second National Report has been compiled in accordance with the requirements of the Convention and of the related documents entitled "Guidelines Regarding National Reports under the Convention on Nuclear Safety" along with the recommendations based on the conclusions of the First Review Meeting.

Following a brief Introduction, the National Report contains four parts dealing with the following:

- the description of existing nuclear installations (mainly the Paks NPP which falls under the scope of the Convention);
- the characteristics of Hungarian legislation and regulations and the role of the Authority;
- general issues of safety (including the situation of financial and human resources, quality assurance, radiation protection and emergency preparedness); and
- a survey of the Safety Analysis Report of the only Hungarian nuclear installation which falls under the scope of the Convention.

By submitting the present National Report, the Republic of Hungary fulfils its obligation of reporting stipulated under Article 5 of the Convention.

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After a short review of the history of the utilisation of nuclear energy in Hungary details of the state of safety in 1997 were given in the first National Report (Budapest, 1998).

Since the submission of the first Report no basic changes have happened in Hungary. The state of the nuclear installations as well as the role and the legal position of the Authority have remained unchanged. Nevertheless, new devices have been taken into operation, new technologies have been introduced and organisational changes have taken place. The increase of safety has got major attention at these modifications. Measures introduced following the recommendations of international reviews have lead to further increase of safety.

During the execution of the actions listed above both the Authority and the Licensee profited from the conclusions of the first Review Meeting and special emphasis was given to the evaluation of the comments addressed to the Report of Hungary.

The main events that have taken place since the submission of the first Report are the following:

- the safety upgrading measures have been introduced according to the original plans;
- the periodic safety review of Units 3 and 4 was completed in 1999;
- the new ministerial decree on the basic principles of radiation protection was put into force in 2000;
- the work of the Hungarian Atomic Energy Authority was reviewed and evaluated by an IAEA IRRT mission;
- the HAEA has decided to introduce quality management system in its work.

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In the second report mainly the changes are detailed but all the still valid basic principles are repeated to present a self-standing report for the readers. Important processes unchanged since the submission of first report are taken to Annexes.

Our main goal is to convince the readers of the report that

- safety is still the top priority in the applications of nuclear energy in Hungary; and
- during the three years elapsed since the first evaluation the level of safety culture has increased and both the licensees and the authorities followed the recommendations of the Safety Convention.

Data presented in this report reflect the state of 31st of December 2000.

During the work of developing the Report the comprehensive presentation of the status of nuclear safety in Hungary was regarded as high priority issue.

The following table shows the correspondences with the Articles of the Convention.

Article (Convention)	Chapter (National Report)
4.	Summary
5.	Summary
6.	1.1, 4.3
7.	2.1, 3.8.1, 3.9.1
8.	2.1.3
9.	2.1.7
10.	2.1.1
11.	3.3, 3.4
12.	3.5
13.	3.6
14.	3.7
15.	3.8
16.	3.9
17.	4.1
18.	4.2

On the basis of details of the National Report, on behalf of the Government of the Republic of Hungary, the Director General of the Hungarian Atomic Energy Authority makes the following declaration:

Declaration

The Republic of Hungary declares that nuclear safety is given priority in all aspects and thus Hungary completely fulfils the conditions stipulated in the Convention and included in its spirit on the basis of the followings:

- *the conditions stipulated in law,*
- *the organisational and financial independence of the Hungarian Atomic Energy Authority and its licensing and inspection activity,*
- *the operator is committed to the priority and continuous improvement of safety concerning the activities it carries out.*

Budapest, September 2001.

Dr. József Rónaky
Director General of the Hungarian Atomic Energy Authority

INTRODUCTION

National energy policy

The energy policy of Hungary was approved by Parliament in April 1993 and the Government is liable to submit a report to the Parliament on the state of its implementation every two years.

The principles and strategic objectives of the energy policy approved in 1993 are in harmony with the realisation of market economy, extension of competition and with the efforts of Hungary for accession to the European Union.

A part of the strategic concepts has already been implemented, and the organisational, economic and legal conditions conforming to the market economy have also been developed.

The basic energy policy principles of primary importance are as follows:
- creating a domestic energy market taking into account the national peculiarities, complying with the principles of the unified European energy market, ensuring the competitiveness of the economy in the interests of the energy consumers;
- enforcing the environmental protection requirements with both in the existing generating or consumer equipment and in their future development in order to realise the sustainable development;
- intensifying the role of energy conservation, increasing the efficiency of the use of energy.

Another aim of the energy policy is to prepare the accession to the European Union and to modify the laws governing branches of the energy industry in accordance with the new directions of the European Union. The document entitled “Principles of the Hungarian energy policy, commercial model of the energetics” passed by the Governmental Decree 2199/1999.(VII.6.) lays special emphasize on the harmonisation of the legal framework related to the European integration process in the field of the energetics.

The role and contribution of nuclear energy

Paks Nuclear Power Plant, the only nuclear power plant of Hungary, is operating as a shareholders' company under the name of Paks Nuclear Power Plant Ltd. In 2000, the contribution of nuclear energy to the total generation of electric energy was 40.6 %, (gross energy production 14,179 GWh, net output 13,347 GWh) and this figure illustrates that nuclear energy is a vital and strategic issue not only for the electric energy supply of the country but also for the country as a whole, and this is expected to remain so in coming years.

The significance of nuclear safety

Act CXVI. of 1996 on atomic energy (hereafter referred to as the Act on Atomic Energy) stipulates that "In the use of atomic energy, safety has priority over all other aspects", and that "The Licensee is obliged to undertake continuous activities to upgrade safety". This is concordant with the spirit of the Convention on Nuclear Safety.

Since the late 1970's, in relation to the installation of Paks NPP, the Hungarian authority has recognised the significance of the issue and has required the submission of safety reports for the licensing of the installation, and prescribes the application of a quality assurance system.

In addition to enforcing conditions stipulated in legal regulations the Hungarian Atomic Energy Authority (hereafter called the Authority) also considers its duty to ensure the practical implementation of the spirit of the law in everyday work. According to the internal procedural order of the Authority, the nuclear safety inspectors are obliged to take decisions in a conservative manner biased towards safety should any not clearly assessable situation arise.

The necessity of periodic safety reviews was first raised in 1990 at a meeting of the International Atomic Energy Agency. As a consequence, Hungary introduced a decree in 1993 stipulating the performance of periodic safety reviews and the submission of safety reports containing the results of such assessments. The first periodic safety assessment of Paks NPP was completed for Units 1 and 2 by the end of 1996 and for Units 3 and 4 by the end of 1999. On the basis of the safety reports submitted by the Paks NPP the Authority extended the validity of the long-term operation license and, at the same time, prescribed further safety upgrading measures.

International reviews

Since commencing operation, Paks NPP has paid special attention to utilising international experience, and on the initiative of the power plant 24 international reviews took place since 1984. All kinds of important reviews organised by the International Atomic Energy Agency have been performed at the nuclear power plant.

The activities of the Authority were surveyed by projects performed by the European Union delegated RAM Group and by the IAEA IRRT Mission. The groups were basically satisfied with the results, however, they formulated several proposals. The new regulatory system introduced in the late nineties took into consideration the suggestions of the first RAM project. The recommendations of the second RAM project and the IRRT mission have played significant role in the development of new working methods in the Authority.

International relations

In Hungary both the Licensee and the Authority maintain wide ranging relations with various international and national nuclear organisations, professional bodies, institutes, nuclear power plants abroad, companies involved in the design, manufacture and implementation of nuclear facilities and research institutes.

These relations serve to interchange knowledge and experience. The fact that Hungarian experts are held internationally in high esteem is demonstrated by their taking active role in several committees, with many of them being board members of international organisations or invited as experts.

The Hungarian Atomic Energy Authority (Authority) is authorised counterpart of and co-ordinates the Hungarian participation in their activity.

International bodies of major importance are: the International Atomic Energy Agency (IAEA), the OECD Nuclear Energy Agency (NEA), the World Association of Nuclear Power Plant Operators (WANO), the WWER-440 operators' club, the WWER users' group, the International Nuclear Safety Programme (the so called Lisbon Initiative), the Nuclear Maintenance Experience Exchange (NUMEX) and the European Atomic Energy Society (EAES). The Hungarian Nuclear Society is member of the European Nuclear Society (ENS), and the Health Physics Section of the Roland Eötvös Physical Society is member of the International Radiation Protection Association.

The Authority has established technical co-operations with authorities of WWER operating countries via the WWER Regulators' Forum. The Authority has signed mutual information exchange agreements with the organisation of Canada, France, Romania, Russia, United Kingdom and the United States of America. The Authority has benefited from the technical co-operation programmes of the International Atomic Energy Agency and from several projects of the European Union's PHARE programme. Hungary has been a member of OECD since 1996, there are Hungarian representatives in eight committees of the Nuclear Energy Agency. The Authority takes an active part in the work of the "CONCERT" group, the Network of Regulators of Countries with Small Nuclear Programmes (NERS) and in two European Commission operated groups: Nuclear Regulatory Working Group (NRWG) and European Nuclear Installation Safety Group (ENIS-G).

The technical support organizations of the Authority take part in research activities co-ordinated by the US NRC.

1. EXISTING NUCLEAR INSTALLATIONS

1.1 Paks Nuclear Power Plant

The scope of the Convention includes all four operating units of Paks NPP. The units were commissioned between 1983 and 1987 and are in good technical condition.

Paks Nuclear Power Plant Ltd. is a state owned economic entity. More than 99 % of the shares are held by the Hungarian Electricity Board Ltd. (with an authority granted by the state) while the remaining less than 1 % is held by local authorities. Proprietors' rights are exercised in the same proportion.

1.1.1 Main technical characteristics

The main technical data of the units of the Paks NPP are summarized in the Table 1.1.1-1

Table 1.1.1-1. The main technical characteristics of a unit of the Paks NPP

Reactor Type	pressurized-water, water-cooled, water-moderated power reactor, type: V-213
Thermal power of the reactor	1375 MW
Electric power output of a unit	460 MW (2 turbines/unit): 2∗230 MW)
Number of primary loops by a unit	6
Volume of the primary circuit	237 m^3
Pressure in the primary circuit	123 bar
Average temperature of the primary coolant	282 ± 2 °C
Height/diameter of the pressure vessel	11.8 m/ 4.27 m
Enrichment of the fuel	2.4-3.82 %,
Fuel quantity per unit	42 tons U in 349 fuel assemblies
Number of turbines per unit	2
Pressure in the secondary circuit	46 bar

Paks Nuclear Power Plant Ltd. operates four pressurised-water units of type WWER-440/V-213: the moderator of the reactors and the coolant is light water. (According to its safety philosophy, the power plant belongs to the group of second-generation WWER-440 nuclear power plants.) The reactor has six cooling loops each connected to a steam generator. Each power plant unit is supplied with a so-called localising tower (operating on the bubble condensing principle) connected to airtight rooms for the managing the accidents caused by pipe ruptures. In these towers, trays filled with water containing boric acid are layered one above the other, completed with air traps. This system of airtight rooms and localising towers makes up the pressure suppression containment for the reactors.

Each unit is furnished with three active safety systems, and in case of off-normal events their electrical supply is ensured by diesel generators. These systems are supplemented by passive systems. Two saturated (wet) steam turbines operate in each unit. The rated thermal power of each unit is 1375 MW, and the rated electric power of the units are 467 MW_e, 468 MW_e, 460 MW_e and 471 MW_e, respectively.

The designers of the power plant chose the twin-unit version previously used successfully in the Soviet Union. This implementation has numerous technological advantages. The turbine hall common for the four units and the reactor halls shared by two units each enable common use of high value maintenance equipment among the units. The shared installation of certain auxiliary systems that are not in constant use reduces investment costs, and their more rational construction also increases reliability. As far as flexibility and reserve formation are concerned, power plant auxiliary systems that are in common use are more advantageous as compared to having them built separately for each unit.

At the same time, the main components and safety systems of the units are independent of each other, the single exception being the emergency cooling water system, where the pressure leg from the pumps to the pressure-equalising tank is shared by two units. (As parts assigned to a single unit can be detached from the common system, the possibility of retroactions can be excluded. However, should the emergency cooling water system be exposed to external impact, both units would be affected.)

Taking the advantages of a common site and the adjacent location of units, the supply systems were designed to be shared by the whole power plant. Therefore, the supply of compressed air, hydrogen and nitrogen, together with the oil handling system are shared by all four units.

1.1.2 Safety reviews

National and international reviews have always been important and promoting elements of the constant endeavours aimed at assessing and increasing the safety of the nuclear power plant facility.

The list of international safety reviews performed at Paks NPP is contained in Table 4.3.8-1. In addition, the AGNES (Advanced and General New Evaluation of Safety) project was of great significance in performing the safety assessment of the nuclear power plant to the accepted international standards of the 90's. Detailed information about the project can be found in the first National Report (1998). The periodic safety review of Units 1 and 2 was completed in 1996 and for Units 3 and 4 in 1999.

The conclusions arising from the reviews were on the whole positive. However, they all highlighted several problems which were dealt with in the following years by scheduled upgrading measures. The realisation of measures aimed at the removal of deficiencies has played a significant role in the further improvement of power plant processes, and in raising safety levels.

Within the scope of the upgrading measures numerous projects has already been implemented while the accomplishment of some long-term projects requiring significant resources is expected in the coming years. The safety upgrading modifications and developments are described in the Chapters 3.7.5 and 3.7.6.

On the basis of the results of the assessments described here and in Section 4.3 in detail, it can be stated that Hungary has fulfilled all those requirements stipulated in Article 6 of the Convention.

1.1.3 Interim storage of irradiated fuel assemblies

Since the possibility to return irradiated fuel assemblies from Paks NPP to the Soviet Union and later to Russia has become increasingly uncertain, the construction of an interim storage facility on the site of the nuclear power plant became necessary. The nuclear power plant commissioned the English company GEC Alsthom to build a dry storage facility of the MVDS type. One of the advantages of this type of construction and storage technology is that the number of storage vaults can be increased in a modular system. The positioning of modules in a row allows the use of a common reception building and loading equipment. Each module is capable to house 450 fuel assemblies.

Irradiated fuel assemblies are held individually in vertical tubes in the storage building. In order to prevent corrosion processes during long-term storage, the storage tubes are filled with nitrogen gas and are placed in vaults surrounded by concrete walls. The removal of the residual heat generated by the irradiated fuel is obtained by natural flow of air through the vaults and the connected stack system. This cooling process is self-regulating. The cooling air does not come into direct contact with the fuel assemblies as they are in a sealed environment.

The storage facility is intended to store the irradiated fuel assemblies discharged from the reactors for a period of 50 years.

The capacity of the first phase of the Interim Storage of Irradiated Fuel ensures the storage of (11 modules) 4,950 fuel assemblies. This amount equals to the number of irradiated assemblies generated during 10 years of operation of all four units. Should it become necessary, the capacity of the facility can be increased for the interim storage of all irradiated fuel generated during 30 years of operation.

In the first phase 7 modules have been built and further 4 modules are under construction. Some 1800 fuel assemblies have been loaded by the end of 2000. In February 2000, the operation license of the Interim Spent Fuel Storage Facility, which is valid up to 31st August 2008, was given to the Public Agency for Radioactive Waste Management (the previous licensee was the Hungarian Power Companies Ltd.).

1.2 The Budapest Research Reactor and the training reactor of the Budapest University of Technology and Economics

Though these reactors do not belong to the scope of the Convention, they are considered worth mentioning here.

The Budapest Research Reactor operated by KFKI Atomic Energy Research Institute was built in 1959 and its full reconstruction was carried out between 1986-1993. The valid safety report meets all the requirements of both domestic regulations and those contained in International Atomic Energy Agency recommendations. A new accident prevention programme was prepared and accepted. A cold neutron source facilitating enhanced solid state researches was installed in 2000.

Main technical data of the reactor:

- tank-type reactor, the material of the tank is an aluminium alloy;
- coolant and moderator: light water;
- fuel: VVR-SM, 36 % enrichment;
- rated thermal power: 10 MW.

The reactor operated by the Institute of Nuclear Techniques at the Budapest University of Technology and Economics was built in 1972 for educational and research purposes. Based on a Periodic Safety Review performed by the Authority in 1996, the licence was renewed for a further 12 years.

Main technical data of the reactor:

- swimming pool type reactor;
- coolant and moderator: light water;
- fuel: EK-10, 10 % enrichment;
- rated thermal power: 100 kW.

2. LEGISLATION AND REGULATIONS

2.1 Legal and organisational framework

2.1.1 The Act on Atomic Energy

The Hungarian Parliament approved the current Act on Atomic Energy in December 1996 (Act CXVI. of 1996 on Atomic Energy) which entered into force on 1st of July 1997. The Act on Atomic Energy considers all legislative, authority-related and operation experience gained during the construction and operation of the nuclear power plant; considers the technological development achieved since the issue of the previous Act on Atomic Energy, our international obligations, and obviously integrates the requirements of the Convention as well. The main criterion and key point of this is Subsection (2) of § 24 which states: "In the use of atomic energy safety has priority over all other aspects.".

Thus the Act on Atomic Energy provides the basis to fulfil the requirements stipulated by Article 10 of the Convention.

For the development of Act on Atomic Energy the recommendations of the European Union, the International Atomic Energy Agency as well as the OECD Nuclear Energy Agency were considered.

The main characteristics of the Act on Atomic Energy and the changes compared to previous regulations are as follows:

- the facility-level licensing authority of nuclear installations was entrusted to the Hungarian Atomic Energy Authority;
- declaration of the priority of nuclear safety;
- the definition and allocation of the tasks of ministries, national authorities and bodies of competence in licensing and supervising procedures;
- declaration of the organisational and financial independence of the Authority;
- utilisation of human resources, education, research and development;
- defines the responsibility of the Licensee for all damages caused by the use of nuclear energy, and fixes the sum of indemnity in accordance with the Revised Vienna Convention;
- entitles the Authority to impose fines should rules be broken;
- prescribes the establishment of a Central Nuclear Financial Fund for financing the final disposal of radioactive waste, the interim storage and final disposal of irradiated fuel elements and the decommissioning of nuclear installations.

2.1.2 The implementation of the Act on Atomic Energy

Several regulations: government decrees and ministerial decrees have been issued for the implementation of the requirements of the Act on Atomic Energy and the issue of further regulations are expected continuously.

The control and supervision of the safe use of nuclear energy is the task of the Government. The Government implements its tasks through the Hungarian Atomic Energy Commission, the Hungarian Atomic Energy Authority and the responsible ministers.

In matters related to peaceful uses of atomic energy the Hungarian Atomic Energy Commission is responsible for the decision preparation, co-ordination and, in specified matters, decision making as well as controlling governmental commission. The members of the Hungarian Atomic Energy Commission are executive officers of the ministries and the central administrative bodies. The president of the Commission (who at the same time supervises the Hungarian Atomic Energy Authority on behalf of the Government) is appointed by the Prime Minister from among the members of the government. The president of the Hungarian Atomic Energy Commission performs the activities related to this position independently of his responsibilities as a minister.

The statute of the Hungarian Atomic Energy Commission and of the Hungarian Atomic Energy Authority is regulated by the Govt. Decree 87/1997. (V.28.).

The presentation of the Hungarian Atomic Energy Authority (the Authority) is contained in Section 2.1.3.

Most of the official issues related to the safety of nuclear installations, in particular in respect to the nuclear power plant, are regulated by the Govt. Decree 108/1997. (VI.25.). The following standards were issued as schedules to this decree:

1. Licensing procedures applied to nuclear power plants
2. The quality assurance standard of nuclear power plants
3. General requirements for the design of nuclear power plants
4. Operational safety requirements of nuclear power plants
5. The nuclear safety standard of research reactors

The standards entitle the Director General of the Authority to issue guides concerning the actual implementation of the requirements. By the end of 2000, 52 guides have been issued and the issue of 9 further guides is expected in 2001. These guides cover issues like classification of equipment and lifetime management connected with the future tasks of the nuclear power plant. Following the 5-year review cycle of the guides prescribed in regulations, the review of the previous guides has been also commenced.

Further detailed regulation of the tasks related to the implementation of legal requirements is ensured by the internal procedural order in the case of the Authority and by the internal system of regulations and instructions prepared and operated by the Licensee.

2.1.3 The Authority

In the case of nuclear installations as defined by Article 2 of the Convention, the relevant authority in Hungary is the Hungarian Atomic Energy Authority, according to Subsection (4) of § 8 of the Act on Atomic Energy; its official tasks related to the Convention are contained in points a) to j) of Subsection (2) of § 17.

The Hungarian Atomic Energy Authority (the Authority) is an administrative body operating in the area of peaceful use of nuclear energy, under the supervision of the Government. It has its own tasks and own official scope of competence and is independent both organisationally and financially. Since the submission of the first National Report (1998) the status of the Authority has remained unchanged.

The Authority's scope of competence comprises the nuclear safety licensing (on the levels of the facility, systems and components) and supervision of nuclear installations, the record and supervision of radioactive substances, the licensing of the transportation and packaging thereof, the licensing of nuclear exports and imports, the evaluation and co-ordination of research and development, the performance of authority-specific tasks related to the preventing of nuclear accidents, and the maintenance of international relations. A new task of the Authority is to represent Hungary in the discussions concerning the accession of Hungary to the European Union. The Hungarian Atomic Energy Authority co-ordinates of all issues related to nuclear energy and radiation protection in the chapters "Energy" and "Environmental Protection".

It is the duty of the Authority to perform the tasks generated by the convention concluded with the International Atomic Energy Agency about the non-proliferation of nuclear weapons, along with the registration and supervision of nuclear substances.

The disposition of the Act on Atomic Energy concerning the financial independence of the Authority will be described in detail under Section 3.3.1 of the Report.

The human resources of the Authority will be described under Section 3.4.1 of the Report.

The activity of the Authority was surveyed by an IAEA IRRT (International Regulatory Review Team) mission in 2000. On the basis of the recommendations of the mission as well as of the findings of the Authority itself and in following the new tasks of the Authority, minor organisational changes have been carried out from 1st of August 2000.

In accordance with the two-tier administrative system existent in Hungary, an organisational unit of the Authority (the Nuclear Safety Directorate) acts as an authority in the first instance in the case of nuclear safety issues, while in the second instance the Director General of the Authority proceeds. The main organisational units of the Nuclear Safety Directorate are as follows:

- the Department for Licensing;
- the Department for Inspections;
- the Department for Technical Support being responsible for analysing and accident prevention activities; and
- the Section of Strategic Affairs is responsible for the enforcement of nuclear safety; reviews and updates laws, regulations and guides and keeps contacts with the counterpart organisations.

These organisational units operate under the direct control of the Deputy Director General in charge of the Nuclear Safety Directorate of the Authority.

Other official tasks of the Hungarian Atomic Energy Authority and maintenance of international relations are undertaken basically by the other organisational unit of the Authority, the General Nuclear Directorate.

The main tasks of the General Nuclear Directorate are:
- to perform the tasks imposed on Hungary by the Safety Convention about the non-proliferation of nuclear weapons (Department of Nuclear and Radioactive Materials);
- to survey the legal situation related to the accession of Hungary to the EU, to co-ordinate duties in connection with the harmonisation process including the analysis of regulations on radiation protection (Department of EU Co-ordination and Theoretical Radiation Protection);
- to maintain external relations and to perform tasks related to the public information (Department of External Relations).

The Section of Legal Affairs, the Section of Informatics and the Department of Economy as well as the management of the quality control operate under the direct control of the Director General.

In the licensing procedures of the Authority related to nuclear safety, all other competent administrative bodies take part as specialised authorities.

Regulations allow the involvement of professional experts (both institutions and individuals) in all cases when the Authority itself does not possess the expertise required.

In order to support its activity, the Authority has concluded separate agreements with several scientific institutions. Such an agreement seals the co-operation with the KFKI Atomic Energy Research Institute, the Institute of Nuclear Techniques at the Budapest University of Technology and Economics, the Department of Radiochemistry of the Veszprém University, the Electrical Power Research Institute Ltd. and the Institute of Isotopes.

The support organisations carry out expert and scientific activities not only for the Authority but for the nuclear institutions as well. These organisations may perform contractual work for several institutions, but a particular expert or scientist is allowed to discharge expert duties at a given time and in a particular theme exclusively for the operator or the Authority and not for both parallelly. A relatively comprehensive system of censure, the internal quality assurance system of the support organisations and the careful selection censors guarantee the independent decision-making in the Authority.

Foreign institutions and experts have also been involved in particular studies.

In addition to those listed, and in accordance with Subsection (5) of § 8 of the Act on Atomic Energy, the work of the Authority is supported by the common Scientific Council of the Hungarian Atomic Energy Commission and the Hungarian Atomic Energy Authority. This council is made up of nationally recognised members of national reputation and its task is to take position over substantial issues of principles and research and development related to nuclear safety and the prevention of nuclear accidents.

On the basis of the above it is stated that the Authority holds all the necessary resources to establish a safety culture of an appropriate standard and meets the requirements stipulated under Article 8 of the Convention.

The Ministry of Health undertakes the tasks of the authority regarding issues related to radiation protection (radiation protection of employees and of the public, performance of tasks related to public health and radiation health matters) and concerning the facility-level licensing and supervision of the storage of radioactive wastes. All other competent administrative bodies take part as specialised authorities within the licensing procedure of the Ministry of Health.

2.1.4 Licensing procedure

The basic principles of the licensing procedure of the nuclear power plant facility and the sphere of authorities taking part in the licensing procedure are regulated by Chapter III. of the Act on Atomic Energy.

For the establishment of a new nuclear power plant or new nuclear power plant unit(s) the preliminary consent in principle of Parliament is required when starting preparatory works, and for keeping the proprietorship of a nuclear power plant in operation and the transfer of the right of operation through any legal construction the preliminary consent in principle of the Government is required.

In concordance with regulations in force, a licence should be obtained from the authorities for all operating periods (site selection, construction, commissioning, operation, decommissioning) during the lifetime of the nuclear power plant. Moreover, a separate licence must be obtained for all changes of construction on the plant or component level. Within the licensing procedures, the technical aspects are enforced by the specialised authorities designated by law. The Authority has to take into consideration the opinions of the specialised authorities. When installing a nuclear power plant, a prerequisite to the starting of the licensing procedure is holding an environmental protection licence. The licences issued on the basis of Act XLVIII. of 1994 (Generation, transportation and supply of electric energy) are also required for the installation and legal operation of the nuclear power plant.

Licences are valid for a determined period of time, and can be extended upon request if all requirements are met.

The Licensee may seek legal redress against the resolution of the Authority, and the appeal against the official resolution can be re-assessed. Legal action can be brought against a decision, which has been re-assessed.

The previous licensee of the units of the nuclear power plant was the Hungarian Electricity Board. Since 1st of January 2001 the Paks NPP Ltd. holds the operation license. The new Licensee is obliged to completely fulfil all tasks defined in the safety licenses related to the operation of the nuclear power plant units issued for the previous licensee.

The periodical reassessment of the safety of the nuclear power plant performed every ten years on the basis of a comprehensive, predefined program is the Periodic Safety Review. Decision on the further validity of the operation license is taken within the framework of this programme.

2.1.5 Inspection and assessment

The Act on Atomic Energy stipulates that nuclear energy can only be deployed in the way defined by law, and with regular inspection and assessments by the authorities. The licensing authority is liable to check the compliance with all legal stipulations, and the safety of the application of nuclear energy.

The Authority is entitled to perform inspections both with previous notice, or without, should it be justified. The inspection can be performed periodically in order to continuously assess the safety of the nuclear power plant unit; based on a comprehensive predefined programme or specifically related to a particular event or activity. The inspection performed by the authority is defined as the observation of an activity carried out on site, the inspection of any documentation, or the checking of a report prepared by the Licensee, or any combination of these. The Authority prepares a programme for comprehensive and periodic inspections, and notifies those involved in due time. Inspections or the evaluation of such inspections can also be performed by external experts or expert bodies upon the written commission of the Authority.

In addition to the Authority's inspection activities, the specialist authorities taking part in the licensing procedure also perform separate official inspections.

In order to ensure the controlled deployment of nuclear energy and to evaluate the activity of the Licensee, the Authority operates a reporting system. The reports are detailed so as to enable the independent assessment, review and evaluation of operating activities and events having taken place.

The inspection of events affecting safety that have occurred during operation and the identification of causes and the taking of measures in order to prevent their repeated occurrence is primarily the task of the nuclear power plant.

Any event affecting nuclear safety should be reported immediately by the Licensee to the Authority in accordance with the regulations in force. On the basis of this notification and of the report prepared pertaining to the inspection carried out by the Licensee, the Authority analyses and evaluates the event and initiates further measures if necessary.

On the basis of the recommendations of the IRRT mission the Authority has improved its supervisory process. Within the frame of this process the Authority introduced an integrated, comprehensive inspection system to be performed in the form of group activity and extended its activity for retracing the events and analysis of safety.

2.1.6 The enforcement of the legal mandates of the Authority

The conditions of the enforcement of the legal mandates of the authorities are contained in Act IV. of 1957 regarding the general rules of administrative procedure, Act IV. of 1978 concerning the Penal Code and in the Govt. Decree 87/1997. (V.28.).

The Authority, in order to enforce the requirements of the regulations in force may initiate an administrative procedure and within the framework of this may oblige the Licensee to eliminate the detected deviation. The Act on Atomic Energy enables the Authority to revoke the licence of the nuclear power plant, or to restrict the period of its validity.

The Authority can oblige the Licensee to pay a fine if it infringes any regulation or safety standard, fails to meet any of the stipulations of any individual official licence issued on the basis of the above, or fails to meet an obligatory standard. If the Licensee infringes the requirements contained in the approval of the specialised authority involved in the licensing procedure, the Authority, upon the request of the specialist authority, conducts the procedure to fine. Fining can also be used independently as an instrument of sanctioning, but it can be also accompanied by other sanctions.

The regulations in force contain the possibility to sanction not only against the nuclear power plant as an establishment, but also against persons employed in the area of the application of nuclear energy.

Principles and objectives formulated during the periodical revisions of the Safety Guides required by the law in every five years serve to strengthen the power of the Authority. Accordingly, one aspect of revisions is to ensure enforceability. It is achieved by technical and legal amendments founded on practical experiences gathered during near five years of application of existing rules.

Revision of the principles helping to fulfil the requirements of rules has also been commenced. Correction and adjustment of rules and regulation on areas having no guidance so far, will improve the enforceability of upper-level rules.

Discharging of legal authority will be facilitated by the enforcement policy formulated in 2000 as the legal aspect of Safety Policy issued in 1996. The enforcement policy summarises the objectives and necessity along with the legal resources. The enforcement activity is performed according to a written procedure. This procedure is an internal document of the Authority but it is expounded to the Licensees, mainly to call their attention to the examples of enforcement included.

The objective of the enforcement policy is to forestall efficiently the infringing of existing rules; and to facilitate the early, voluntary revealing of discrepancies; to support their reporting and correction - even by means of sanctions, if necessary.

For achieving this objective the Hungarian Atomic Energy Authority declares the enforcing measures intended in the case of various particular discrepancies, including assessing a fine according to regulation, taking into account the effect of the discrepancy onto the nuclear safety.

2.1.7 Communication policy of the Authority

The Authority is striving to thorough presentation of its work. Its annual reports are published in the media.

In case of nuclear disturbances press releases are issued by the nuclear operators, the Authority takes part in the classification of the events into the International Nuclear Event Scale (INES). An Internet-based service is integrated into the communication policy of the Authority. Regulations concerning the users of nuclear energy, the R&D results related to the activities of Authority, reports about emergency preparedness, reports of international revisions and missions, along with topical information and news are published on Internet. One can find the National Report on the home page, both in Hungarian and in English.

2.1.8 Responsibilities of the Licensee

The Act on Atomic Energy primarily makes the Licensee responsible for the safe use of nuclear energy and the fulfilment of safety related requirements. The basic responsibilities of the Licensee are as follows:

- to establish the technical, technological, financial and personal conditions for safe operation;
- to prevent the occurrence of an unintentional and uncontrolled nuclear chain reaction;
- to prevent the evolution of any unacceptable damage affecting employees, local public, the environment or material assets, caused by ionising radiation or any other factor;
- to maintain the radiation exposure of the employees and the public at the lowest level reasonably achievable;
- to continuously check radiation levels and provide the local public with relevant information;
- to minimise the production of radioactive waste;
- to carry out continuous activities in order to increase safety, and to finance the costs of related research and development activities;
- to regularly revise and upgrade his own regulatory system serving to fulfil the safety related requirements;
- to take into account the limits of human performance from the aspect of safety;

- to fulfil the obligations of the Republic of Hungary arising from the international contracts in the field of peaceful uses of atomic energy;
- to ensure that the qualifications, professional education and health of the employees are in line with the requirements prescribed;
- to hire subcontractors and suppliers only that have an appropriate quality assurance system;
- to ensure the financial coverage of indemnity (insurance);
- to appropriately handle extraordinary events;
- to indemnify within a limited time under a certain amount for the damages caused;
- to ensure the safeguarding of the establishment by armed guards, and to prevent unauthorised persons from access to nuclear materials and equipment;
- to make regular payments into the Central Nuclear Financial Fund to cover the costs related to the final disposal of radioactive waste, the interim storage and final disposal of irradiated fuel and the decommissioning of the nuclear power plant.

From those listed under Section 2.1.7 it can be stated that the Republic of Hungary fulfils all stipulations in Article 9 of the Convention concerning the responsibilities of the Licensee.

3. GENERAL SAFETY ISSUES

3.1 The safety policy of the Authority

The Authority plays a prominent role in the inspection system of the safety of nuclear installations whose operation is regulated by law. The Authority as an organisation functions on the basis of unified principles, and its work is independent of the subjective views of individuals.

The documents issued by the International Atomic Energy Agency set the basic principles of safety. These are the principles which the Hungarian Authority follows and applies taking into account the fact that each country has to follow its own practice in the actual implementation. The "Safety Policy and the Operational Principles of the Authority" is the basic document of safety and it was supplemented in 2000 by the document entitled Enforcement Policy. In the spirit of these documents several assessments were performed by the Authority to survey the operator's safety culture. The Authority evaluates the level of its own safety culture through self-assessment. Internal safety assessments have been performed every two or three years among the Authority staff in the form of anonymous questionnaires. The IRRT mission of the International Atomic Energy Agency and the RAMG project also contributed to the self-assessment of the Authority.

3.1.1 Objectives

The key objective of the Authority's activities is to ensure that the local public, the environment and the operating personnel do no suffer any damage due to effects generated by the nuclear installation. It is also the Authority's objective to make the Licensee completely fulfil his tasks related to his responsibility to maintain the full scale safety of the nuclear installation throughout its entire lifetime. The Authority exercises its inspection activities in order to reach these goals, and these activities comprise licensing, inspection, supervision, analysis, evaluation and the enforcement of laws.

It is also an objective to constantly raise the standard of safety culture both for its own operation and for the organisations under its supervision.

The fulfilment of all principles and criteria defined by the Authority is the warranty to reach the above objectives.

3.1.2 Responsibility

The Authority is responsible for the licensing and inspection of nuclear installations, systems and components along with the enforcement of official requirements.

In order to achieve this goal, the Authority should be independent, competent and duly prepared, it should clearly understand all processes under its supervision and should be open toward society and associated authorities. It has to make all the efforts necessary to obtain and retain the confidence of the population and it should make itself understood by the public. The Hungarian Authority meets all the above requirements.

In addition, the responsibility of the Authority includes the accident prevention activity described in Chapter 3.9 of this Report. It is prepared to act as an independent assessor and advisor in such a process by giving diagnoses and prognoses at an early phase of a potential nuclear accident. It is also prepared to take part in the approval of the schedule prepared by the Licensee concerning the necessary measures to prevent the accident and in the checking of the Licensee's emergency preparedness.

3.1.3 Basic principles of the operation of the Authority

The function of the Authority is regulated by the Government, in accordance with the Act on Atomic Energy. The rules regulating the work and the activities of the Authority are all aimed at maintaining risks to a minimum, but the principle of *reasonably low risk* should be kept in mind at all times.

It is the responsibility of the Licensee to keep the risk on an appropriate level. In the field of safety improvement measures, however, the Authority should also set a priority list. Priorities should be examined not only from the point of view of the reduction of risk but also to take costs into account.

Technical problems and human mistakes can be defined as initiators of accidents, thus the primary task is to minimise the frequency of these. The secondary task is to mitigate the serious consequences originating from multiple failures, for the accomplishment of which the weight of components in the process of accident evolution and the availability of systems suitable for relieving interventions must be known.

The probabilistic and deterministic approaches should be used in a complementary way for assessing safety and when identifying weak points.

The Authority follows the above principles in its work.

3.1.4 The practical side of the Authority's work

The Authority makes every effort to handle issues in a rapid and exact manner, but speed must never jeopardise precision. If, for any reason, an uncertainty arises the Authority decides in favour of greater safety.

The Authority, when performing administrative tasks, considers the aspects of the Licensee as far as possible.

The Authority endeavours to weigh issues according to their importance. Importance is determined in relation to safety. Such weighting may not be a reason for breaching regulations prescribed by law, or for neglecting or denouncing the tasks prescribed by law.

It assesses the severity of occurring off-normal events by processing them in an increasingly precise manner and initiates the feed-back of experience gained into the operation process.

A clear picture should be obtained about the performance of the Licensee including its strengths and weaknesses and their changes over time. It is not allowable to define irrational requirements and conditions.

High standards of work should be ensured through the operation and continuous maintenance of the internal quality assurance system. The quality assurance system of the Authority is described in Chapter 3.6.3.

3.2 The safety policy of the Licensee

The Govt. Decree 108/1997. (VI.25.) concerning the implementation of the Act on Atomic Energy consistently applies the principle of priority to safety, by obliging the Licensee to have prepared a safety policy by the time the application for a commissioning licence is submitted at the latest. The role of this document is to contain the concepts and objectives of the Licensee related to safety and to reflect in a convincing manner the fulfilment of the principle of nuclear safety having priority before all other aspects.

The same Govt. Decree obliges the Licensee to perform the preparation of the Safety Policy and to check the fulfilment of all safety requirements, together with the establishment of its own internal supervisory body. Such a body is to be independent of operation control.

The Safety Policy (as a document) was created in order to summarise the main safety-related activities of Paks Nuclear Power Plant Ltd. and to proclaim the principle of the priority of safety: "... the management of the Paks Nuclear Power Plant Ltd. ... considers that, in the operation of the nuclear power plant, the preservation and improvement of safety, and primarily nuclear safety is the key issue... ". The Safety Policy itself illustrates the possibilities of realising this basic principle along with the set of instruments that can be used for its accomplishment. It deals with the definite methods of practical implementation only indirectly, since these are enforced through regulations, procedural orders and instructions at a lower level.

During the time elapsed since the definition of the objectives of the Safety Policy in 1993, most of the requirements included in the policy have been fulfilled. To meet new expectations and conditions the Safety Policy has been completely revised in 2000.

In order to maintain and enhance safety, the safety policy of the Paks NPP determines responsibilities and formulates expectations for each employee. It stresses the importance of the general responsibility of the director general and the particular responsibility of the safety director for the realisation of safety and protection of the operating staff, the public and the environment. The Safety Policy emphasises the importance of the commitment to safety, its manifestations in endeavouring to safety, in revealing the factors compromising the safety and in upgrading the safety culture. It stresses the importance of the education, information and the backfitting mechanism for enhancing the safety.

The Safety Policy sets concrete safety objectives to the particular jobs.

According to the Safety Policy, a suitable programme should be at hand to control and supervise the operation and other activities.

3.2.1 The responsibility of executives

The Director General of the nuclear power plant is responsible for the proper and safe operation of the power plant as well as for the quality. He is assisted by the Director of Safety who holds a transferred right of competence.

The executives are responsible, within the framework of their organisation, for the fulfilment and enforcement of safety requirements in addition to the enforcement of the Safety Policy.

In order to define the various tasks, responsibilities and competence together with legal responsibilities, the Director General set up the regulatory hierarchy defined in their Quality Assurance Manual. Job descriptions also lay down rights and areas of competence.

3.2.2 The role of the personnel in maintaining operational safety

All members of the *operating staff* hold qualifications and training necessary for the accomplishment of their particular function. Qualifications are received by passing an examination that is either performed within the plant or before the representatives of the Authority, depending on the potential effect on safety of the particular position. This licence examination should be repeated at regular intervals. The training and qualification requirements toward operating staff working in shifts and employed by the operating organisations are contained in the Education Manual. The shift operating personnel may transfer their responsibility to other individuals in a regulated manner only and under regulated circumstances, be it during normal operation or in the case of an off-normal event. The unit control room activities of non-shift executives are also regulated. Direct intervention into the operation process can only be executed by persons holding appropriate qualifications, and they can only do so if this is prescribed in their job descriptions and they are performing shift operator service according to the appropriate sequence. Other persons are forbidden to intervene directly.

It is the task and responsibility of the *maintenance staff* to keep all power plant equipment in a reliable and operable condition. The maintenance process of the nuclear power plant is continual and follows a structured format with work instructions. An administrative instruction guarantees that only those jobs are accomplished which are planned and well prepared and given the appropriate licences. Inspection and assessment functions are integrated into the work process in a way laid down in the procedural order. The Maintenance Training Center of the nuclear power plant contributes to the preparation of the maintenance staff (detailed information on the Maintenance Training Center can be found in Chapter 3.4.2).

It is the task of the maintenance organisations to maintain and reconstruct all installations, to handle failures and prepare them for official inspections, to execute all welding and technological assembling works, repair and manufacturing tasks occurring at the nuclear power plant, along with the planning and provision of all safety, human resource and material related conditions necessary for such works.

It is the task of the maintenance staff to precisely document all accomplished works and to archive these documents.

The tasks of the *technical support organisation* are as follows:

- elaboration of safety analyses;
- preparation of reactor physics calculations;
- definition of the scope, time schedules and cycle times of technological tests;
- preparation, conciliation, review and modification of operating instructions, operating schemes, programming and scheduling of tests;
- keeping records of tests performed in a manner sufficiently detailed to prepare reliability and trend analyses, on the basis of which conclusions can be drawn concerning the adequacy of components and systems;
- preparation of and commenting on production regulations and the upgrading thereof within the prescribed time intervals, along with keeping records of these;
- planning and preparation of major overhauls, weekend maintenance and weekly operative works, together with the control and co-ordination of the accomplishment thereof;
- planning of in-service works and the definition of methods and conditions of implementation thereof;
- collection, arranging, recording and evaluation of data concerning major overhauls;
- composition and time scheduling of service walk-down activities;
- ensuring the availability of appropriate quality documentation necessary for work performance, appropriate documentation and archiving of works performed.

Activities performed by the *auxiliary personnel* do not influence safety directly. In accordance with changes in the legal regulations and in the allocation of tasks they ensure the updating of the order of concluding contracts.

3.2.3 Responsibility and safety related issues concerning the employment of external contractors

On the premises of the nuclear power plant, work can only be performed by external contractors holding a valid qualification approved by Paks Nuclear Power Plant Ltd. External contractors should undergo re-qualification on a regular basis. This qualification is implemented following the requirements of the Nuclear Safety Standards and the procedural order approved by the Authority, under regular inspection by the Authority. Paks Nuclear Power Plant Ltd. is responsible as auditor for the legal performance of the auditing and evaluating procedure and for the constant fulfilment of the conditions of qualifying.

The fulfilment of the requirements of the Quality Assurance Manual - and those of the more detailed internal regulations - is mandatory for all external organisations and contractors performing work on the premises of the nuclear power plant. The hiring organisation inspects the work performed by the external contractor, by appointing a technical inspector for all works.

In the area of engineering services, analyses, calculations and assessments requiring professional knowledge are performed by research institutes, universities and engineering offices. The co-ordination and inspection of outside works is done by the hiring organisation.

On the basis of Sections 3.1 and 3.2 it can be stated that the key principle of safety (concordant to Article 10 of the Convention) is properly followed in Hungary by both the Authority and the Licensee, and safety culture achieves the appropriate standards.

3.3 Financial resources

3.3.1 Financial resources of the Authority

In order to ensure the normal operation of the Authority, the Act on Atomic Energy provides two financial sources:

- a specific sum should be provided annually from the state budget to cover:
  - the costs of technical funding activities assisting the work of the Authority,
  - the development costs related to the prevention and handling of nuclear accidents and
  - the costs of the Authority as a consequence of its international obligations;
- the Licensees of nuclear installations are obliged to pay an inspection fee to the Authority in the way and to the extent defined in the Act on Atomic Energy.

Thus, the Authority is financially independent of the nuclear installations and its funding is sufficient to carry out its duty efficiently. The wages of the Authority staff however, in contrast with the international demands, are significantly lower than the wages of the staff of the nuclear power plant.

3.3.2 Financial resources of the Licensee

Act XLVIII. of 1994 regarding the generation, transportation and supply of electric energy stipulates that the price of electric energy should contain the return of the costs of justified investments and efficiently operating Licensees, along with a profit necessary for long term operation. When defining the initial price, the expenditures necessary for the safe operation of the power plant were defined including obligations related to environmental protection. In the past years the annual price covered all the justified costs of the Paks NPP.

The Act on Atomic Energy prescribed the creation of a Central Nuclear Financial Fund from 1998 for financing the interim storage and final disposal of radioactive waste and irradiated fuel elements and the decommissioning of nuclear installations. In order to fulfil these requirements an independent organisation, the Public Agency for Radioactive Waste Management was established in 1998. The amount to be paid annually by the nuclear power plant into the fund is calculated by the Public Agency for Radioactive Waste Management on the basis of planned investment and operational costs along with international data. These payments are approved by the Parliament as part of the act concerning the annual budget agreed upon with the Hungarian Energy Office and with the Hungarian Atomic Energy Authority. These payments should be considered when determining the price of electric energy.

On the basis of the preceding safety reviews and the results of the AGNES project the power plant compiled the investments and developments necessary for holding long-term operation license. They will be realised in the period 1996-2002. The Paks NPP Ltd. finances the developments necessary for regular safety improvement activities of the plant, and other investments and modifications aimed at increasing sales and ensuring availability, from depreciation sources. The activities performed so far show that there is a real possibility to complete the programme.

3.4 Human resources

The Hungarian system of higher education provides a wide range of professional knowledge through the education of mechanical engineers, electrical engineers and chemical engineers. At the Faculty of Mechanical Engineering of the Budapest University of Technology and Economics, students obtain significant knowledge regarding power plants and nuclear power plants within the framework of subjects related to energetics and a postgraduate course of nuclear engineering is going on.

3.4.1 Human resources of the Authority

The Authority employs a total of 93 individuals, 75 of which are experts holding a higher education degree (university or college), 36 % of whom have two degrees (the second degree usually being in the area of nuclear technical disciplines). Fourteen individuals have an academic degree, and 43 persons have passed a state examination of either one or more foreign languages.

Those employed by the Authority may perform official activities on their own (licensing and inspection) only if they pass a nuclear safety or nuclear material inspector's examination (to be repeated every 3 years).

To make the staff of the Authority acquainted with the practice of the power plant, their training is done mostly at the nuclear power plant or in another form which conforms to the training system of the power plant. International courses are also integrated, along with "on-the-job training" which forms an integral part of the above-mentioned training system.

A systematic education plan has been prepared by the Authority for training the inspectors. The plan is based on individual training profiles and consists of three basic training types:

introductory training, re-training and advanced courses. The accident prevention preparatory program is an independent and continuous part of the education plan.

The representatives of the Authority take part in international technical public life.

3.4.2 Human resources of the Licensee

As of 31st of December 2000, the number of individuals employed by Paks Nuclear Power Plant Ltd. was 2,794; of which 91 persons are heads of divisions or executives of a higher level. The number of persons engaged in operation is 1,224; the number of those in the maintenance staff is 788 and the number of others ensuring support activities is 773. The composition of employees in relation to qualifications is as follows: 751 with a higher education degree, 1,464 with a secondary school degree and 579 skilled workers or persons with other types of qualification. From among those in the operating personnel, 357 persons have a valid official licence for performing 25 types of functions.

A job description comprising the basis of a unified system and qualification requirements are laid down for all jobs. The management of the power plant laid down the expected and appropriate rules of behaviour for its employees in a Code of Ethics.

Within the power plant, the system of expert training is well regulated, the material and personal conditions are also assured by the power plant. The expert training system consists of a series of modules ordered in hierarchic structure and it is job oriented. Theoretical training is followed by practical training in any case. Both theoretical and practical trainings are concluded by exams, passing of which entitles the individual to be engaged in a particular position. However, training is not concluded by obtaining the qualification. Training courses and check-ups aimed at increasing knowledge are continuously going on together with periodic adequacy tests in every three years. Annual medical and psychological fitness tests are also a prerequisite.

In the case of posts of greater responsibility and vital to safety, the trainings are concluded by an official licensing examination. The method and content of the examination are contained in licensing procedures and instructions.

In addition to general basic training, radiation protection training involves the greatest numbers of employees. The education of those professionally engaged in radiation protection, the operative staff, the maintenance staff and those performing technical assistance activities goes on separately. Employees engaged from outside on a contractual basis also have to answer the requirements concerning the fulfilment of qualification and examination.

Paks Nuclear Power Plant Ltd. executes the training of its experts at its own cost and in its own training centres. Comparison of the system and infrastructure of training in the nuclear power plant with domestic and international experience clearly indicates that the training infrastructure is duly developed, the facilities of the training centres are well equipped. Teachers and instructors are well prepared and qualified and in addition to being involved in education, they are also engaged in technical development.

A full-scope simulator has been in operation in the Simulation Centre since 1989. It serves for all four units. The simulator has been continuously developed, so as to follow the modifications performed on the units. In addition to the training of operators the simulator plays an important role in technological development projects. Most remarkable of these is the reactor protection refurbishment project in which the simulator was used for development, testing and validation.

A comprehensive development of the personnel training was performed in a project supported by the International Atomic Energy Agency and realised in the period of 1994 – 1998. In addition to the renewal of the methodology, the number of personnel in the teaching staff has increased by a factor of three. The most spectacular result of the project is the construction of the Maintenance Training Centre, unique in the world, furnished with real primary components and mechanical equipment for training aims. Its particular feature is that training and education is performed on full-scale primary components (reactor, steam generator, main circulating pump etc.) under inactive conditions.

On the basis of Sections 3.3 and 3.4 it can be stated that the financial and human resources necessary for the safe operation of nuclear installations are available in Hungary, thus all requirements stipulated in Article 11 of the Convention are met.

3.5 The human factor

3.5.1 Taking the human factor into consideration

Conclusions drawn from the analysis of nuclear accidents which have occurred world-wide to date justify that it is necessary to approach and handle the human factor as a key element, and the preparedness of the personnel should be continuously increased; the analysis of organisational issues and working conditions should be analysed and constantly reviewed; and the decisions and measures necessary to eliminate the detected deficiencies should be taken immediately.

When evaluating the results of the annually accomplished probabilistic safety analysis, it was clearly shown that the accurate work of the personnel play a significant role in avoiding the core melt-downs, and consequently the human factor should be given vital importance.

In the past years several international reviews assessed the operation and safety of the power plant. Their recommendations included comments concerning the improvement of the safety culture of the power plant and the recognition of the vital role of the human factor.

Both the Authority and the Licensee consider the role of the human factor throughout the entire process of design, building, licensing and operation of nuclear installations.

Probabilistic safety analyses are always carried out taking the human factor into consideration and assessing the numerical values of probabilities of human error during various particular activities.

When evaluating simulator trainings and potential off-normal events, further data can be derived concerning the probabilities of the occurrence of events originating from human error.

3.5.2 The selection of manpower

The management of the nuclear power plant is aware of the fact that a safe, economical and reliable operation can only be achieved by having a team of well-prepared experts fully aware of its responsibility related to safety.

Paks Nuclear Power Plant Ltd. constantly enforces the requirement that only such people may perform work in the nuclear power plant on his or her own who holds the qualifications, skills and examinations prescribed for the given job and in addition meets medical and psychological requirements. The corresponding manager and the employee himself or herself are jointly responsible for the fulfilment of all these requirements. Admittance to different areas of the nuclear power plant should only be issued on fulfilment of the above-mentioned conditions. From the point of view of safety the whole area of the power plant is divided into zones.

Training and examinations are conducted in the power plant and in a unified and identical way for both the NPP staff and the hired outside employees.

Medical adequacy is checked once a year. The fulfilment of psychological criteria is checked yearly in jobs requiring periodic examinations and bi-yearly for workers exposed to radiation. Before taking the periodic examinations, the representative of the Authority examines that all tests have been performed and all prerequisites are met. Medical and psychological adequacy tests are bound to particularly strict parameters in the case of personnel engaged in control, operation and supervision.

3.5.3 The improvement of working conditions

The regulation limits overtime to 200 hours a year and 40 hours a month, in harmony with the National Labour Code. As this means a particularly strict limitation of extra hours and overtime work, the Human Resources Department of the Human Affairs Directorate keeps continuous records of the workload of employees.

The fact that within a given shift the proportion of those holding higher qualifications is constantly increasing as compared to that of those with lower qualifications is also a trend that tends to reduce work loads.

In order to ensure undisturbed work, the power plant established and operates a social system the scope of which in several areas reaches far beyond the services usually granted in the rest of Hungary, and its quality and standard are much higher than anywhere else. Areas of such services are: industrial health care, psychology, transportation of employees, rehabilitation, recreation, professional clothing, protective clothing, meals, retirement benefit insurance fund, work insurance, etc.

3.5.4 Future aspects of human resources

In order to ensure supply of well prepared workers, the Human Affairs Directorate of the nuclear power plant constantly measure the optimum manpower demands and handles the manpower shortage or redundancy according to the probable lifetime of the power plant.

Shutdown of reactors immediately or before their designed lifetime has not been on the agenda in Hungary in recent years. Moreover, the option of considerable extension of operating lifetime of the units has been put forward. The life extension opens a perspective for the career of employees, maintaining the interest of specialist staff and the proper replacement of experts can also be solved.

In the human resource strategy of the NPP performance planning and evaluation, career planning and opening of professional and manager career possibilities play important roles. Emphasis is also placed on managing the employment of new specialists performing quality-based replacements and systematic recruitment of young people.

3.5.5 The feedback of experience in order to increase safety

It is laid down in the safety policy of the nuclear power plant that the commitment to safety should manifest, among others, in the open detection of factors compromising safety and in an endeavour to enhance safety and safety culture. The objective of the faultfinding revisions is drawing conclusions rather than calling one to account.

Investigation and analysis of non-planned events in the nuclear power plant are regulated in a separate procedural order. Any human error found during the investigation should be analysed in more detail. Specialists help to detect initial causes, take part in the psychological analysis work as well as in the definition of the direction of necessary changes and modifications. The results of the investigations with the definition of the related concrete tasks and measures are recorded in minutes.

In the case of issues related to safety culture, the forms aimed at the disclosure and review of general experience are preferred. For enhancing the safety culture the NPP, involving outside experts, three times performed the assessment of the actual level of safety culture. Using the results of these studies the measures leading to enhancement of the safety culture, have been determined.

3.5.6 Safe working conditions

The reduction of the probability of erroneous human interventions is intended to be assisted by the endeavour to put the accident prevention and handling instructions on a new basis: status orientation instead of occurence-orientation. (This work is being done with the co-operation of the Westinghouse company and will be completed by the year 2001.)

Successful management of inadvertent events is facilitated also by the steady on-duty service of the independent safety controlling organisation.

A healthy work environment (proper temperature, lighting, noise and vibration levels, clean air) is created in accordance with standard values. In case the existence of any of these conditions in a particular workplace is doubtful, accurate measurements are performed on the basis of which supplementary measures are taken. The proper use of personal protective equipment (the use of which depends on work circumstances) is ensured by regular checking and sanctioning.

It is usual practice to modify or change the external conditions, the ergonomic environment or the man-machine interface by re-constructions and modifications in a way to significantly reduce the probability of the repetition of errors and mistakes.

All tools, measuring instruments, maintenance and other special equipment, etc. meet the requirements both in quality and quantity.

On the basis of the contents of Section 3.5 it can be stated that the capabilities and limitations of human performance have been taken into consideration at Paks Nuclear Power Plant and thus the requirements in Article 12 of the Convention are met.

3.6 Quality Assurance

3.6.1 Basic principles

Quality assurance is one of the key components for guaranteeing nuclear safety. The successful accomplishment of quality assurance affects not only safety but the reliable and economical operation of the installation as well.

The basic principles of the quality assurance system are as follows:

- in order to achieve their goals, the management and the *executives* of the installation ensure that all activities are accomplished according to the procedural order, in an organised and controlled manner;
- the manufacturing entities and the *performers* of activities are responsible for quality;
- the *inspectors* of the quality assurance system check whether processes and individual tasks are carried out according to the requirements.

In operating and developing quality assurance systems nuclear safety is always the key objective.

Design, manufacturing, installation, mounting, commissioning, in-service inspections, test etc. of the components are performed on the basis of the requirements of the Nuclear Safety Standards and of the associated guides. There are still some professional areas where Hungarian directions and standards have yet to be prepared, in these cases we apply the directions of the countries with advanced nuclear industry in these areas. It is an important fact that the suppliers of the power plant have to be in possession of a valid qualification for the relevant activity.

3.6.2 The national quality assurance system

Subsection (2) of § 11 of Act CXVI. of 1996 prescribes that "Only those institutions, organisations, …. which possess appropriate quality assurance systems can take part in activities related to nuclear facilities, nuclear systems and equipment". Moreover the Act on Atomic Energy prescribes that in the field of the application of nuclear energy only such persons can be employed who have all necessary qualifications, and that the existence of the quality assurance system defined in § 11 should be verified.

On the basis of these legal requirements, the principles of the quality assurance system were included in Volume 2 of the Nuclear Safety Standards, and these requirements were composed according to Code 50-C-Q of the International Atomic Energy Agency. Volume 2 on quality assurance and the 14 associated guides enforce the requirements of the law and define the quality assurance expectations not only toward the operator but also toward the suppliers.

3.6.3 The quality management system of the Authority

The management of the Hungarian Atomic Energy Authority decided to establish a new quality management system. This decision is a part of the Medium Term Strategic Plan of the Authority. The main objectives of the system are:

- to improve the confidence of the public in the activities of the Authority;
- to promote the Authority in achieving its strategic goals;
- to make the processes more transparent;
- to clarify the points where the processed taken at different departments merge;
- to improve the uniform regulation and organisation of the activities;
- to guarantee the possibility of a continuous improvement.

In the first phase of the development of the system the management of the Hungarian Atomic Energy Authority:

- decided to establish the new system in accordance with the requirements of ISO9001:2000;
- appointed a member of the management with suitable independence, responsibility and competence to implement, initiate and maintain the system;
- formulated the goals, policy and basic principles of the system;
- involved a well-known advisory company in the process;
- performed a preliminary study together with the advisory Company;
- approved the plan of the quality management system;
- determined the basic processes and connections of the Authority.

The development of the system has been ongoing according to the plan.

3.6.4 The quality assurance system of the nuclear power plant

Control

Quality Policy is the highest level document of the quality assurance system, and it includes the commitment of the management of the nuclear power plant, defines the fundamental requirement of quality, the quality objectives, the available set of instruments and responsibilities.

On the basis of the quality policy, the quality assurance organisation has elaborated and regularly updated the *Quality Assurance Manual* of the nuclear power plant.

The education of personnel is a key element of the quality assurance system of the nuclear power plant. Organisations perform necessary training in accordance with the Education Standard.

In the nuclear power plant, all works are preceded by a task plan developed to the necessary extent determining the prerequisites of the work, the ways of its accomplishment, the human and material resources needed, the inspections and the extent of the anticipated documentation.

All tasks within the nuclear power plant are accomplished in a way laid down and regulated in procedural orders. The preparation, review, licensing, issuance, distribution, modification and elimination of such procedural orders have been defined in a company-level instruction.

An *indicator system* is used for the assessment of the correct functioning of the quality assurance system of the nuclear power plant. The indicators indirectly reflect the adequacy of the functioning of the quality assurance system, and necessary measures can be determined upon the evaluation of these indicators.

One of the most effective elements of developing quality assurance systems is the evaluation of events at different levels and the feedback of *experience*. Accordingly, the nuclear power plant examines events according to their severity and in a way regulated by the procedural orders. When performing such evaluations, initiating causes and necessary measures are identified.

Non-conformances detected during the operation of the nuclear power plant are followed by an evaluation in all cases. Depending on the severity of the non-conformance, the assessments are performed either by the authority, the quality assurance experts of the power plant or the professional areas themselves. Separate procedural order has been prepared for the handling of non-conformance, but professional procedural orders also include the methods of handling potential non-conformance.

Implementation

Design works necessary for the operation of the nuclear power plant are performed by or on behalf of the technical support organisations. The parts related to the design process are as follows:

- collection of input data;
- design process;
- internal review of design (internal jury);

- submission of designs for licensing.

The process of *procurement* is fully regulated (from orders to import).

The calibration of measuring instruments and measuring systems is performed by the organisations operating and using the instruments and systems, under regulated circumstances and meeting the requirements of the Act on Measurements in all cases.

Operating activities are accomplished in a way prescribed in the regulations, process instructions procedural orders, and the Manual of Operating Procedure. Operations are performed on the basis of the handling and operating instructions. Special attention is paid to the clear identification of equipment at all times and the continuous monitoring of the condition of equipment (open state, isolation, test states, failures). The shift changes are performed in a documented way in all cases, with the clear indication of the status of the equipment valid at the moment of hand over. All necessary temporary modifications are performed according to the procedural order, which defines the clear identification (equipment, system status), the validity period and the method of the documentation of the temporary modifications. Regulated fuel handling procedures covering the entire cycle is also an important element of quality assurance of operation.

The maintenance instruction, process instructions, procedural orders and implementation ensure the proper control of the maintenance process documents.

The control over *technical background* activities is also performed according to technical instruction, process instructions and procedural orders. Requirements concerning reactor physics, diagnostic analyses and the process of waste treatment have also been defined.

Reviews

The safety and quality assurance organisations of the nuclear power plant exercise *internal inspection* over the executing organisations.

Organisations perform their own evaluation through *self-assessments*. These self-assessments are performed on their own, with the professional support of the quality assurance supervisor organisation. The results of the self-assessments are reported to the executives of the given organisation who determine the potential measures needed. Internal assessments, unlike audits, are not formalised, but are effective instruments for quality improvement.

Audits are performed by the quality assurance supervisor organisation and generally regulated by the procedural order on the basis of an annual audit plan. Positive experiences obtained from such audits are widely presented. Auditors receive special training or when auditing certain professional areas, experts familiar with the given area assist them.

The power plant checks the adequacy of the quality assurance systems of suppliers, particularly the meeting of requirements related to qualifications and the level of regulation of the organisations.

3.6.5 The role of the Authority in checking the quality assurance system

The official inspection of the elaboration and operation of the quality assurance system is a task to be undertaken by the state as declared in both the Act on Atomic Energy and the decree concerning its implementation. The inspection includes the documentation of both the control and the implementation and inspection activities.

The Authority performs a comprehensive inspection either as a system audit or a process audit. Audits are carried out on previously designated areas and by internal auditors, the elimination of the remarks recorded in the audit minutes should be reported.

Pre-planned inspections are performed according to the yearly schedule of the Authority and according to the overhaul decision for units under refuelling. Non-planned single inspections are performed related to events adversely affecting quality, or upon the individual designation of the authority.

The areas of the operator's quality assurance system regularly inspected by the Authority are as follows:

- in connection to the control activities:
  - structure of the organisation,
  - training and qualifications of staff,
  - documentation,
  - treatment of non-conformity;
- in connection to the executive activities:
  - normal operation,
  - maintenance and repair works,
  - handling of nuclear fuel,
  - selection of contractors,
  - design,
  - modifications.

The inspection of supervisions includes both independent assessments and those performed by the management. The official inspection is carried out according to written procedural orders approved by the head of the Authority and known to the Licensee.

The Authority primarily expects the quality assurance organisation of the Licensee to take improvement measures related to remarks made at the official inspection and to report these measures. If this is neglected or not performed adequately, the Authority in a special resolution will prescribe the improvement measure.

On the basis of Section 3.6 it can be stated that the requirements related to quality assurance stipulated in Article 13 of the Convention are met in Hungary.

3.7 The assessment and certification of safety

3.7.1 The system of safety analysis reports

According to globally accepted international practice, the system of safety analysis reports is a vital element of the basic documentation guaranteeing safety throughout the entire life-time of the installation.

The method of preparation and application of safety analysis reports is prescribed by a legal regulation at the Government Decree level. The official procedure related to the installation is based on the Preliminary Safety Analysis Report that is followed by the Final Safety Analysis Report necessary for the commencement of the operation of the nuclear installation.

The requirements regarding the contents of safety reports are based on the guidelines of the Reg. Guide 1.70 of the US NRC (United States National Regulatory Commission), taking national characteristics into consideration.

Govt. Decree 108/1997. (VI.25.) stipulates that the Final Safety Report should be updated annually, so that the safety analysis report can serve as an authentic and continuous basis for the assessment of the safety of the installation, throughout the entire life-time of the nuclear installation.

The Authority performs a periodic nuclear safety assessment within ten years upon the first day of the validity of the Operating Licence issued for the commencement of operation for the first time, and it repeats this assessment every ten years following the first one. The Licensees are liable to perform their own internal assessment one year before the deadline set for the performance of the assessment and to submit the Periodic Safety Report about the results of this assessment to the Authority. In the Periodic Safety Report, the Licensee presents the factors determining the operating risk of the installation as compared to that contained in the Final Safety Analysis Report. This serves as a basis for the Operating Licence. If needed, the Licensee takes safety improving measures to eliminate or moderate risk factors. The Licensee proposes a programme of safety improvement measures, which includes the establishment of deadlines, and submits this to the Authority as part of the report.

The Authority issues a resolution based on its own safety assessment and the Periodic Safety Report of the Licensee, in which it lays down the conditions of future operation. The Authority carried out the first assessment for Units 1 and 2 of Paks NPP in 1997 and for Units 3 and 4 in 1999. The Authority issued a resolution based on its own safety assessment and the Periodic Safety Report of the Licensee, in which it lays down the conditions of future operation of the Units, the scope and schedule of short and medium term safety upgrading measures.

3.7.2 In-service inspections and tests, material testing

The in-service inspections and tests as well as tests and periodical material testing associated with overhauls are performed accurately in the Paks NPP. These tests are going on unchanged so as detailed in the previous Report. Their detailed description is given in Annex 1.

3.7.3 Management of the ageing of equipment

In the Nuclear Safety Standards issued as annex to the Govt. Decree 108/1997. (VI.25.), separate sub-sections are designated to the topics of ageing and lifetime management. Handling of the ageing of equipment in the Paks NPP is being performed according to the Nuclear Safety Standards, in the same manner as described in the first Report. Its detailed description can be found in Annex 2.

3.7.4 Seismic safety

The issue of the seismic strength of Paks NPP first arose in 1986. When performing the site assessments necessary for the scheduled extension of the power plant, it was found that the actual seismicity of the area differs from the values considered during the design of the plant. An expert mission organized by International Atomic Energy Agency confirmed this finding and recommended further studies.

Upon the recommendation of the Authority, the Paks NPP developed a safety upgrading programme aimed to assess the site and to evaluate and enhance earthquake resistance. The programme covers the following measures:

- analyse the seismicity of the site, specify the characteristics of level SL-2 earthquake (one earthquake in 10,000 years) including the geotechnical exploration of the site and study of soil liquefaction as well as microseismic monitoring of the site and its surroundings;
- seismic instrumentation of the power plant, preparing strategies and operating instructions to be applied in the case of an earthquake;
- establish the technology necessary for ensuring earthquake resistance, identify the buildings, systems and instrumentation important to seismic safety (classification into seismic categories);
- assessment of seismic resistance of the above-mentioned building structures, systems and instrumentation, identification of the necessary reinforcements and development of the suitable technologies;
- implementation of the reinforcements and reconstruction.

Evaluation of the safety achieved by the implementation of the above programme is being performed through probabilistic safety assessment.

As a result of the revision of the seismicity of the site completed in 1996, the value of the maximum free-field horizontal acceleration caused by design basis earthquake was found to be 0.25g and the response spectra were determined. These data serve as input to the design of seismic safety analysis and reinforcements (details can be found in Section 4.1.5).

Basic requirements related to seismic safety

According to prevailing international practices for nuclear power plants already in operation, the guiding principle of reassessing earthquake resistance and of increasing safety is that in the case of seismic design, the maximum reasonable nuclear safety level should be attained. Conservative approaches used in the design of newly built power plants may be partly neglected, taking advantage of all existing safety margins. The difference between the reassessment of the Paks NPP and the relevant international practice for operating nuclear power plants is that the reassessment and seismic upgrading of the Paks NPP are implemented for the level SL-2.

All significant works carried out in operating WWER-440 nuclear power plants with the assistance of the International Atomic Energy Agency aimed at adapting the above approach.

The realisation of earthquake resistance

The programme is based on the description of a technology required to realise seismic safety. Structures and systems of the power plant can be classified into two groups:

- systems needed to ensure seismic safety and to be qualified for the design base earthquake (SL-2 level) including structures and components whose damage endanger the systems important to safety;
- structures and systems belonging to safety classes 1-3 but not necessary for implementing seismic safety. When modifying or reconstructing these, they should be qualified for level SL-1 (one earthquake in 100 years).

The assessment of seismic safety and the reinforcements had been implemented by the power plant in two phases:

- a so-called “easy-fix” project, based on estimated preliminary earthquake input, was performed between 1993-1996 (i.e. until the accomplishment of the site assessment). During the execution of the easy-fix project the seismic resistance of existing instrumentation and building structure units was increased by mechanical reinforcements. As a result the seismic safety of the Paks NPP increased significantly;
- general review and complex reinforcements are being performed between 1996-2002, for the final seismic input.

The most important elements of the second phase are as follows:

- earthquake resistance calculations of the buildings;
- assessments concerning the stability of the foundation;
- development and design of reinforcements;
- assessment of the seismic strength of the complete technology needed to accomplish seismic safety;
- implementation of the necessary reinforcements and modifications.

The assessment of seismic strength has practically been completed and the design of reinforcements and modification is approaching to an end. On most part of technological systems and components inside the hermetic area implementation of works have been completed, the upgrading of buildings is in progress, the implementation of reinforcements on the secondary circle are in the preparative phase.

Earthquake alarm and protection system

In addition to free-field measurements, several triaxial acceleration gauges are located within each twin-unit: three of them are practically fixed onto the base plate and three additional pieces are installed at different locations of the reactor building important from both structural and mechanical points of view. The earthquake monitoring system provides sufficient measurement data for the evaluation procedure.

In order to prevent unit shutdowns triggered by false signals, the earthquake alarm and protection system presently operates off-line. According to international recommendations and to the modern practices, the criterion for unit shutdown is the transgression of limit values set for the cumulative absolute velocity and for the response spectrum. Actions to be taken in case of an earthquake are laid down in the Manual of Operating Procedure and the Emergency Operating Instructions of the reactor.

3.7.5 Periodic Safety Review

The International Atomic Energy Agency issued its recommendations concerning Periodic Safety Reviews in 1994 (Periodic Safety Review of Operational Nuclear Power Plants, Safety Series No. 50-SG-O12). This recommendation schedules regular reviews approximately every ten years, which can provide a comprehensive view of the safety of the nuclear power plant units, and due to their systematic approach, they are sufficient for the definition of the necessary safety improvement measures and priorities.

In Hungary, the Authority issued a disposition and a Guideline about Periodic Safety Reviews. The guideline set the objectives, principles of implementation, legal regulation, technical background of the review and related documents.

In the official disposition concluding the review taking during the previous term of reporting, the Authority extended the validity of the long-term safety operation licence of Units 1 and 2 of Paks NPP up to 31st of December 2008.

In order to solve the problems identified in its own, in the Periodic Safety Review Report the power plant scheduled the accomplishment of different tasks related to modifications, organisation, education and analyses. The Authority made slight additions to the improvement list of the power plant and prescribed the following improvement measures with the bias as indicated below:

a) 23 measures the delayed accomplishment of which would suspend the validity of the operation licence (a detailed list of these can be found in Table 4.3.1-1);
b) 12 additional important measures, the advancement and accomplishment of which should be reported in detail;
c) 65 further measures, the accomplishment of which should only be reported in brief.

Accordingly, the operator performed the Periodic Safety Review of Units 3 and 4 of Paks NPP following the Act on Atomic Energy and the related regulations. An important novel addition to previous approaches was that the scope of the review is supplemented by two additional elements: the analysis of environmental radiological effects and the preventing of nuclear accidents.

In the official disposition concluding the Periodic Safety Review the Authority, taking into account the tasks related to modifications, organisation, education and analyses scheduled by the power plant, prescribed the following upgrading measures with attributed priorities as indicated below:

a) 15 measures, the delayed accomplishment of which would suspend the validity of the operation license (a detailed list of these is given in Table 4.3.1-2);
b) 50 measures, the advancement and accomplishment of which should be reported in detail, and the delayed accomplishment of which would involve a fine.

3.7.6 Major measures taken to improve safety

Paks NPP embarked on an activity aimed at improving safety in 1986. In the beginning, the activity was focused on the assessment and preparatory works related to the accomplishment of the measures recommended by the Soviet supplier, but the sphere of measures improving safety was gradually extended.

The Periodic Safety Review completed for Units 1 and 2 verified that the establishment of priorities approved by the Authority and the power plant was correct. The Review also provided a legal framework for the accomplishment of the necessary measures. The Periodic Safety Review for Units 3 and 4 added further measures to the list. Detailed listes of safety upgrading measures are given in Tables 4.3.1-1 and 4.3.1-2.

Until the end of 2000 the following major safety improving measures have been taken:

- the reconstruction of the sumps of the containments;
- installation of hydrogen recombiners inside the containment, designed for the design basis accident conditions;
- the inhibition of the refilling of the tanks of the low-pressure emergency core cooling system;
- the relocation of the auxiliary emergency feed-water system and the arrangements for its proper shielding - (the failure to solve this problem used to be the greatest risk factor);
- the construction of a system for gas removal from the primary circuit;
- the reconstruction of the uninterrupted electrical supply system (replacement of motor-generator sets);
- elimination of artificial voltage cutting in the case of off-normal events with switching into operation of the ECCS;
- technology of emergency injection and drain in the primary circuit;
- reinforcements against earthquake in the primary circuit.

Ongoing major safety improving measures to be completed by 2002 are as follows:

- refurbishment of the reactor protection system;
- management of primary-to-secondary leakage;
- replacement of the primary-circuit safety valve system;
- introduction of a status-oriented system of accident management instructions;
- construction of a post-accident sampling system.

Due to the measures implemented, the safety of the units has risen significantly. The risk of core melt-down - that is the most characteristic safety indicator of nuclear power plant units - has been reduced by one order of magnitude, its present value is $4 \div 5 * 10^{-5}$/year.

Preparatory works are going on for modifications aimed at the adequate handling of off-normal events accompanied by the leakage of steam generators. The replacement of the primary circuit safety valve system, the reconstruction of the reactor protection system and the construction of a post-accident sampling system are also under way.

Based on Section 3.7, it can be stated that Hungary meets all requirements stipulated in Article 14 of the Convention related to the assessment and verification of safety.

3.8 Radiation protection

3.8.1 Regulatory framework

As far as general radiation protection is concerned, the Act on Atomic Energy allocates regulatory, official and professional administrative tasks to several ministries. The regulation of radiation protection (radiation protection directly affecting humans) belongs to the Ministry of Health, the technical side of radiation protection is the task of the Authority, the issue of releases and thus protection of the environment belong to the Ministry for Environmental Protection, while tasks related to the radioactivity of the soil and the vegetation belong to the scope of the Ministry of Agriculture and Regional Development.

The major regulations presently applied in the field of general radiation protection are as follows:

- The Act on Atomic Energy defines the legal responsibilities of the users of nuclear energy and of the authorities.
- The Decree 16/2000. (VI.8.) EüM of the Minister of Public Health on the implementation of some decrees of the Act on Atomic Energy lays down the basis of radiation protection according to the recommendations of the ICRP 60 and the IAEA Safety Series-115.
- The Govt. Decree 108/1997. (VI.25.) focuses on the technical part of radiation protection in nuclear power plants.
- The Decree 1/1980. (II.6.) OKTH of the National Commission on Environmental Protection regulates the atmospheric emission of the nuclear power plant, while the limits and other conditions of liquid discharges were defined in the water use licence for the Paks NPP by the regionally competent environmental and water resources administration during the licensing procedure of the nuclear power plant.

No prescribed values exist presently for the soil, vegetation and foodstuffs in decrees (or instructions), the setting of this takes place by special decisions.

The Decree 16/2000. (VI.8.) EüM stipulates that a radiation protection service should be set up in all installations using nuclear energy. All users are obliged to prepare an internal radiation protection standard, which should be approved by the competent authority (the State Public Health and Medical Officer’s Service in this case). The annexes of the Decree specify the limits of the doses of workers and members of the public; the radiation safety principles of workplaces, methods of radiation protection training; dosimetric control; the treatment of those suffering from a radiation injury; the tasks of the radiation protection service, the handling of accidents, and the special radiation protection requirements for nuclear power plants.

The Govt. Decree 108/1997 (VI.25.) put the technical issues of radiation protection related to nuclear installations and their systems and equipment into the Authority's scope of competence. These issues are addressed in the Nuclear Safety Standards that are schedules of the Decree.

Volume 1 of the Nuclear Safety Standards defines the contents of the radiation protection related sections of the Preliminary Safety Analysis Report necessary for the request of the installation and Operating Licences and that of the same section of the Final Safety Analysis Report. The same volume prescribes the regular analysis of the radiation protection indicators of the operation and the utilisation of the experience within the framework of the periodic safety review.

Volume 3 sets out the main radiation protection principles related to the design of nuclear power plants, the stipulations concerning the handling of fresh and irradiated fuel and radioactive waste, and the requirements toward dosimetric control systems, shielding and systems influencing radioactive emission.

Volume 4 summarises the requirements concerning the execution and documentation of radiation protection activities. The same volume deals with the requirements related to the handling of nuclear fuel and radioactive wastes.

3.8.2 The system of dose limitation

The following table (3.8.2-1) summarises the dose limits set in the domestic regulations.

Table 3.8.2-1. Annual dose limits for workers employed in the use of nuclear energy and for individual members of the public

dosimetric quantities	subjects of exposures		
	workers (2) (above 18)	students and apprentices (3)	members of the public
effective dose	100 mSv/5 years 50 mSv/year	6 mSv/year	1 mSv/year
dose equivalent for the lens of eye	150 mSv/year	50 mSv/year	15 mSv/year
dose equivalent in skin and extremities	500 mSv/year	150 mSv/year	50 mSv/year

Remarks:

(1) These limits apply to all exposures received from external and internal man-made sources, except for medical exposures.

(2) Pregnant women are not permitted to be occupationally exposed.
Breast-feeding mothers are not allowed to work with unsealed sources.
In special circumstances higher exposures may be permitted for volunteers, provided that the doses received shall not exceed 50 mSv/year and the period of permission shall not exceed 5 years.

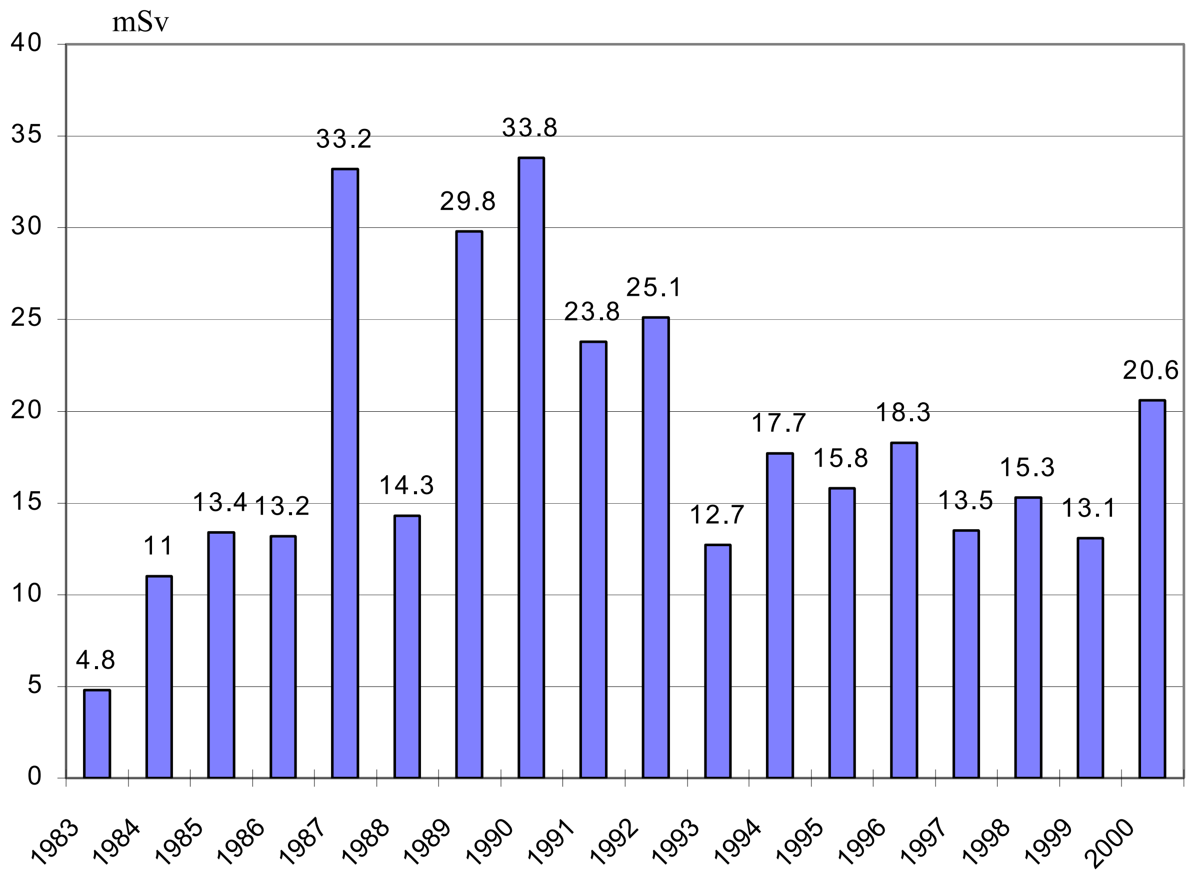
(3) These limits apply to apprentices and students, aged between 16 and 18 years, who are participants in a specialised course on subjects concerned with radiation and its use. For all other secondary school students, the dose limits are identical with the limits for members of the public.

3.8.3 Occupational exposure at Paks Nuclear Power Plant

The patterns of annual exposures

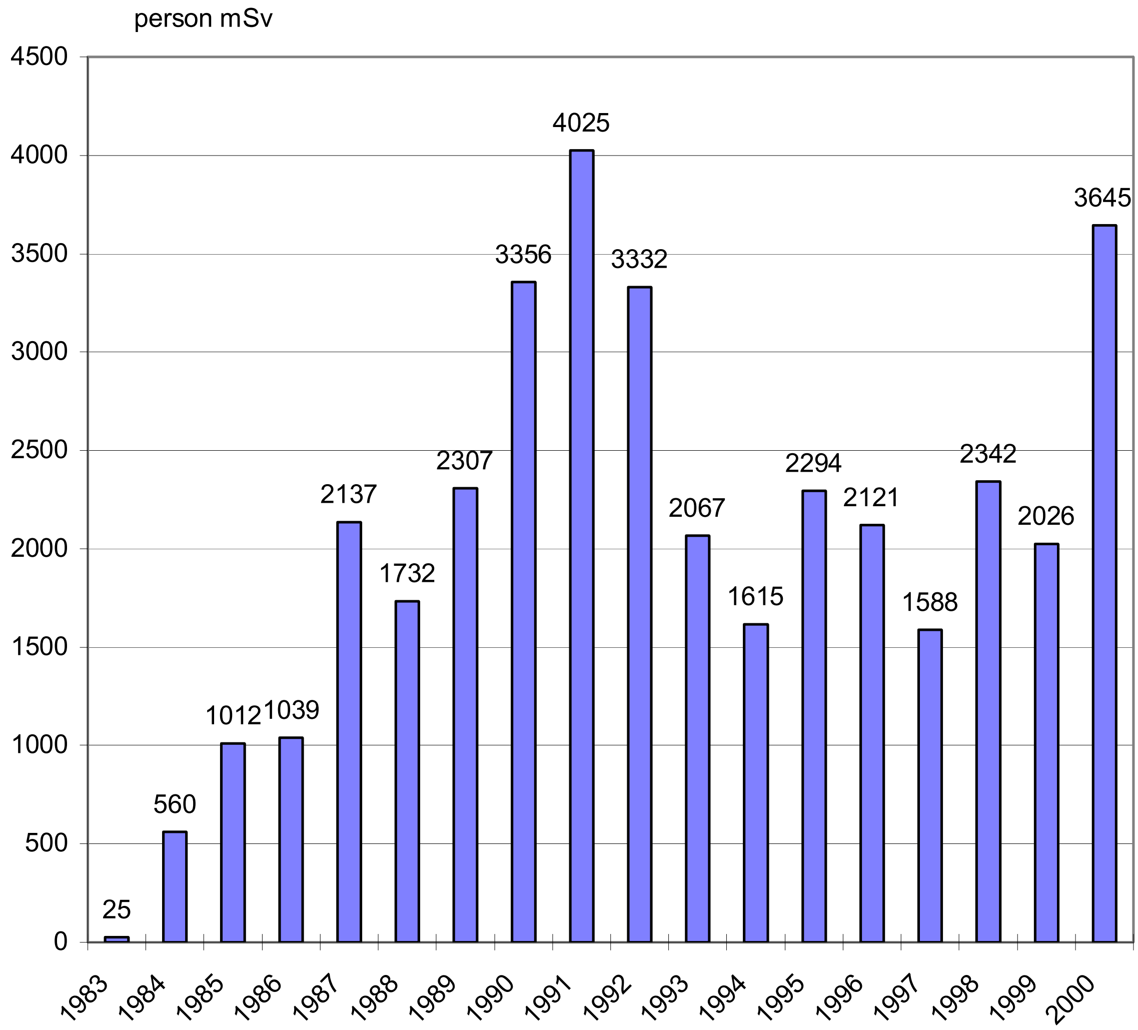
The official film-dosimetric readings should be considered as official data concerning radiation exposure of workers. On the basis of the Internal Radiation Protection Standard of the Paks NPP dosimetric control should be performed to all workers employed in affected jobs (both for their own staff and the hired outside employees). The doses measured by operative dosimetric devices are obviously lower than the doses according to the official film-dosimeter readings since the operative monitoring concerned only workers whose exposure may exceed the level 0,2 mSv/day in their daily work.

The following charts demonstrate the patterns of annual collective and maximum individual doses of workers, based on the measurements of the film dosimeters evaluated by the authority.



Maximum annual individual doses according to official film-dosimeter readings

Figure 3.8.3-1



Annual collective doses according to official film dosimeter readings

Figure 3.8.3-2

Increase of the collective dose in the year 2000 is partly due to the changes introduced in the official supervision system of film dosimeters, namely using the personal effective dose. On the other hand the intensive safety upgrading modifications in the plant obviously resulted in higher exposures.

Radiation exposures during the overhaul period

In the Paks NPP most of the exposure of the personnel originates from the overhaul activities during the outages. Taking into account the low share of radiation load from the operation, it is worth to evaluate the radiation exposure of the personnel by the analysis of the radiation load received during the outages.

The value of personal exposures increased in 2000 in comparison to former years. This can again be explained partly by the new dose unit introduced by the Authority. Moreover, the inadvertent additional works aroused during outages (e.g. replacement of feed-water collectors of steam generators, removal of magnetite deposits in the steam generators) lead to increases.

The dose planning, radiological permission of particular maintenance operations, identification of necessary radioprotective measures are based on the comprehensive radiation level measuring programme performed by the health physics personnel in the introductory phase of overhaul period just after the shutdown of the unit in the immediate surroundings of the main components and in the rooms involved in the overhaul works. Data gathered concerning the radiation conditions could be used for the dose planning for the next years.

As for the personnel performing the maintenance and repair works their dose values were determined on the basis of the operative dose values obtained by the Paks Nuclear Power Plant Ltd. Collective doses for 2000 were 790; 1263; 336.4 and 359.5 man∗mSv for unit 1, 2, 3 and 4, respectively.

Dosimetric measurements show that collective doses in the nuclear power plant are very low even by international standards (0.1-0.2 person∗mSv/GWh).

The plant also regularly controls the patterns of internal exposure, by thyroid and tritium excretion measurements and by whole body measurements. Internal exposure generally has a very low contribution to the annual exposure of workers. In 2000, internal exposure exceeding the recording level 0.1 mSv was not found. In December 1998 a new whole body measurement system was installed which improved the reliability of the measurements.

The power plant itself performs the dosimetric control of employees engaged from external companies.

Summing up, it can be stated that the official dose limits have not been exceeded during the operation of the nuclear power plant. The radiation exposure of the personnel shows an acceptable low level also in terms of international comparison.

The application of the ALARA principle

At Paks NPP, optimal radiation protection is ensured by administrative and technical measures.

Among these administrative measures, the radiation protection training provided to workers employed in affected jobs should be highlighted. This comprises basic radiation protection training and further upgrading and supplementary courses, along with the regular examination of knowledge obtained.

Technical standards comprise measures aimed at providing protection through distancing, reduction of the radiation field and minimisation of the time spent in the radiation field (e.g. by the application of remote control, pre-manufacturing, set-up of installed and mobile radiation protection shielding, decontamination, and inactive training to major maintenance operations). During unit overhauls, a technical measure used is the shutdown cooling schedule, which is aimed at positively influencing the deposition of corrosion products during cool-down.

When making preparations for works with particularly enhanced exposures, a qualitative ALARA programme is developed for all activities where this is justified by the radiation dose rate of the working area (> 4 mSv/h). The programmes contain all technical and administrative measures that are needed to achieve the optimal radiation protection of the activity in question. A quantitative method was also introduced for the optimisation of radiation protection in the Paks NPP. The suggested quantitative methodology is the differential cost – benefit analysis deriving the optimum level by evaluating the costs of radiation protection versus the benefits of restriction of exposure. For the Paks NPP the standard cost for 1 man∗mSv is set to HUF 25000 for the time being, and this value is to be periodically revised.

3.8.4 The radiation exposure of the public in the vicinity of the nuclear power plant

Atmospheric and liquid release

The official limits of additional radiation dose caused by any releases in respect to the most affected group of the public are 100 μSv/year for nuclear power units and 10 μSv/year for the interim storage facility of spent fuel. According to disposition No. 1/1980 of the National Environmental Protection Office, the activity limits of atmospheric emission are as follows (see table below):

Table 3.8.4-1. Atmospheric radioactive emission limits for 1000 MWe power units

Radioactive substance	Emission limit [Bq/day] [(1)]
Sr-89 and Sr-90	$5.6*10^4$
Radioiodine isotopes, in I-131 equivalent	$1.1*10^9$
Total radioactive aerosols (with a half-life over 24 hours)	$1.1*10^9$
Radioactive noble gases [(2)]	$1.9*10^{13}$

Remarks:
(1) values apply for the emission averaged over 30-day;
(2) in the case of simultaneous boric acid control of two reactors this value may achieve a maximum of $6.5*10^{13}$ Bq/day once a week.

Limits imposed on liquid discharges were defined in the water use licence issued by the regionally competent environmental and water resources administration during the licensing procedure of the nuclear power plant. These values are shown in the table below:

Table 3.8.4-2. The limits of annual liquid discharges for the four units

Radioactive component	Activity limit [GBq]
Gross beta	14.8
Sr-90 from the gross beta	0.148
H-3	$30*10^3$
Total alpha	Near background level (under the detection threshold)

The limits of atmospheric and liquid releases are basically identical to the design values featured in the technical designs of the nuclear power plant.

Table 3.8.4-3 shows the actual releases in terms of percentage of the mandatory limits.

Table 3.8.4-3. Summarised data of releases as a percentage of values prescribed by authorities

Year	Number of operating units	Gaseous [%]				Liquid [%]		
		Noble gases (total)	Aerosols (T >24 h)	^{131}I equivalent	$^{89, 90}$Sr	Gross beta	^{90}Sr	^{3}H
1983	1	3.3	< 0.1	< 0.1	NM	15.0	NM	84
1984	2	2.7	< 0.1	< 0.1	5.5	7.6	8.9	52
1985	2	1.8	< 0.1	< 0.1	3.6	7.5	8.0	57
1986	2	2.4	< 0.1	< 0.1	0.5	5.7	3.3	41
1987	3	2.8	< 0.1	< 0.1	0.4	8.6	3.1	49
1988	4	1.2	< 0.1	< 0.1	0.4	3.4	1.1	55
1989	4	1.5	0.15	< 0.1	0.4	4.0	3.9	50
1990	4	1.5	< 0.1	< 0.1	0.4	5.1	2.8	46
1991	4	1.3	< 0.1	< 0.1	0.6	9.3	1.9	53
1992	4	1.6	< 0.1	< 0.1	0.3	7.6	3.2	53
1993	4	1.3	< 0.1	< 0.1	0.4	6.6	1.4	60
1994	4	1.4	0.11	< 0.1	0.8	7.4	0.5	61
1995	4	1.4	< 0.1	< 0.1	1.9	8.1	2.8	67
1996	4	0.6	0.1	< 0.1	3.3	5.5	3.2	65
1997	4	0.4	0.2	< 0.1	5.6	4.5	7.0	52

Remark: NM – no measurement.

3.8.5 Radiation protection control of the nuclear power plant and the environmental monitoring system

The site of the power plant is divided into free access and controlled zones. Radiation levels in the free access zone may not exceed 1 μSv/h. Within the controlled zone, rooms are classified into 3 categories according to permitted radiation levels and surface contamination. These are the manageable, restricted manageable and not manageable rooms. Radiation protection is continuously controlled on the premises of the plant by an installed radiation protection system with 500 measurement channels per twin-unit. The control includes the gauging of dose rates and air-activity concentrations in the rooms, and the measurement of the activity of different technological substances. Signals from the detectors are transmitted to the Dosimetry Control Room, where they are visually displayed with audio warning (alarm and emergency levels). The computerised display and archiving of measurement results also takes place in this control room. In addition to the installed system, local measurements and laboratory tests of samples are performed as well.

Release and environment monitoring is carried out in two fundamental ways:

- the *on-line* system has an installed telemetric system, the units of which are situated at the stacks (iodine and noble gas activity, aerosol and airflow measurement), at the water sampling stations (total gamma activity, temperature, water flow measurement), at the meteorological tower and at the environmental monitoring stations set up at about 1.5 km distance of the power plant (air iodine activity, dose rate). Data are transmitted to the above mentioned Dosimetric Control Room;
- *off-line* laboratory measurements serve to enhance accuracy of the data given by the remote measuring system. The remote data are completed with sensitive laboratory measurements of a large quantity of samples taken from emissions and from the environment. The stations perform off-line measurements of fall-out, dry-out, grass, soil, aerosol, ^{14}C, atmospheric tritium activities and doses.

In addition, sampling stations which measure dry-out activities and doses are situated within a 30 km radius of the nuclear power plant. Moreover, numerous samples are collected in the environment surrounding the power plant, e.g. related to water, mud, fish, plants, milk and soil. Measurements have shown only insignificant amounts of radioisotope activity generated by the nuclear power plant in the environment so far, the additional dose of the public from the emissions is less than nSv/year.

At the Interim Storage of Irradiated Fuel Assemblies radiation protection monitoring was also commenced on both the location and the surroundings of the facility. Experience so far shows radiation levels to be very low, and the additional exposure of the public caused by the releases is below the nSv/year range.

Monitoring of releases and the environment is constantly carried out by the competent authorities as well, independently of the operational monitoring system. Authorities generally obtain the same results.

3.8.6 The radiation protection activity of the authorities

As described under Section 3.8.1, as far as general radiation protection is concerned the scopes of competence are shared by different authorities.

The Tolna County Institute of the State Public Health and Medical Officer's Service regularly inspects the radiation protection conditions of the work areas of the nuclear power plant facility by involving the National Research Institute for Radiobiology and Radiation Hygiene as a professional body.

Regular and unplanned inspections of the Authority include partly the analysis of documentation on the matter and partly the performance of on the spot inspections in the following fields of technical radiation protection:

- source evaluation;
- operation of systems providing operational adequacy;
- technical radiation protection during maintenance;
- handling and collection of radioactive wastes;
- off-normal radiation situations.

The Alsó-Duna-völgyi (Lower Danube Valley) Environmental Inspectorate enforces the fulfilment of requirements related to discharge limits and other environmental stipulations contained in resolutions and applicable to the nuclear power plant. The Inspectorate is an environmental protection licensing authority in the first instance but it also participates in different licensing procedures as a specialised authority.

The regionally competent County Veterinary Sanitary and Food Inspection Stations monitor the activities in soil, vegetation and foodstuff.

The Environmental Radiation Protection Monitoring System of the authorities performs independent local measurements, sampling and laboratory tests in order to check the fulfilment of radiation protection requirements, bearing in mind however, that *monitoring is primarily the task of the operator*. The Data Collecting, Evaluating and Processing Centre of the system was set up in the National Research Institute for Radiobiology and Radiation Hygiene. The authority has evaluated the radiation protection aspects of the operation of the plant in annual reports published since 1984. As it is generally not possible to trace radioactive substances released by the plant into the environment, or it is only possible in a few specific cases, the radiation doses of the public can only be estimated by migration and food-chain models. Annual effective doses estimated for a distance of 3 km fell into the 100-500 nSv range.

Based on Section 3.8, it can be stated that Hungary makes all the efforts possible to maintain radiation doses at the lowest reasonable level achievable, and thus fulfils all those requirements stipulated in Article 15 of the Convention.

3.9 Emergency preparedness

3.9.1 Regulatory framework

The National System for Nuclear Emergency Preparedness was created by Decree 135/1989. (XII.22.) of the Council of Ministers. This Decree has been amended several times since.

Act LXXIV. of 1999 prescribes a unitary system of protection against all kinds of catastrophes. Govt. Decree 248/1997. (XII.20.), amended by Govt. Decree 40/2000. (III.24.), regulates the organisation and tasks of the National System for Nuclear Emergency Preparedness as well as scopes of duty and competence of the Hungarian Atomic Energy Commission and the Authority in agreement with modern public administration structures. The new regulation considers the obligations generated by international contracts, the recommendations of international organisations and the regulations of the European Union.

3.9.2 The operation of the national system for nuclear emergency preparedness

The protection against catastrophes is managed by the Governmental Co-ordination Committee.

The composition of the Governmental Co-ordination Committee is as follows:
- president: the Minister of Internal Affairs;
- vice president in case of nuclear emergency: the director general of the Hungarian Atomic Energy Authority;
- members: the administrative state secretaries of the ministries involved in the emergency and the head appointed by the minister without portfolio governing the national safety services

The organs of the Governmental Co-ordination Committee are the Secretariat, the Operational Staff the National Defence Committee and the Scientific Council.

Under normal circumstances, the organisations of the National System for Nuclear Emergency Preparedness carry out works and training: several organisations perform continuous tasks related to data acquisition, planning, information or co-operation.

The administrative tasks of the Governmental Co-ordination Committee are managed by the Secretariat functioning on the base of Directorate General for National Emergency Management whose tasks include also co-ordination of the activities of the National Defence Committee, The Operational Staff and the Scientific Committee. The Minister of Interior appoints the head of the Secretariat.

The state of a nuclear emergency is declared or withdrawn by the president of the Governmental Co-ordination Committee or, in the case of urgency and for the area under his control, by the president of the County (Capital) Local Committee for Nuclear Emergency Preparedness, based on the information received from the plant.
In the case of a nuclear accident, it is the task of the Defence Committee to give expert opinion and advice to the decision-makers. The Committee is coming into force on the base of Ministry of

Interior, its head is appointed by the state secretary of the Ministry of Interior, members are appointed by the heads of corresponding ministries and organs of national competence. The Hungarian Atomic Energy Authority operates an expert section within the Defence Committee in case of nuclear emergency.

The employment of intervention forces is to be recommended by the head of the Operative Staff. The Operative Staff consists of the delegates of Directorate General for National Emergency Management of the Ministry of Interior and the corresponding ministries. The Minister of Interior appoints the head of the Operative Staff.

Members of the nuclear emergency section of the Scientific Council of the Governmental Co-ordination Committee are invited by the Director General of the Hungarian Atomic Energy Authority. The main duty of the Scientific Council is to give technical and scientific aid to support the decision-making process and the decisions in order to rise emergency preparedness and to handle the consequences of an emergency.

Within the nuclear installation, the person responsible for the accomplishment of tasks related to the prevention of the accident is the head of the installation together with the president of the regionally competent County (Capital) Local Committee for Nuclear Emergency Preparedness and the president of the Governmental Committee at the national level.

In the case of nuclear emergency it is the task of the Hungarian Atomic Energy Authority to evaluate and forecast the nuclear and radiation situation and its propagation. Information to support the estimation and decision-making are provided by the following organisations:

- the Nuclear Emergency Information Centre of the Hungarian Atomic Energy Authority, which is in direct data communication contact with the Paks NPP;
- The International Contact Point at the Authority;
- the Nuclear Emergency Information Centre operated by Directorate General for National Emergency Management of the Ministry of Interior;
- the Emergency Information Centre of the National Radiation Monitoring, Warning and Surveillance System working on the basis of the Ministry of Health.

The nuclear emergency preparedness organisations of various sectors and areas

The management and operating structure of the sector-wide system is determined by the corresponding Ministers and the heads of organs of national competence. It belongs to the tasks of the County (Capital) Local Committees for Nuclear Emergency Preparedness to set-up nuclear emergency prevention organs for each sector, to designate the forces and instruments taking part in the implementation of countermeasures and to prepare and continuously maintain the accident mitigation and response plan.

3.9.3 The National Emergency Action Plan

The current National Emergency Action Plan entered into force in 1994 and was prepared in line with the structure and duties valid at that time. The Plan consists of a charter and several annexes. The four main chapters of the charter are as follows:

- general and basic information;
- control, management and co-operation;
- evaluation of nuclear risks;
- tasks and actions to prevent nuclear emergency situation

The revision of the National Emergency Action Plan is presently in progress and will be finished in 2001. As a result of the revision, the new plan reflects the recent changes in the Hungarian emergency preparedness system. Its structure and content follows the recommendations of the International Atomic Energy Agency.

3.9.4 The nuclear emergency prevention system of the nuclear power plant

The power plant plans and carries out its emergency prevention activities within the framework of the National System for Nuclear Emergency Preparedness.

Three emergency categories are applied to nuclear power plant accidents. Categories are formed on the basis of the status of the units along with the availability of functions to mitigate the emergency and the radiation situation.

The basis for emergency intervention levels is the children inhalation dose from radioactive iodine, at the border of the exclusion zone. This dose is determined by computer using the data collected by real-time on-line environmental monitoring system of the power plant (data about meteorological and release conditions and environmental radiation).

The Emergency Action Plan of Paks Nuclear Power Plant Ltd.

The accident prevention of the power plant is based on the Emergency Action Plan. The plan contains the organisational and technical measures aimed at the assessment, limitation and management of a nuclear emergency.

Based on the assessment of emergencies, it lays down the current emergency classes, defines the procedure of emergency management and control, the operation of the Emergency Organisation of the nuclear power plant, and the emergency responsibilities of particular persons. The tasks to be accomplished in an emergency situation are given in a table form. A suitable alarm system ensures the rapid response of an Emergency Organisation in the power plant.

The plan prescribes the order of internal and external alarms and communication and the method of operation and control of the necessary telecommunication devices. The protection of personnel, i.e. checking their number, their rescue and decontamination is regulated in detail. The plan also includes the list of materials and technical equipment for accident management. The detailed regulation of the prescribed tasks is contained in the annexes, related procedure orders and implementation instructions of the plan. The plan also sets down the regulations concerning the preparation, training and exercises of the personnel.

The Emergency Action Plan is regularly revised based on experience obtained in practice and according to changes introduced in domestic and international requirements.

The system of providing the public with appropriate information in the event of a nuclear emergency, media relations

The protection of the public is the task of the authorities, but in the early stages of an accident the power plant itself faces duties of this nature.

In case of an actual emergency, the public is warned by a set of sirens installed within a 30 km vicinity of the power plant. In the event of an emergency, it is the duty of the national media to give appropriate information, but the power plant is also ready to issue press release and to notify public through local and country-wide radio, television and press in agreement with the Authority The nuclear power plant is represented in the working group of the Governmental Co-ordination Committee.

Supported by the Paks NPP, municipalities located around the NPP established the so-called Association for Social Control and Information. This organisation ensures more direct relation between the plant and the settlements involved, and it serves also for information and preparation of the public for emergency situations. It supplies regular information about the emergency preparedness activities of the Paks NPP based on the relations with national media.

The order of preparation and exercises

On-site and off-site exercises, including national and international exercises, are organised regularly according to yearly plans as defined in the Emergency Action Plans.

The entire personnel of the power plant are in preparation for potential emergency tasks. The members of the accident prevention organisation receive regular training to handle their specific tasks. The power plant carries out its own exercises based on a yearly exercise schedule. Exercises can be alarm exercises; practices when different organs of the Emergency Organisation are prepared for their tasks; or system exercises when tasks are accomplished in co-operation with county based or national organs.

Certain sectors organise part-exercises independently of the central administration. In addition, the Emergency Action Plans prescribe the regular testing of the reliability of communication systems.

Hungary as a Member State of the OECD Nuclear Energy Agency regularly takes part in the international nuclear emergency exercises called INEX. Hungary participated in all four INEX-2 exercises, moreover, in the case of one, it was the host country of the site of a supposed accident.

Preparations for the exercise in 1998 centred to Hungary contributed a lot to enhance the level of emergency preparedness, to highlight the weak points and the measures to perform. Review of experiences has been completed, most of necessary modifications and developments has been realised. As a result of these conclusions and of the regional projects of the International Atomic Energy Agency, aimed at the harmonisation of the emergency preparedness of the region, the level of the emergency preparedness in Hungary is complying with the international recommendations and it is comparable with that of the European Union countries of the same size.

3.9.5 International relations

International conventions

It is a fundamental task of the Authority to ensure the participation of the Republic of Hungary in the international system of co-operation related to the prevention and handling of nuclear accidents. This co-operation is based on the conventions concluded within the framework of the International Atomic Energy Agency.

The Republic of Hungary was among the first nations to sign the following multilateral conventions concluded in 1986:
- the Convention on early notification about nuclear accidents;
- the Convention on providing assistance in the event of nuclear accidents or radiological emergencies.

Hungary, as a Member State to the Vienna Convention, signed the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention in 1990.

The Republic of Hungary joined the International Nuclear Event Scale (INES) in 1991, which was introduced by the International Atomic Energy Agency.

Hungary is an active participant of the regional harmonisation project related to the prevention and management of nuclear accidents launched by the International Atomic Energy Agency. This project provided significant assistance to the revision of the Emergency Action Plan.

The establishment of co-operative relations with the professional bodies of the European Union is an integral part of our accession. As an initial step to co-operation, negotiations are in progress concerning our joining the ECURIE, the early notification system operated by the European Union.

Bilateral inter-governmental agreements

Bilateral agreements have been concluded with the following countries in the areas of early notification, mutual provision of information and co-operation: Austria (1987); Czech Republic and Slovakia (1991); the German Federal Republic (1991); Slovenia (1995); Romania (1997); Ukraine (1997) and Croatia (2000).

On the basis of the Section 3.6 it can be stated that emergency preparedness system required in Article 16 of the Convention is available in Hungary.

4. THE SAFETY OF INSTALLATIONS

4.1 On-site and off-site factors

4.1.1 The location and surroundings of the site

Paks NPP is situated about 115 km south of Budapest. The nuclear power plant is situated 5 km to the south of the town of Paks, 1 km to the west of the Danube river and 1.5 km to the east of National Highway No. 6. Its geographical co-ordinates are 46°34’24” (northern latitude) and 18°54’53” (eastern longitude). The area of the site is 585 ha, which is the property of Paks Nuclear Power Plant Ltd. with an additional 68 ha that has been appropriated for the purposes of potential extension. The site is used exclusively for activities related to the generation of nuclear energy.

The main technological components reach the power plant by road, rail or by boat.

External man-made hazards

The region is mainly characterised by cultivated land. There is no significant industrial activity in the immediate vicinity of the site. There is no airport (neither civil nor military), take-off or landing safety zone or military establishment either in the near or wider vicinity of the power plant. According to regulations related to airspace usage, flights cross the area in a radar-controlled airspace above the altitude of 2,400 m above sea-level, and flying is fully prohibited within a 3 km zone around the power plant. According to conservative estimates the probability of military aircraft crashing and falling on the most sensitive 100,000 m^2 area of the nuclear power plant is $3.2*10^{-7}$/year.

According to the analysis of road and waterway accidents during the transport of hazardous substances, the probability of releasing hazardous substances by road accidents is $4.8*10^{-7}$, that of a poisoning is $3.1*10^{-7}$, while that of an explosion is $2.6*10^{-7}$ events/year. In case of transport by water, a very conservative analysis regarding the probability of accidents and release of substances resulted in less than 10^{-7} events/year.

4.1.2 Population

Comprehensive demographic analysis prepared in 1973 revealed the development trends of the settlements within the vicinity of the power plant along with the influencing factors defined the anticipated number of the population and its regional distribution. It also assessed the expected scale and nature of tourism and recreation within the vicinity of the power plant and related areas.

The original analysis has been revised several times during the past years. Modifications were made in order to modernise regulation and to adopt new international recommendations.

The population in a 30 km radius around the nuclear power plant is approximately 200,000.

4.1.3 Meteorology

According to the measurements performed in Paks, the annual mean temperature is rising slightly. The length of extremely cold periods (25 ^{o}C below zero) spans a few days only. Experience shows that the nuclear power plant is able to prevent the freezing of components caused by such cold weather by taking temporary measures. The Paks meteorological station is often the one to report the most intensive night cooling in the entire country, as the sandy soil of the region allows strong heat emission, thus the microclimatic layer cools down more easily on clear nights. No specific tendencies can be found regarding maximum temperatures.

The distribution of precipitation shows great variations, and this is obviously caused by the Danube river, being close by.

Surveys found that the dominant wind direction is north-western, though the north-eastern direction is becoming more predominant during winter. No significant new trends were found concerning wind speeds.

Other effects (e.g. hurricanes) are so rare in the region that they were not even taken into account when the plant was designed.

Since the installation of the nuclear power plant, weather conditions proved to be rather capricious within the range of values characteristic for our climatic zone, but it can not be shown that the plant has had any effect on the microclimate. Climatic changes do not affect the safe operation of the nuclear power plant.

4.1.4 Hydrology

In the vicinity of the site the only significant surface water is the Danube river, which is slightly low-course nature here. The section of the power plant is situated at 1,527 river km from the mouth of the Danube. The Danube is well regulated in the region.

The average yield of the river in the region is 2350 m^3/s, water speed is 1m/s and water level is 88 m above Baltic-see.

The quantities of heated cooling water discharged into the Danube from the power plant are as significant as the amounts of heat flows that determine the natural heat balance of the river, thus the natural river water may become heat polluted under unfavourable circumstances. If all four units are in operation during autumn, some 10 to 11 % of the total yield of the river have to be removed for cooling. The plume of hot water returned to the river completely mixes on its way to the border of the country (some 80 km), but no obvious temperature rise can be measured after the midway of this section. According to the water use licence issued jointly for the four units, the heating of the cooling water returning to the river may not exceed 11 ^{o}C, or 14 ^{o}C if the temperature of the water is below 4 ^{o}C. The cooling water temperature is continuously measured by the Licensee, the limit has never been exceeded. The maximum temperature of the hot water stream may not exceed 30 ^{o}C, 500 m further down from the point of entry. This parameter is randomly checked by the Authority, the measured values have never exceeded the set limits. The temperature of discharged water has never reached these limit values consistently during the operation to date.

Water quality has improved as compared to previous data. This can be explained by the fact that industrial and agricultural production has fallen back both in Hungary and in certain neighbouring countries where our river waters mostly originate from.

Statistical analyses of floods with different probabilities of occurrence have assessed the differences between icy and ice-free conditions of high water levels. The flood level with a probability of 10^{-4}/year (0.01 %) is 96.36 mB (above the Baltic Sea) as calculated for icy waters and 95.62 mB as calculated for ice-free waters. Floods usually begin at the 93.3 mB water-level, and the frequency of this does not even reach 1 day/year (0.18 day). The landfill level of the power plant site has been defined at 97.00 mB; this level is 40 cm higher than the formation level of the flood-control dike in the section of the power plant, and 24 cm higher than the highest water-level calculated to occur in 10,000 years.

4.1.5 Assessment by earth sciences

Geology, tectonics

According to geological research, three main groups of formations participate in the geological composition of the region: pleistocene-holocene surface sediments, neogene basin sediments and the paleozoic-mezozoic basin base.

Seismo-tectonic characteristics

The final evaluation of the seismicity of the site was elaborated with the help of experts of the International Atomic Energy Agency and accepted by the Authority. The value considered when designing the plant was 6 on the MSK scale based on the catalogue of historical earthquakes in Hungary and the isoseistic map that can be drawn from this. Seismicity is low in Hungary as a whole, though stronger vibrations (with epicentral intensities of about 8 on the MSK scale) do occur, though they are few in number. These are rather unevenly distributed regionally. Based on the frequency of seismic disturbances in the time period elapsed from the middle of the 19th century to the present day, a quake the intensity of 4 can be expected once a year while one of intensity 8 may occur once every 40 to 50 years. Relations between known tectonic elements and available seismologic data can only be shown in certain cases. The focal depth of quakes in Hungary is usually 9 to 12 km, and the quakes are usually of the strike-slip nature.

The characteristics of the SL-2 earthquake (maximum horizontal acceleration, uniform hazard response spectra were determined by calculation using probabilistic earthquake hazard analysis based on a 10000 year repetition rate. Calculation of free-field characteristics has taken into account the non-linear transmission of upper loose soil layers. Input for these calculations was taken from the results of the site geo-technical study programme. For maximum free field horizontal acceleration of the SL-2 earthquake a value of 0.25 g has been accepted.

On the seismic profiles taken at the site and its surroundings, several fault lines can be seen in the Pannon layer which suggest movements 6 million years ago. Based on the data obtained it can be presumed that the fault lines generally follow the W-SW – E-NE direction, while a few of them follow the SW-NE direction. At the same time none of the profiles of the minimum 45,000 year old Quaternary upper layer had fault lines. Detailed geological and geophysical analyses performed at the site and its surroundings show that there is no obvious sign of a Quaternary fault. No Pannon structure can be related to measurable activity. No Quaternary faults can be found in the loess to the west of the site either. Deterministic analyses showed no faults reaching the surface. In spite of this, low-probability activity of structures within the Pannon layers around the Paks site was taken into consideration in the probabilistic risk analysis.

Joint evaluation of data of micro-seismic monitoring put into operation in 1995 and that from the recent neo-tectonical scientific results was performed in 1998. These studies justified that the assumptions taken as base for the evaluation of site seismicity and for analysis of the present activities were correct, there is no need for their revision. The microseismic monitoring is continued by the Paks Nuclear Power Plant Ltd.

Soil liquefaction

The basis of the assessment of soil liquefaction was the detailed geotechnical analysis of the site, following the recommendations of the International Atomic Energy Agency (50-SG-S9). The upper soil layer (about 30 m) at the site is a young river-water sandy, gritty loose sediment with a shear wave speed of 250 to 355 m/s. This covers the Pannon layer of around a minimum 500 m/s shear wave speed. The quality of the soil meets the requirements for foundations.

On the areas not exposed to the base pressure of buildings, the probability of soil liquefaction is less than 10^{-4}/year, thus in the case of a maximum design basis earthquake with a probability of 10^{-4}/year, no soil liquefaction can be expected.

Reassessments of the site

Following the commissioning of the fourth unit of Paks NPP in 1987, partial reassessments were executed several times, last time in 1998.

The reassessment of the seismicity of the site, including the related geotechnical programme, was completed in 1996. According to the requirements of PSA, the analysis concerning the seismic risks and soil liquefaction of the site has been extended to a probability range of 10^{-2}-10^{-7}/year in 2000. The 2nd volume of the Final Safety Report analysed in detail the characteristics of the site, the relevant new information and the changes that have taken place in the environment. Presently, analysis of coincidence of the environmental effects, study of the stability of the site-characteristics, re-evaluation of the extreme meteorological conditions is going on.

Based on Section 4.1 it can be stated that Paks and its surroundings meet the requirements of Article 17 of the Convention regarding the selection of an adequate site.

4.2 Design and construction

4.2.1 Requirements concerning design and construction in the Hungarian system of regulations

Volume 3 of the Nuclear Safety Standards issued as Schedule 3 to Govt. Decree 108/1997.(VI.25.) contains the general nuclear safety-related requirements concerning the design of nuclear power plants. The requirements lay down in detail the following principles and rules well known from the international practices.

Multilevel protection

The principle of defence-in-depth should be applied to all activities related to safety, be it in relation to organisation, operation or design, in such a way that any failure can be compensated for or corrected, and the occurrence of serious accident situations can be prevented. The levels of protection are aimed at maintaining the normal state of operation, preventing the development of accidents and to mitigate the consequences of design basis accidents. Moreover, specific auxiliary systems and components should be installed - for the further protection of the public and the operating staff - the task of which is to mitigate the consequences of occurrences and accidents more severe than those considered in the design.

The application of technologies proven by experience and qualified by testing or analysis

Equipment for proven and verified technologies should be at disposal for the following cases:

- to shut down the reactor safely and to maintain it in a safe shutdown condition in each state of operation;
- to remove residual heat after the shutdown;
- to reduce the emission of radioactive substances and to ensure prescribed limits of emissions.

Safety functions and the systems and components executing these functions should be classified into safety classes according to their influence on safety. The classified safety systems and components should meet the strictest applicable manufacturing, structural, inspection, maintenance and operational standards.

New design constructions can be used only provided that they are based on adequate research and development efforts. Before commissioning and during operation, all constructions should be tested, paying special attention to the new characteristics.

It is required to determine the scope of those safety-related systems and components which should be designed to be inherently safe and, as much as possible, insensitive to any human error.

Reliable, stable and easily manageable operation

In order to attain a reliable, stable and easily manageable operation, the nuclear power plant standards lay down, among others, the following principles in the fields of instrumentation, informatics and control engineering:

- Control and measuring instrumentation should be installed in order to control safety parameters, systems and components during normal operation, anticipated operational occurrences and design basis accidents.
- An adequate communication system should be established between different locations.
- The constant study of operational parameters (important to safety and indicative of the condition of the plant) should be ensured. The same systems should ensure the automatic registration and archiving of measurement data and instructions given to certain systems and components.
- Adequate control and regulating instruments should be utilised in order to maintain the operational parameters, systems and components within the prescribed operational range.

Moreover, the standard prescribes the establishment of a unit control room, a reserve control room and an accident control room, and lays down the requirements to be considered for their construction.

4.2.2 The fulfilment of requirements at Paks Nuclear Power Plant

Design principles applied when the power plant was constructed

The design of the units of the Paks NPP was completed in two phases and was based on Soviet standards. These documents also served as a basis for the Hungarian standards entitled Nuclear Power Plant Safety Standards which were issued in 1979. The prevailing Soviet standards at the time were basically in line with the internationally accepted design principles of the late 70's.

When preparing the design bases, a strictly conservative engineering practice was used; In spite of this, the following requirements have not got the due attention:

- basic design requirement related to protection against natural phenomena;
- basic design requirement related to external dynamic effects;
- requirement concerning the unit control room.

The fulfilment of up-to-date safety requirements

The Paks NPP was designed in such a manner that during normal operation and in case of failures occurring relatively often, the first three physical protective barriers might not be breached (thus the fourth barrier inhibiting the release of radioactive substances had no function here). During those design basis accidents that were used for the design of the power plant, with a low probability of occurrence, the fuel matrix should not be damaged. However, to a certain extent the cladding of the fuel elements and the tightness of the primary circuit may be damaged, thus the containment function becomes necessary. The power plant was designed in such a way that as a consequence of design basis accidents the amount of radioactive substances released into the environment and the radiation dose of workers may not exceed the corresponding health requirements. The handling of severe accidents that are more severe than design basis accidents but the probability of which is minimum was not directly taken into account among the design principles of the units.

The elements of the "defence-in-depth" principle were accomplished in the nuclear power plant according to the requirements of Soviet standards.

The analyses and investigations of the AGNES project (before the issue of the Act on Atomic Energy) and those of the Periodic Safety Review were aimed basically at assessing whether the safety of the power plant is in line with modern international safety requirements and expectations featured also in the Nuclear Safety Standards issued in 1997.

When assessing the fulfilment of special design criteria, analyses related to single failures and common mode failures, investigations concerning fire safety, internal flooding and pipe ruptures of high energy were performed, and the possibility of unintended dilution of boric acid was assessed.

From experience gained from the deterministic accident analyses, probabilistic safety analyses (level one) and severe accident analyses, and from the summarised evaluation of all results, recommendations were made for safety improvement modifications and further complex analyses.

One of the improvement measures is the upgrading of the reactor protection. This large and complex project not only had safety enhancing objectives such as the installation of auxiliary protections and consistent physical separation but also included changes in devices, which were justified by technical and economic aspects.

The refurbishment using the most up-to-date control and instrumentation equipment is being performed separately on each unit in consecutive years. By the end of 2000 refurbishment on units 1 and 2 were completed, it will be performed on units 3 and 4 by the end of 2001 and 2002, respectively. Results of former upgrades of international level (core control system) will be integrated into the project. As it is shown by the experiences so far, the new system, according to the expectations, significantly increased the sensitivity and reliability of the system.

Based on Section 4.2 it can be stated that the design and construction of Paks Nuclear Power Plant meets the majority of the obligations included in Article 18 of the Convention, and the implementation of further safety improving measures is under way.

4.3 Operation

4.3.1 Safety analyses

When Paks NPP was established and commissioned, Hungarian practices followed those accepted in the developed countries. Based on the Technical Design provided by the supplier, a Pre-Construction Safety Analysis Report was prepared, which was followed by the Pre-Commissioning Safety Analysis Report that was aimed at the role of the Final Safety Analysis Report.

As time passed gradually more deficiencies were revealed in the Safety Analysis Reports when compared to western requirements. That is why the safety of the power plant needed to be re-evaluated. The Hungarian Atomic Energy Commission launched the AGNES project in 1992 to reassess the safety of Paks NPP to the standards of the 90's.

The AGNES project was concluded successfully at the beginning of 1995 and brought reassuring results. An analysis was prepared to compare the Pre-Commissioning Safety Analysis Report with the results of the analyses for off-normal events in the frame of the AGNES project. The AGNES project finally concluded that the power plant could be safely operated.

The analyses of the Periodic Safety Review performed for the Units were based on the above results of the AGNES project with the addition of some other elements.

The Periodic Safety Reviews embraced the analysis of single failures and common mode failures, tests related to fire protection, flooding and pipe ruptures of high energy and the assessment of the possibility of an unintended boric acid dilution. The evaluation of the load bearing capacity of the airtight rooms included the hydraulic pressure and integrity tests of the containment and issues related to the sub-criticality of fuel storage systems. Systems and components related to safety have been qualified (the required environment-tolerance during and following accidents has been defined).

In parallel with the Hungarian analyses concerning the load bearing capacity of the airtight room, other studies have been accomplished (Table 4.3.1-1, line 18) and are in progress (Table 4.3.1-2, line 11) in the frame of a PHARE/TACIS project initiated by the OECD and the European Union.

Details of the containment analysis are described in Annex 3.

The results obtained so far led to the conclusion that the containment is basically complying with the design base. In a conservative approach, the strength analyses showed that the reinforced concrete structures can bear the pressure load in case of break of primary and steam pipelines (taking into account also the margins used in the calculations and based on the Hungarian standard for reinforced concrete), if the pressure relief system functions at a minimum efficiency of 75 %. Parallelly, the results of the PHARE project proved, that the passive pressure relief system in the bubble condenser and the bubble trays are capable to fulfil their designed functions in case of the design base accident.

For the integrity of the hermetic area it has been established that the critical and characteristic structural elements ensuring the tightness are fully complying with the strength criteria, replacement of sealing material is prescribed (Table 4.3.1–2, line 5). Ageing of reinforced concrete structures has not yet been investigated, it will be put on the agenda later.

Within the framework of level one PSA analyses, event trees and fault trees have been prepared concerning technological initiating events. The value of core-damage probability was calculated and sensitivity and uncertainty analyses were performed. All probable external effects jeopardising safety were assessed. Within the framework of the review, accident analyses were prepared for the entire scope of design. The documentation of the Periodic Safety Review described the accepted methodology of analyses and presented the results of analyses performed as well. The list of initiating events applied included all initiating events considered to be globally important plus the cases especially characteristic for WWER reactors. The most sophisticated and modern computer programmes were used for the analyses.

On the basis of the deterministic analysis of the basic accident processes performed within the frame of the severe accident analyses conclusions were drawn about processes inside the reactor and phenomena inside the containment, including the distribution of radioactive substances. The document contains the strategy of accident management procedures to be elaborated.

As a result of the AGNES project and the Periodic Safety Review performed, the Final Safety Analysis Report of the nuclear power plant could be re-issued. The Authority prescribed that the safety analysis report would have to be issued and annually updated in the future. The Paks NPP issued the first, actualised version of the Final Safety Analysis Report on 6th of June 2000 in line with the results of the Pre-Commissioning Safety Analysis Report, the AGNES project and the Periodic Safety Reviews. Inspection and evaluation of the report is currently under way.

The major improvement measures necessary and considered to be the most important by the Authority (based on the Periodic Safety Review) are contained in Tables 4.3.1-1 and 4.3.1-2. Deadlines quoted relate to the last unit subject to revision. Items in the tables dated to the past are consistently completed on every unit, and the items 1, 2 and 3 in the line 21 of Table 4.3.1-1 are completed on unit 1.

Table 4.3.1-1. Major upgrading measures taken as a result of the Periodic Safety Review for Unit 1 and Unit 2

N°	upgrading measure	execu-tion
1.	Complete separation of the auxiliary emergency feed-water system from the operational feed-water system	1997
2.	The introduction of a systematic training system for the maintenance staff, putting the Maintenance Training Centre into operation	1997
3.	The establishment of the hydrogen-handling system of the containment for design basis accident processes	1997
4.	Prevention of sump clogging	1997
5.	Prevention of the refilling of the tanks of the low-pressure emergency core cooling system after they have been emptied.	1997
6.	Gas removal from the primary circuit during accidents through the installation of a gas removal system	1997
7.	A comprehensive revision of the Emergency Action Plan, a more modern definition of accident categories, regular accident management exercises, feedback of exercise experiences to the regulation.	1997
8.	Completion of the elaboration of quality assurance requirements for all processes and activities.	1997
9.	Increasing the reliability of human activities by the gradual introduction of SAT based training	1998
10.	Assessment of subcriticality of irradiated fuel storage facilities; defining of realistic situations leading to optimal moderation; if the probability of these exceeds the permitted limit, the introduction of organisational and administrative measures	1998
11.	The qualification of valves, electric and control engineering cables and valve drives of unidentified types that have been left out of the qualification procedure	1998
12.	The prevention of the formation of a plug diluted in boric acid in the reactor after shutting down; the assessment of the necessity of further administrative and/or technical measures	1999
13.	The introduction of "bleed and feed" principle with potential re-qualification and modification of the equipment	1999 2000
14.	The protection of the reactor against overpressure in the cold state through modifications of the accident management procedure and through the installation of protection equipment	1999 2000
15.	Reduction or elimination of the risk of the instrumentation and control equipment (transducers) being flooded in case of any accident involving flooding and the same applies to the phenomenon that water coming into the rooms of the electric gallery during extinguishing of a possible fire may cause the inoperability of several redundant safety systems.	1999 2000

16.	The elimination of artificial voltage cutting, as this results in a significant increase in the frequency of core melt-downs	1999 2000
17.	Replacement of the reactor protection system	2000
18.	Validation of the containment thermo-hydraulic models based on large-scale experiment, evaluation of the thermo-hydraulic functions of the localising system, the examination of the interaction existing between the flow and the structural elements	2000
19.	The reduction of the consequences of steam generator leakage (flows from the primary circuit into the secondary circuit) through the reconstruction of protection and safety systems	2000
20.	The increasing of human reliability through the introduction of a status-oriented system of accident handling instructions	2001
21.	The extension of level 1 probabilistic safety analyses to the following: 1. off-normal events and accidents occurring during low power operation; 2. fire risks, flooding; 3. external events; 4. High energy pipe ruptures.	2001
22.	The inhibition of the spread of environmental (external) effects in the case of equipment that is qualified as partially adequate or not adequate, or the replacement of such equipment	2001
23.	To increase the earthquake resistance of units, and to modify the safety systems in order to ensure the shutdown and cooling of units	2002

Table 4.3.1-2. Major upgrading measures taken as a result of the Periodic Safety Review for Unit 3 and Unit 4

N^o	upgrading measure	execu-tion
1.	Reconstruction of the systems for controlling the emission and the environment	2002
2.	Reconstruction of the fire alarm system	2003
3.	Avoiding that a possible pipeline break in the turbine hall influence the conditions in the electric galleries through the check valves of the ventilation system.	2002
4.	Examination of the installation environment of the partially qualified or partially adequate equipment, identification of design conditions to obtain adequate qualification, taking the necessary measures.	2002
5.	Replacement of sealing material at the boundaries of hermetic area with silicon or, in several instances, with other sealing material.	2002
6.	Reduction of adverse influence of human factor, development and introduction of new, state-based disturbance management procedures	2002
7.	Decrease of the consequences of steam generator leakage (from primary to secondary side) via adequate modification of protection and safety systems	2002
8.	Enhancement of seismic resistance of the units	2002

9.	Modification of the primary pressure relief system, introduction of "bleed and feed" processes, realisation of a protection against cold overpressure	2002
10.	Modification of the reactor protection system with introduction of new protection functions and operating conditions, applying consistently specific design principles.	2002
11.	Experimental control of the containment behaviour and development of further investigation programmes.	2002
12.	Extension of the application of Level 1 PSA to the areas of fire, flood and seismic events.	2002
13.	Comprehensive study of high-energy pipeline breaks	2003
14.	Finalisation of accident management strategies mitigating the consequences	3004

Commissioning instructions

The Pre-commissioning Safety Analysis Report contained the detailed technical data of the 28 nuclear power plant components of crucial importance. It also features the technical requirements of manufacturing, hand-over and commissioning. These requirements are described in detail in Annex 4.

4.3.2 The Manual of Operating Procedure

Paks NPP prepared its Manual of Operating Procedure in 1988 in line with the operating instructions in force at that time, the supplementary material obtained before then, the views of the main constructor, analyses issued by expert institutes and the experience gained from operation.

It is the operator's task to constantly upgrade and update it. Changes to be introduced are to be approved by the Authority.

4.3.3 Internal regulations, procedural orders

The present power plant has a modern system of regulations that are able to ensure efficient and safe operation through a chain of regulations, instructions and procedural orders. The regulations and procedural orders meet the requirements of the Quality Assurance Manual. Standards and implementation instructions have started to be processed on the power plant's Intranet as well.

The Quality Assurance Manual has been revised in such a way as to primarily contain requirements. These quality assurance requirements are to be integrated into the separate internal implementation instructions of the different professional areas. Within the regulations of accident prevention, accident categories have been defined more accurately and in a more modern manner. The feedback of experiences of accident handling exercises was implemented. The elaboration of a status-oriented system of accident management instructions that is comparable to international practices is also performed. This is to be done in co-operation with power plants of similar types.

In 1999, along with the modification of the organisation of the power plant its internal regulation system was also modified. The new regulation system, similarly to the organisation, is based on the functional processes. That means that the functioning and the documents providing regulation are closely linked together and they determine the requirements for the processes. Being that also the organisation is built onto processes, the whole functioning, regulation and organisation is process based of the power plant is process-based, clear-cut. That structure ensures the conformity to the environmental requirements imposed on the nuclear energetics, along with the efficient realisation of necessary interventions.

4.3.4 Accident management instructions

Since the commissioning of the first two units, the basic administrative requirements of safe operation were constituted by the operating instructions provided by the suppliers of the plant and other conditions and limitations prescribed in the delivery documentation and in the operating manuals.

Since 1993, Paks NPP Ltd., as an observer, participated in the work of the Lisbon Initiative aimed at the preparation of status-oriented accident management instructions. The initiative was launched between the United States of America and the interested states of the former Soviet Union. Its main aim was to substitute occurrence-oriented accident management instructions applied to date by status-oriented ones, and the preparation of such status-oriented instructions with the assistance of the USA for all operators of WWER reactors.

The framework of Lisbon initiative did not warrant the necessary conditions for the preparation of instructions, therefore, in December 1996, the Paks NPP entered into a contract with Westinghouse Europe Company (Brussels) concerning the preparation of instruction system. The instruction package has been completed, its validation was performed at the end of December 2000. The introduction of the system, after full training and qualification of the personnel is planned on units 1 and 2 at the end of 2001 on units 3 and 4 at the beginning of 2002. The education of main control room personnel consists of an introductory theoretical course followed by training on unit simulator.

4.3.5 Maintenance

The system and the types of maintenance, cycles

The maintenance of power plants forms part of its operation, and is always a task of vital importance to be accomplished by the operator. Maintenance affects the safety, availability, operational safety, efficiency, lifetime and economy of the plant.

The maintenance body of the nuclear power plant is divided into professional divisions (mechanical engineering, electrical, I&C and civil engineering) but operates according to unified principles.

The system of maintenance and overhauls has remained unchanged from the submission of the first Report, its detailed description can be found in Annex 5.

4.3.6 Technical support

Technical and preparatory bodies

In the present organisation of Paks NPP, technical support is basically divided into professions. The safety function and responsibility of the technical support is ensured through the following items:

- licensing of installation and utilisation;
- definition of the scope, scheduling and cycle times of technological tests; preparation, review, revision and modification of test scenarios and programmes;
- planning, preparation, control and co-ordination of overhauls, weekend maintenance, weekly operative tasks and in-operation works and the setting of conditions thereof;
- plotting the changes arising in the states and conditions of significant technical equipment;
- inspection of the existence of licenses, materials and parts and the handling thereof;
- computerised recording and archiving of documentation needed for the planning and implementation of maintenance, repairs, reconstruction and investment activities;
- technical inspection of the work performed by external contractors involved;
- preparation of the components and systems for the safety inspections and ensuring the adequate conditions of these inspections;
- providing the technical base, licensing, planning and full scale implementation of modifications;
- operation and development of the computerised planning and documentation system;
- maintenance and updating of the “as-built” documentation;
- medium term planning and co-ordination;
- technical development.

Decision supporting committees

Committees of regular or periodic operation may be set up to make recommendations concerning emerging tasks. The tasks and operation of such are prescribed by the entity establishing them. The major committees of technical nature are listed below:

- Technical Committee;
- Maintenance Working Committee;
- Operation Investigating Committee;
- Fuel Committee;
- Company Quality Assurance Council.

Domestic and foreign support institutions

The nuclear power plant maintains close relations with all Hungarian companies performing support activities for the power plant.

The power plant maintains relations with the foreign companies (or their successors) that have contributed to the design and construction of the plant or in the manufacturing of its equipment, e.g. ATEP, Skoda and Hidropress.

Close relations are maintained with foreign companies of outstanding experience in nuclear technology. Some of these companies are: IVO/FORTUM , Siemens/FRAMATOME, Westinghouse EdF, and Nuclear Electric.

According to contracts presently in force, the general design services are provided by ETV-ERŐTERV Ltd., while the chief consultant is the KFKI Atomic Energy Research Institute.

4.3.7 Reports to the Authority

According to requirements concerning the Licensee's reporting obligation, two categories are to be distinguished:

- Regular reports
  - quarterly report: notifying the Authority about the state of operational characteristics, current issues of operation and the factors affecting operation;
  - annual report: based on the quarterly reports, but as more information is available due to longer periods of time elapsed, a more comprehensive description, evaluation and analysis is available;
  - annual safety report: the final safety report should be updated by the Licensee according to the changes related to nuclear safety having taken place in the installation;
  - reports about overhaul and small repair activities: concerning small repair activities affecting safety and overhauls accompanied by fuel reloads;
  - other information: providing the Authority with up-to-date information;
- Specialised reports
  - events under the obligation of instant reporting should be reported within two hours following their occurrence; the INES classification of all events bound to reporting should be performed, and the relevant recommendation should be submitted to the Authority within 16 hours following the occurrence,
  - all occurrences bound to reporting are to be reported to the Authority in writing within 24 hours upon their occurrence,
  - the occurrence-investigation report should be submitted to the Authority within 30 days of the occurrence of the event.

4.3.8 Feedback

Own operational experience

As operation and maintenance is mostly profession-specific, as far as equipment and activities are concerned within the different professional areas (mechanical, instrumentation and control, electrical engineering), data collection and processing is separated as well. As a result of this, monitoring and the utilisation of the data received also differs in its depth and complexity. A joint database of failures from different professional areas has been developed in order to ensure the uniform data acquisition and processing. The availability and operability data have been collected on the plant level in separate databases for more than 10 years.

The analysis of reliability and availability indicators should be the basis of the replacement, modernisation or modification of components or systems. These data are used in the safety analyses as well. The power plant shows good indicators even by international comparison, as far as safety systems are concerned. In order to achieve a unified and uniform system of data collection within the power plant, a plant-level regulatory framework has been prepared.

Safety-related events occurring in the power plant are investigated with the involvement of the entire technical staff. Events are investigated at different levels, which are intrinsically determined by the severity of the event. Events reported to the Authority are investigated on plant level, other events are investigated on professional line level. From 1992 onwards, events are classified according to the INES scale, and previous events were also classified retrospectively. Since 2000 several events have been analysed also by probabilistic methods.

On the four units of Paks NPP in 1998 four events, in 1999 three events in 2000 five events got INES classification 1. In the three years considered no event occurred with INES classification 2 or higher.

The results of investigations and the corrective measures are widely presented. Deadlines and responsible personnel always mark measures, thus they are traceable. Not only single events but also trends are monitored as well, including the changes occurring in the reliability of safety systems. Trends disclosed lead to modifications or other technical or administrative measures if needed. Experiences are used in education through simulator training. The constant and regular revision of the operating instructions and the Manual of Operating Procedure proves the feedback of operating experiences.

The Operation Supervising Committee reviews the safety indicators, the experiences of event investigations and the accomplishment of all measures taken. The Operation Supervising Committee is an organisation operated by the Safety Directorate, it prepares disputed issues for consideration. The head of Safety Directorate has the right of decision on this forum.

The utilisation of the experiences of other power plants

It is of vital interest to Paks NPP to learn and make use of the operating and other experiences imparted by other installations and international information sources. This fact was acknowledged by the experts of the NPP at the very beginning of the installation phase and has always been given special attention. Accordingly, numerous forms of relations and methods of exchange of experience came into existence:

- The Paks NPP takes part in the work of large international nuclear organisations. Thus it is the beneficiary of support: of the legal and informational background; of the organisational framework; and, in several cases, of the concrete professional co-operation. On the other hand, offering its professional experiences, assuming the international conventions, Paks NPP serves the strengthening of the nuclear industrial community. The International Atomic Energy Agency and the OECD Nuclear Energy Agency are the most important relations in this field.

- There exists a closer co-operation in the form of taking part in the professional work of the groups collecting the operators of nuclear power plants. In this case the objective is to address in common effort the issues related to nuclear plants, in some cases those of similar construction to that of Paks NPP. Such organisations are the World Association of Nuclear Operators (WANO) and the Club of Operators of VVER-440.
- The closest co-operation can be established between partner nuclear plants. In these relations many kinds of mutually advantageous occasional or long-term activities can be identified, including joint projects, exchange of experiences and data supply. Good examples of the former are the co-operation with the Loviisa power plant in the framework of the fuel diversification project, or the changes of maintenance experience with several VVER plants. The Paks NPP maintains good terms also with the Isar-II power plant in Germany.

Reviews by external entities

Since operation commenced, Paks NPP has paid great attention to international reviews, The measures aimed at the elimination of deficiencies discovered through assessments or confirmed by external experts greatly contribute to the improvement of power plant processes.

The following international reviews were performed at Paks NPP:

Table 4.3.8-2. International reviews

Year	Subject of the review	Review performed by
Between 1984-1987 yearly	Operation, maintenance	Experts invited by the Soviet supplier
1988	OSART (full scope)	IAEA
1990	Operation, maintenance	Experts invited by the power plant from 4 countries
1991	Design for safety	IVO
1991	Post-OSART review	IAEA
1992	Peer Review	WANO
1992	ASSET	IAEA
1993-1996	Site seismicity - 6 occasions; seismic safety programme – 2 occasions	IAEA
1995	Post-ASSET review	IAEA
1995	Peer Review follow-up	WANO
1996	The assessment of the accomplishment of safety improvement measures	IAEA
1997	Nuclear Liability Insurance Engineer’s Inspection	International experts of the insurance pool
1997	quality assurance audit	Blayais Nuclear Power Plant

1999	PSA analysis of low power states (IPERS) (VEIKI-Paks NPP joint studies)	IAEA
2000	Pre-OSART mission	IAEA, Paks NPP

The reviews are normally concluded with positive evaluations and the measures taken so far to eliminate the identified deficiencies clearly demonstrate the process of continual development of domestic operating practices since the early 80's to the present.

The power plant intends to continue the practices followed to date and have the plant assessed by major international reviews in the future, in at least every 2 or 3 year.

4.3.9 Radioactive wastes

The safe handling of radioactive wastes of the nuclear power plant is the responsibility of the entity generating the waste, i.e. Paks NPP Ltd. The collection, processing and interim storage of wastes is part of the operating tasks, and preparations for safe final disposal are made within the framework of a national project. The classification of radioactive wastes, according to the Hungarian Standards, is given in Table 4.3.9-1.

Table 4.3.9-1. The classification of radioactive wastes

criterion	low level	medium level	high level
activity concentration (kBq/kg)	$< 5*10^5$	$5*10^5$-$5*10^8$	$> 5*10^8$
dose rate (at 10 cm from surface) (μGy/h)	< 300	300-10,000	> 10,000

The Act on Atomic Energy and its Schedules established a new framework to the disposal of radioactive waste. The Public Agency for Radioactive Waste Management was formed on 2nd of June 1998. This agency is charged with the responsibility for the disposal of radioactive wastes, for the interim storage and final disposal of the spent fuel along with the de-commissioning of nuclear facilities. According to the law, the waste generating entity is obliged to create the financial funds to the waste disposal and decommissioning by payments in a Central Nuclear Financial Fund. From the 1st of January 1998 this Fund serves also to cover the activities aimed at the final disposal of radioactive wastes, namely preparatory works and investigations. The operator of this Central Nuclear Financial Fund is the Hungarian Atomic Energy Authority. The Fund is disposed by the minister supervising the Hungarian Atomic Energy Authority, for the time being the Minister of Economy.

Operational low and medium level radioactive wastes

In order to prevent the release of radioactive substances into the environment above the strict safety limit values prescribed by the authorities, all waste streams contaminated with radioactive substances should be inspected and cleaned, if required. The used air filters, ion exchange resins and concentrates generated by the evaporation of waste water make up the major part of low and medium level radioactive waste.

During the operation so far 3644 m^3 of evaporation residue has been generated. Average quantity of evaporation residue over the period from 1985 to 2000 amounts to 234 m^3/year. The amount of spent ion-exchange resins discharged from water treatment systems and accumulated during the operation so far is 39 m^3.

Contaminated protective devices, tools, spare parts, cleaning tools, debris from reconstruction, metal waste and scrap generated in maintenance workshops constitute further components of low and medium level (solid) wastes. During the operation so far, 2080 m^3 of processed (compressed or solidified) waste has been generated, 1580 m^3 thereof was transported to Püspökszilágy for final disposal at the Radioactive Waste Treatment and Disposal Facility. The average amount of solid and processed radioactive waste generated from 1985 to the end of 2000 is 126 m^3/year.

In the auxiliary building of Paks NPP a limited capacity is available for the interim storage of waste packages containing solid and solidified waste. This interim storage provides sufficient capacity for about 6-7 coming years for the storage of waste on the plant site.

There is a project in progress for the adaptation of a Finnish technology ensuring the dramatic decrease, on the long term, of the liquid radioactive waste to be stored, by means of the separation of boron and caesium components.

Interim storage of high level radioactive wastes

During the operation and in particular during the fuel reloading of units, high level radioactive waste is generated.

Concerning the operation of Paks NPP, it is mainly the surface dose of the components taken out from the reactor which features such a high value that justifies the handling as high level waste. This waste is put into the storage pits installed in the controlled zone of the power plant. There are altogether 1114 pits at the plant. The final disposal of wastes from the pits will take place at the final decommissioning of the power plant.

Only conditioned waste packages can be put into the pits. The radioactive waste to be disposed is put into uniform containers, so that they can be recovered at any time. Only solid waste can be put into the pits.

The Interim storage of spent fuel has been discussed in Section 1.1.3.

Activities aimed at supporting the final disposal of low and medium level wastes from the power plant

The Radioactive Waste Treatment and Disposal Facility was opened in 1976 in Püspökszilágy (about 30 km from Budapest). This site receives the radioactive wastes generated in research, medical and industrial institutions of the country. From 1983 to 1997 low level solid wastes generated by the power plant were transported to the above-mentioned site, within the framework of a contract concluded with the approval of the Authority. From 1997, solid radioactive wastes from the power plant are not transported to the site in Püspökszilágy. Therefore, until the establishment of the new storage facility for final disposal, safe interim storage should be accomplished at the nuclear power plant itself.

Disposal of the power plant radioactive waste is of national interest, its safe solution is a governmental task and for its solution an inter-ministerial project was initiated.

The central task of this project was the site selection for a repository to dispose of low and intermediate level waste from the NPP. Between 1993 and 1996, based on available literature data, the whole territory of the country was screened for identifying geological objects possibly adequate to host a low and intermediate level waste repository. These studies showed that the investigation should be continued on the Mezőföld area and the hilly region South of it. This conclusion was supported also by the fact, that this area is not far from the plant site and it is situated on the same side of the Danube river. Preliminary site investigations were started only on the sites (six places) where the local municipalities supported the project. The final report about the geological, technical, safety and economical studies suggested to continue examinations in the Üveghuta area (belonging to administrative territory of Bátaapáti, Tolna county) in view of a subsurface repository excavated in granite, and for an alternative, investigations for a possible surface repository in the Udvari area. Relying on the results of the safety analyses, the subsurface repository (Üveghuta, in granite) turned to be the safest solution, therefore, it was decided, endorsed by the Hungarian Atomic Energy Commission, that detailed investigation should be commenced there in 1997.

The summary report about the geological investigations performed in the period of 1997-1998 stated that the Üveghuta site is suitable for detailed geological and site characterisation works to justify the licensing and the construction. In spite of the broad consent on the issue, several experts put this statement under doubt. Therefore the HAEA invited International Atomic Energy Agency to organise, in the framework of its Waste Assessment and Technical Review Programme (WATRP), the revision of the methodology used to select and assess the site for repository of low and intermediate level radioactive waste by international expert team.

Experts of international reputation invited by the International Atomic Energy Agency concluded that the Üveghuta site is potentially acceptable to host the repository for the radioactive waste from the operation and decommissioning of the power plant, but the site characterisation and the design of the repository should be continued.

The competent authority, the South Trans-Danubian Regional Office of the Hungarian Geological Service, assumed the same position and, in accordance with the WATRAP suggestion, they also suggested to continue the investigations. Taking into account all these facts a geological map synthesising the geological knowledge has been developed and the updated safety report was prepared. The results of that show that the selected technological process on that particular site fulfils the safety criteria with considerable margins.

Additional geological and technical studies necessary to licensing are to be performed, a comprehensive research programme has been developed. The work will be concluded in 2004 with the application for licensing of the Preliminary Environmental Impact Assessment.

Preparatory works for the final disposal of high level radioactive wastes

The Boda aleurolit formation in the Western Mecsek Mountains seems to be potentially suitable to the disposal of long lived radioactive wastes of high activity level and the spent fuel assemblies (not regarded as radioactive waste according to the present regulation) generated in Hungarian nuclear facilities. Examinations justifying this statement were started in 1989 on the base of uranium ore exploration and the infrastructure and knowledge base of mining. The usual methodology and quality level ruling at that time in the domestic mining were applied. Starting from the advantageously traced gangways, in 1994 the deep exploration of the Boda aleurolit formation was performed at a depth of 1100 m. Underground examinations completed by 1999 justified the capability of the formation but, due to the decision concerning the closure of the mine, the in-depth exploration could not be continued.

Taking into account all these and in accordance with the first Medium- and Long-Term Plan, the Public Agency for Radioactive Waste Management started to develop their long-term policy concerning the final disposal of the high-activity radwastes in the year 2000. Meanwhile, the environmental monitoring systems in the region have been kept in operation, expectably supplying the first evaluable results in one or two years, due to the long duration of several measurements.

Based on Section 4.3 it can be stated that Hungary and Paks Nuclear Power Plant Ltd. meet the requirements prescribed by Article 19 of the Convention concerning operation.

Questions concerning radioactive wastes and spent fuel are to be discussed in detail in another national report to be prepared under the relevant Convention.

4.4 Plans concerning safety improvement

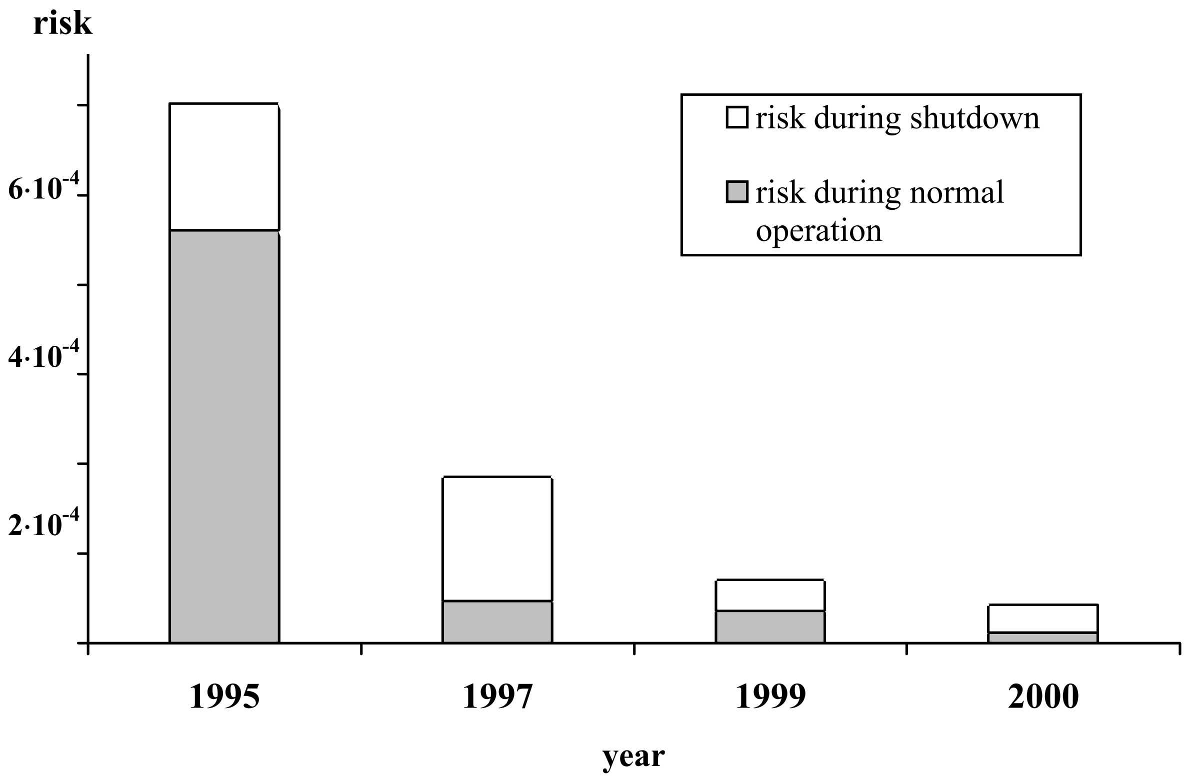
The present Section summarises the plans related to safety improvement and the measures to be implemented. These were already described in detail in the previous Sections.

Priorities of safety upgrading measures are revised periodically. As a result of the safety improvement modifications completed in 1998, the risk of a core damage in the power plant was reduced by a whole order of magnitude. According to PSA analyses performed during the revision of unit 3 and 4 it further decreased, now it is around $5*10^{-5}$/y for each unit. As a result of further measures the core damage probability will continue to decrease. Decrease of the core damage probability during the period from 1995 to 2000 is shown in Fig. 4.4-1.

Table 4.3.1-1 contains the activities aimed at increasing safety up to the year 2002.

Beside the process modifications an important element of safety improvement is the more careful consideration of the human factor. This is the objective also of the modernisation of the system of *accident management instructions*. The preparation of status-oriented accident management instructions was lasted from 1996 to 1999, and their validation was performed in 2000. At the beginning of 2001 training will be held and at the end of 2001 new instructions will be introduced into practice.

Both the Authority and Paks Nuclear Power Plant Ltd. consider it their primary task to continue with the accomplishment of safety improvement measures.



Core damage probability during the period from 1995 to 2000

Figure 4.4-1

Annex 1

In-service inspections

Types of operational tests

The preparation, scheduling, performance, evaluation and documentation of tests and inspections performed regularly or on an ad hoc manner on the systems, sub-systems and components of the nuclear power plant is regulated by the instruction of Paks Nuclear Power Plant Ltd.

According to the instruction, the processes and activities related to the tests are regulated in the following classification:

- in-service technological test - this is the function testing of systems in standby state of operation while taking the lowest risk possible;
- unit shutdown technological test - to check the operability of components and systems taking part in the shutdown, and to obtain information for maintenance works;
- overhaul technological test - to check the operability and function of components and systems maintained during overhaul;
- unit start-up technological test - a full-scope test following maintenance;
- non scheduled technological test – full-scope or partial testing necessary for other reasons, to verify operability.

Scheduling of in-service tests

The tests in the first step are scheduled on an annual basis, the annual time schedule is prepared by considering the cycle times of tests. For the branches of multiple, redundant systems, tests are scheduled for different times. The specific dates and times of the performance of the tests are decided upon at weekly planning meetings, when the operational status of the unit and the permissible deviation in cycle times are already known.

Evaluation of in-service tests

The minutes evaluating the tests are the basic documents to verify adequacy. The evaluation is done by the organisation responsible for the performance of the test. As a result of the evaluation, maintenance, reconstruction, quality assurance concepts and cycle times may be modified.

All minutes of operational technological tests have been kept by the power plant since 1992 and they have been processed in detail.

Over time the in-service tests performed have verified the adequate availability of components, systems and protection. In some cases, supplementary measures had to be taken as a result of an unsuccessful test, but the operational safety of the units was never jeopardised, and no unit was ever shut down for this reason.

Tests related to overhauls

During overhauls three groups of tests are performed:
- *before* shutting down the unit, tests are scheduled to check the systems necessary for shutdown and cooling;
- *during* the overhaul of the unit, upon completion of the maintenance of the safety systems, the adequacy of these are tested, before handing over the next system for maintenance;
- *after* the overhaul of the unit, the systems necessary for the start-up and operation of the unit are tested.

Tests are scheduled depending on technological conditions. The sequence of tests and the condition for establishment of further operational states are regulated.

Among the above listed groups the one performed after the unit overhaul contains the most tests. These are the following:
- functional and interlock tests of individual components;
- tightness and pressure test of the systems;
- full logical and real functional testing of protection systems;
- the hydraulic pressure test of the main cooling circuit and of the steam generators, according to cycle times;
- the integral tightness test of the hermetic zone;
- criticality tests on the reactor, in order to verify the physical calculations;
- tests performed at different power levels.

The scope of tests performed after weekend maintenance is decided upon by a special consideration when the nature of interventions done and the time elapsed are already known.

The system of requirements related to material testing

In Paks NPP, the unified programme and criteria for periodic material testing have been elaborated simultaneously with the commissioning of the units and on the basis of Soviet requirements and standards, pre-commissioning tests and international experience, and with the involvement of domestic research institutes.

These requirements have been approved by the National Energetics and Energy Safety Engineering Inspectorate, competent at that time, and any modification in it requires the permission of the Authority. The documents are revised yearly and necessary changes are made.

One of the guides of the Nuclear Safety Standard following the entry into force of the new Act on Atomic Energy prescribes the performance of periodic material testing on nuclear power plant component. The guide stipulates that the scheduling of nuclear power plant tests should be set in material testing framework programmes; their execution should be set in the testing technologies; and the requirements concerning evaluation should be laid down in a list of criteria.

Periodical material testing

The scope of periodical testing is defined by the material testing programmes, which specify the testing area, the method of testing, the scope and frequency of testing, reference to the corresponding item of the list of criteria, the technological conditions needed for the test, engineering safety requirements and the anticipated method of documentation for each component element or group of components. The full-scope periodical and non-destructive material testing of primary and secondary circuit equipment comprises the following units:

- the reactor and its sealing units;
- the upper block;
- the reactor internals;
- main circulating loop;
- steam generators;
- the pressuriser;
- emergency core cooling tanks;
- primary circuit components and piping;
- local sealings;
- secondary circuit components and piping;
- clamping structures;
- fuel containers.

The criteria for the evaluation of the tests are contained in the volume entitled "General Methodology and List of Criteria for Non-destructive Material Testing". This document contains the objectives and principles of tests, the testing engineering data and the criteria of evaluation for all methods and types of tests.

Annex 2

Handling of the ageing of equipment

Basics of the management of ageing

The nuclear power plant meets the official requirements related to management of ageing in such a way that creates the possibility to maintain the safe conditions of operation of the power plant even beyond the design lifetime (30 years) of the plant. This concept is in accordance with

- the international (mainly American) and domestic experiences related to the management of ageing and lifetime management;
- the aspects of nuclear safety;
- the constant development of scientific and technical knowledge.

In respect to certain selected components considered to be critical, Paks NPP carries out a systematic ageing management activity. The strategy includes:

- identification of critical components;
- the definition of the zones of these components that are particularly prone to ageing, along with all potential degradation processes that are characteristic for the given part;
- the consideration of the actual values of loads put on the component;
- the revision of structural, assessment, maintenance and material testing programmes and their modification if required;
- the establishment of a status monitoring system for the components;
- continuous monitoring.

The selection of critical components

The components screened for the management of ageing have been selected primarily during the review of the equipment which play a prominent role in the cooling and safe shutdown of the reactor core, and of structures inhibiting the release of radioactive substances (the principle of defence-in-depth). At the selection procedure, the document of the International Atomic Energy Agency entitled "Methodology for the Management of Ageing of Nuclear Power Plant Components" has played an important role.

Accordingly, only those items were included in the list of critical components which demand long term ageing management because of their unique characteristics, or the replacement of which would constitute a serious financial and technical challenge. The components considered to be critical are as follows:

- reactor pressure vessel;
- pressuriser;
- balancing pipeline between the main circulating loop and the pressuriser;
- pipelines of the main cooling loop;
- steam generators;
- main circulating pumps;

- main gate valves;
- the driving mechanisms of the control rods;
- concrete structures and casings in the hermetic zone together with the reactor support and sealed penetrations;
- power supplies for safety equipment (cables and connections);
- feed-water pipeline;
- diesel aggregates;
- reactor internals.

Procedural order

According to the procedural order, the main tasks of the responsible organisational units of the power plant are as follows: to ensure the safe operation of the units beyond their scheduled lifetime, to ensure availability, to examine technical problems related to the ageing of components of distinct importance and to allocate tasks related to ageing management and to co-ordinate the accomplishment thereof.

Cycle numbers

One of the administrative limitations for the operation of a critical component comes from the cycle numbers limited in the Manual of Operating Procedure. The cycle numbers of certain loads were determined by design, thus both its pace of decrease and the actual load may be different from that scheduled. It should also be taken into consideration that loads may arise that were not considered when designed (e.g. heat flux differences as a result of logged flow).

Fatigue monitoring is an important task and it also provides the possibility to reassess the administrative limitations defined while designing, which can be an important factor for a possible life extension.

Annex 3

International study on the containment

On the initiative of the OECD and the European Union an experimental project was launched to investigate if the containment supplied with bubble condensers performs its designed function.

The project Bubble Condenser Experimental Qualification (BCEQ) specified two kinds of experiment to be performed and these were accomplished within the framework of the project PHARE/TACIS 2.13/95.

In the first series of experiments the thermal-hydraulic behaviour of the bubble condenser and the dynamics of related building structures were studied. The experiment was performed at the organisation EREC in Russia. The bubble condenser of the Paks NPP was taken as model for the design of experimental equipment.

The second series of experiments studied the integrity of the steel structural elements of the bubble condenser under the circumstances of a design base accident, with static load. These experiments took place in Slovakia at the institution VUEZ. At designing the experimental model the structure of the Dukovany and Bochunice power plants was followed.

The third part of the project, conceived later, contained experiments on small-scale models for studying analytically several partial effects, accomplished at the organisation SVUSS, Bechovice, Czech Republic.

The report summarising the results of the experiments was presented in December 1999 in Brussels, on the session of the Technical Advisory Committee of BCEQ, and later in April 2000 in Berlin, on the meeting of the OECD Support Group.

The results gave favourable answers to most of the questions raised. However, a set of unresolved problems and uncertainties remained. Aimed at their removal, the Paks NPP, concluded a contract with the Institute for Electric Power Research Ltd., Hungary to perform several technical computations based on the test results. The software package GASFLOW 3D has been used and the results were in good agreement with the data acquired during the experiments. Thus, the uncertainties concerning the flow and temperature distributions could be resolved.

Based on all those said above one could conclude that the BSEQ tests and the consecutive calculations proved the functionability of the Paks containment in accordance with the design in case of a big LOCA event.

In spite of the results, positive so far, it seems to be expedient to perform several additional experiments to further validate the codes used for simulating the containment processes.

After completion of these works one could continue with the analysis of beyond-design-base accident scenarios as for example the partial or complete lack of water in the containment trays.

For the request of the Authority in the last years containment integrity tests were performed also with pressures exceeding 120 kPa specified for the pressure tests after refuelling. In the period of 1994 to 1997 tests were accomplished with elevated pressure (170 kPa) once a year on each unit. On the base of the results and the updated leakage characteristics the Authority and the Licensee set at negotiations about technical measures. As a result, beside the annual tests, an additional pressure test at 170 kPa is to be performed in every four years on each unit. Moreover, preparations have been started to perform a single pressure test at full design pressure of 250 kPa.

Annex 4

Manufacturing, acceptance, installation and testing of technological equipment

The Pre-commissioning Safety Analysis Report contains the detailed technical data of the 28 nuclear power plant components of distinct importance. It also features the technical requirements of manufacturing, quality assurance, characteristics, manufacturing tolerances; the conditions of transportation, storage and conservation; the requirements of acceptance inspection and super-inspection and the non-conformances revealed by these; the requirements, accomplishment and non-conformances of mounting and erection; and the documentation to be prepared by the manufacturer and for hand-over. It lays down the consequences of non-conformances in all cases. This is followed by the description of 37 systems of distinct importance and 7 additional systems. Finally, it deals with the quality assurance of the fuel.

Start-up, commissioning acceptance tests and the commissioning programme

Commissioning plans laid down the objective, prerequisites, implementation, completion criteria, documentation and licensing requirements of certain steps. After the works were completed, all evaluations and statements had to be attached to the documents. Tests and commissioning took place in the following major steps:

- commissioning of the fresh fuel storage and the technological transportation system;
- commissioning of electrical components and systems;
- commissioning of control system equipment and radiation protection systems that directly serve the technology;
- cleaning of technological systems (primary, secondary and ventilation systems);
- operational testing of technological systems;
- pressure test and circulation flushing of the primary circuit, along with functional tests scheduled for this phase;
- start-up tests on the secondary side using auxiliary-steam taken from the temporary boiler for the first unit and from the operating unit in the case of consecutive units;
- the first revision, which included the dismantling and inspection of the reactor, the steam generators and other primary circuit components, the inspection of the cleanliness of the equipment after the pressure tests and circulation flushing, mounting and erection practices for the maintenance staff under inactive circumstances;
- the low-power test of the primary circuit;
- the second revision: status inspection requiring repeated dismantling;
- the integral pressure test, tightness test and the exact assessment of leakage values, with comparison of these with the limit, for the hermetic zone including the primary circuit;
- the physical start-up;
- the first connection of the unit to the grid, followed by the tests of power start-up at different power levels: loading of the reactor up to around 20, 35 and 55 % of its rated capacity, followed by the shutdown of the unit for scheduled preventive maintenance; further loading of up to 75 % of rated power, then to 100 %; and finally a 72-hour complex testing of the unit in rated operational state;

- guarantee performance tests and certifying the unit as operational equipment.

Annex 5

Maintenance

The maintenance of the power plant aims to ensure a high technical standard of equipment and the nuclear safety thereof; and to maintain its operability through reasonable expenditures. The key element of the maintenance system is that of being well planned with the emphasis on prevention rather than repair. The basic objective is to carry out all maintenance activities (the overhaul of equipment, periodic maintenance with the units in operation, and so-called service-road maintenance that is carried out regularly through a maintenance review) in a well-planned, scheduled and regular manner.

General overhauls consist of the following activities:

- technical and safety reviews;
- periodic maintenance works;
- works prescribed by the authorities;
- repairing failures having occurred during operation;
- safety upgrading measures, modifications, reconstructions.

Periodic maintenance works performed with the units in operation are accomplished on equipment which bear sufficient reserves and thus can be handed over during the rated operation of the unit as well. This reduces the work done at overhauls.

Regular maintenance review serves the assessment of the condition of operating equipment or those in stand-by state. Maintenance of the equipment is scheduled based on such assessments.

Preparation is a key element of maintenance. Preparation is aimed at creating a database of the planned phases of continuous activities repeated periodically, and to establish optimal maintenance cycle periods in order to prevent unjustified over-maintenance.

Overhaul strategy

One of the most important factors affecting the availability of the power plant is the time required for overhauls. Recently, continuous efforts have been made to decrease this time period.

The long-term strategy is aimed at the implementation of a series of measures that can reduce the time taken by overhauls to an optimal level both from the aspect of economic efficiency and the adequate use of workforce.

The essence of the overhaul strategy is the introduction of three basic types of overhauls. These types and the related principles of implementation are as follows:

- major overhauls performed every 4 years;
    - modifications of larger scale, reconstruction works, the revision of main components in line with long term schedules should be performed at this time;

- medium overhauls:
  - technical and safety reviews which can be performed, pre-assembly works related to larger modifications and reconstructions, certain modifications and works of periodic maintenance should be performed at this time;
  - it is advisable to define a maximum time period, which must not be exceeded when defining the time period taken, if the time period needs to be modified, then this is to be approved by the Maintenance Working Committee if the organisation applying for such a permission provides sufficient justification;
- small overhauls:
  - only such works can be scheduled for this overhaul, the completion time of which does not affect the critical path (the reactor line).
  - the time taken depends on the shortest time necessary for the following process: shutdown, reactor dismantling, fuel reloading, reactor assembly, restarting;

The order of executing maintenance activities

Maintenance activities in the nuclear power plant are regulated in a comprehensive manner in the Maintenance Quality Assurance Standard and the instruction of the Director General entitled "The Order of the Accomplishment of Maintenance, Reconstruction and Investment Activities". These documents include:

- the systems and components in question and their parts thereof;
- the activities to be performed;
- materials used directly or indirectly during the activities.

The system of requirements ensures that all activities related to the civil, instrumentation and control and mechanical engineering maintenance of the power plant are of adequate quality. Separate instructions regulate quality assurance, which is done by an independent internal organisation.

The basic document of maintenance works is the work instruction. The work instructions ensure the normal, well organised work of organisations taking part in the maintenance, and their efficient co-operation.

The Overhaul Scheduling and Implementation Order includes all tasks related to documentation and names the personnel responsible. The management body of overhaul scheduling is the Overhaul Planning Conference. The operation of this is regulated by conference rules. The implementation of the overhaul is determined by the overhaul authorisation plan, the overhaul net diagram and other instructions in force. Separate instructions regulate the planning and accomplishment of planned preventative and periodic maintenance works. The lowest level of maintenance regulation consists of several hundred equipment-specific maintenance technologies.

The method of involving external contractors into maintenance is also regulated in detail. Two basic methods of commissioning contractors are used in the power plant: the first is by adding the external experts to the corresponding team of the power plant on a temporary and task-oriented basis, and the other is by giving them individual tasks to be accomplished. In the first instance, the management of the experts is governed by the procedures established for regular employees of the power plant. In the second case, the factors ensuring supervised work are: the contract, the authorisation of the employed technology, the system of work instructions, the hand-over of the working area and the obligatory inspection exercised by the executives of the given professional area. The proportion of contractors hired of the latter type has risen during recent years.