NATIONAL REPORT

REPUBLIC OF HUNGARY

Document prepared in the framework of the
Convention on Nuclear Safety

1998

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 20 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 No. 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.

The following National Report has been compiled in accordance with the requirements of the Convention and of the related document entitled "Guidelines Regarding National Reports under the Convention on Nuclear Safety".

Following a brief introduction, the National Report contains four chapters dealing with the following:

- the description of existing nuclear installations (mainly Paks Nuclear Power Plant which falls under the scope of the Convention);
- the characteristics of Hungarian legislation and regulations;
- 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.

***

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 authority and its licensing and supervising activity,*
- *the operator is committed to the priority and continuous improvement of safety concerning the activities it carries out.*

Budapest, September 1998.

György Vajda
Director General of the Hungarian Atomic Energy Authority

0. INTRODUCTION

National energy policy

Due to geographic factors, Hungary is poor in natural energy resources and this unfavourable condition has continuously constrained the energy policies of the country.

The current energy policy of Hungary was approved by Parliament in April 1993. Following this approval, the Government is liable to submit a report to Parliament every two years.

A part of the principles and strategic concepts elaborated previously has already been implemented, and the remaining part is currently under implementation.

The basic energy policy principles still of primary importance are as follows:

- maintaining and increasing the safety of energy supply, including the reduction of the one-sided import dependence, the establishment of the technical and political conditions of a diversified structure of energy procurement and boosting of strategic reserves;
- intensifying the role of energy conservation, increasing the efficiency of the use of energy and thus improving the competitiveness of the Hungarian economy;
- creating an organisational, economic and legal environment conforming to the market in order to enable the Hungarian energy sector to gradually adapt to the evolving unified European energy market;
- enforcement of environmental aspects, raising of the role of the public in energy policy decisions and the related administrative procedures;
- European integration in energetics.

The spirit of this policy gave rise to Act No. XLVIII. of 1994 about the generation, transportation and supply of electric energy, Act No. XLVIII. of 1993 about mining, Act No. XLI. of 1994. about gas supply and promoted the creation of the Hungarian Energy Office.

The role and contribution of nuclear energy

Paks Nuclear Power Plant, the only nuclear power plant of Hungary, is currently operating as a shareholders' company under the name of Paks Nuclear Power Plant Ltd. The electricity generated by the power plant has played an important role in electric energy generation of the country ever since the first unit was connected to the grid. In 1997, the contribution of nuclear energy to the total generation of electric energy amounted to 35 GWh, i.e. 40 %, 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

The issue of nuclear safety has been given top priority since the earliest stage of the installation of the nuclear power plant, as illustrated by the complete range of legal regulations; policies and committed activities of the authority and the operating entity.
Act No. CXVI. of 1996 (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 Nuclear Power Plant, 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 it 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 and are expected to take prompt decisions should any unexpected, urgent and not clearly assessable situation arise.

Paks Nuclear Power Plant Ltd. has embarked on the implementation of a safety upgrading programme, initially at its own initiative and later following the requirements of the Authority, with the commissioning of the power plant units. The implementation of this programme has been continuously in progress.

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, as a new but equally important element of safety reviews, the submission of safety reports containing the results of such assessments. The first periodic safety assessment has been performed for Units 1 and 2 and will have been concluded for Units 3 and 4 by the end of 1999.

International reviews

Since commencing operation, Paks Nuclear Power Plant has paid special attention to utilising international experience, and on the initiative of the power plant 22 international reviews took place between 1984 and 1997. All kinds of important reviews organised by the International Atomic Energy Agency have been performed at the nuclear power plant. Within the Central and Eastern European region, Hungary was the first country where the International Atomic Energy Agency conducted a full scale OSART and the World Association of Nuclear Power Plant Operators conducted a Peer Review mission. All reviews resulted in favourable conclusion.

The activities of the Authority were surveyed by the European Union delegated RAM Group with full satisfaction. The new regulatory system introduced following the survey took into consideration all the recommendations made by the delegation.

International Relations

Hungary maintains 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.

The Hungarian Atomic Energy Authority (Authority) is authorised counterpart of International Atomic Energy Agency (IAEA) and of the OECD Nuclear Energy Agency (NEA) and co-ordinates the Hungarian participation in their activity.

The Authority has signed mutual information exchange agreements with the counterpart organisation of Canada, France, Romania, United Kingdom and the United States of America. It maintains close professional relations with the authorities of other countries operating WWER reactors and with the authorities of Belgium and Spain. The Authority has benefited from the technical co-operation programmes of the IAEA and from several projects of the European Union's PHARE programme.

The Authority takes an active part in the work of the "CONCERT" group and in the Forum of the authorities of countries operating WWER reactors.

The Paks NPP is member of 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), NUMEX (Nuclear Maintenance Experience Exchange) and NMAC (Nuclear Maintenance Applications Centre).

These relations serve to interchange knowledge and experience and are the main guarantee of maintaining and increasing nuclear safety.

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.

1. EXISTING NUCLEAR INSTALLATIONS

1.1 Paks Nuclear Power Plant

The scope of the Convention includes all four operating units of Paks Nuclear Power Plant. The units were commissioned between 1983 and 1987 and are in good technical condition. They have been operating for 12 to 16 years and, as a consequence, some one-third to a half of their scheduled lifetime is over.

Paks Nuclear Power Plant Ltd. is a state owned economic entity. It came into existence on 31 December 1991 by an exclusive foundation, with the transformation of Paks Nuclear Power Plant Company and as its legal successor. 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 The installation of the nuclear power plant

In 1966, Hungary and the Soviet Union concluded an inter-governmental agreement for the construction of a Hungarian nuclear power plant. The Soviet party undertook the design, supply of equipment, and co-operation in the implementation of the technical tasks. Hungary introduced its own quality assurance system from the initial preparatory stages, and repeatedly proposed the successful revision of original concepts on the basis of this system. These modifications resulted in the improvement of safety in all cases.

Following a temporary suspension of works, a decision was taken in 1971 to resume construction. The technical design for the first two units was completed in 1974.

The personnel of the power plant were recruited following a thorough selection procedure. Those employed had studied, trained and gained experience in national research institutes and power plants abroad.

The dates of connection to the grid of the individual units are as follows: December 1982, September 1984, September 1986 and August 1987.

Authority background was established simultaneously with investment. For the supervision of major licensing milestones (pressure test, fuel loading, long term operation) and of the commissioning, a separate committee, the State Committee for Start-up and Supervision Acceptance was established.

1.1.2 Main technical characteristics

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 bubbling 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 each unit is 460 MW.

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 sharing 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.

The diesel generators are different: the generators in Units 1 and 2 were manufactured in the Ukraine, while those in Units 3 and 4 are of Hungarian make. The start-up time of the Hungarian generators is shorter than that of the Ukrainian ones, and their output power is also higher. The diesel generators of the twin units have been situated in a common building, but in separate compartments. The six individual diesel generator units located in the same building do not share any technological equipment.

1.1.3 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. Preparations for voluntarily undertaken inspections and the external pressure to improve safety and operating indicators have proved very useful.

The list of international safety reviews performed at Paks Nuclear Power Plant is contained in Table 4.3.7-2. 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. The periodic safety review of Units 1 and 2 was completed in 1996, while that for Units 3 and 4 are currently under in progress. (Detailed information about the AGNES project can be found in Section 4.3.1).

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.

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

1.1.4 Interim storage of irradiated fuel assemblies

Since the possibility to return irradiated fuel assemblies from Paks Nuclear Power Plant 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. As a result of a wide-range research and evaluation work, taking all aspects into consideration, 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.

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 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.

The first 450 irradiated fuel assemblies were loaded into the facility in 1997.

1.2 The Budapest Research Reactor and the training reactor of the Technical University of Budapest

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. Its full reconstruction started in 1986 during which its safety system was extended, and as a result the principle of defence-in-depth has been completely adopted. The new safety report meets all the requirements of both domestic regulations and those contained in IAEA recommendations. During the reconstruction works a new accident prevention programme was prepared and accepted. The reconstructed reactor resumed operation in 1993.

Main technical data:

- 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 Technical University of Budapest was built in 1972 for educational and research purposes. The first operating licence of the reactor expired in 1995 and, based on a Periodic Safety Review performed by the Authority, the licence was renewed for a further 12 years.

Main technical data:

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

2. LEGISLATION AND REGULATIONS

The first regulations on radioactive substances and radiation hygiene in Hungary were issued in 1964. A high level legal regulation concerning nuclear technology was first issued in 1978. This was a decree of the Council of Ministers and listed the tasks of authorities related to the establishment of Paks Nuclear Power Plant and allocated the corresponding responsibilities to the different ministries. In 1979, a ministerial decree was issued concerning the safety issues related to the nuclear power plant. The detailed professional and procedural requirements were contained in the standards making up the annexes of this decree.

In the first half of the 1990's, the international expectations and the economic and social transition taking place in Hungary urged the creation of a new Act on Atomic Energy that would substitute the 1980 act, and reform the regulating framework. Following several years of preparatory work, the Hungarian Parliament approved the new Act on Atomic Energy in December 1996 (Act No. CXVI. of 1996 on nuclear energy), which entered into force on 1 July 1997.

2.1 Legal and organisational framework

2.1.1 The Act on Atomic Energy

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-NEA were considered.

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

- the exclusive state ownership of nuclear installations and radioactive substances was terminated;
- 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 obligations undertaken by Hungary in the 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;
- establishes new principles on informing the public;
- introduces a new concept regarding the emergency preparedness and accident prevention.

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.

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

2.1.2 The implementation of the Act on Atomic Energy

Forty five regulations have been prepared (a number of which are still in preparation) for the implementation of the requirements of the Act on Atomic Energy. Twelve of them are Government Decrees and 33 are ministerial decrees.

The statute of the Hungarian Atomic Energy Commission and of the Hungarian Atomic Energy Authority was re-regulated by the Govt. Decree No. 87/1997. (V.28.).

Most of the official issues related to the safety of nuclear installations, in particular in respect to the nuclear power plant, have been re-regulated by the Govt. Decree No. 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 (20 guides have been issued so far and the issue of 38 further guides is expected by the end of 1998).

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 e) 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.

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. 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.

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 Licensing Department;
- the Supervising Department (the seat of which is situated at the nuclear power plant facility);
- the Technical Department being responsible for analysing and accident prevention activities; and
- the Quality Assurance Division responsible, among other tasks for internal quality assurance.

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, such as the organisation and co-ordination of research and development programmes together with the maintenance of international relations are generally undertaken by the other organisational unit of the Authority, the General Nuclear Directorate.

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 and the Electrical Power Research Institute Ltd. 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 a Scientific Council. 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 (and the Sections of the Report referred to) 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. As with the Authority, 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. The obligation of licensing, the procedure of licensing and the requirements to be enforced by the Authority are contained in the Govt. Decree No. 108/1997.(VI.25.) (referred to above) and its schedules.

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 during the lifetime of the nuclear power plant. Should only the licence corresponding to the current life period of the installation be held, a separate licence entitling the relevant activity must be obtained for the following activities to be carried out: the construction, utilisation and modification of facilities of the nuclear power plant, and the manufacture, import, erection, operation, modification and decommissioning of such equipment of the nuclear power plant that are classified into safety classes and the same activities related to the nuclear fuel. 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 No. XLVIII of 1994 (Generation, transportation and supply of electric energy) are also required for the installation and legal operation of the nuclear power plant.

Within the licensing procedure of a nuclear power plant, the requirements related to geology, water management, sanitary and veterinary rules, environmental protection, radiation health care, security, safeguarding and the preventing of nuclear accidents are enforced by the specialised authorities designated by law. At all phases of the licensing procedure, the opinions of the specialised authorities are obtained and submitted by the Licensee to the Authority annexed to the licence application. During the licensing procedure conducted by the Authority, the Authority is not entitled to evaluate the assessments of the specialised authorities and the obligations prescribed by them, these form obligatory elements of the final decision.

The documentation serving as a basis for the application is the Preliminary Safety Analysis Report when applying for an installation licence, and the Final Safety Analysis Report when requesting an operation licence. The Authority has six months to evaluate the licence application.

According to Subsection (1) of § 38 of the Act on Atomic Energy, an installation licence for a nuclear power plant can only be issued if the interim storage or final disposal of generated radioactive wastes and irradiated fuel is ensured and this disposal conforms to modern scientific methods and prevailing international practice. The final disposal of radioactive waste generated by
the Paks Nuclear Power Plant has not yet been ensured. The licensing of the power station today could be based on the availability of interim storage facilities.

Before issuing an installation licence, and in accordance with the decree regarding the general rules of environmental protection, the public should be informed through the corresponding local authorities and a public meeting should be held. As far as power plants are concerned, a separate decree regulates the preparation and performance of public meetings, and the evaluation of the results thereof.

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.

2.1.5 Supervision and assessment

The Act on Atomic Energy stipulates that nuclear energy can only be deployed in the way defined by law, and with regular supervision 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. Continuous supervision is the responsibility of the Authority.

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.

The authority performing the inspection is required to take immediate measures in order to eliminate any discrepancies detected, or to initiate such measures deemed necessary.

The regular reassessment of the nuclear power plant performed on the basis of a comprehensive pre-planned programme is the Periodic Safety Review. This is to be performed every 10 years, within the framework of which

- the current level of the safety of the nuclear power plant unit should be assessed, and it should not be lower than the level obtained when the Operation Licence was issued;
- the current state of the nuclear power plant unit should be assessed, taking into consideration the ageing and wear of the systems and components, and all factors both inside and outside the site that may affect the safe operation of the installation in the future;
- at the time the inspection is performed, the current characteristics of the installation should be compared with requirements considered to be modern in international practice, and any non-conformances should be identified which according to modern specifications jeopardise the safe operation;
- the risk factors disclosed on the basis of the above criteria should be prioritised, and a safety upgrading programme of measures for their management should be implemented.

In order to ensure the controlled deployment of nuclear energy and to evaluate the activity of the Licensee, the Authority operates a reporting system, within the framework of which the Licensee submits reports to the Authority regarding the operation of the nuclear power plant and the activities related to the safety thereof. These are:

- annual reports;
- quarterly reports and
- specific reports concerning events occurring during operation which affect safety.

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.

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 No. IV. of 1957 regarding the general rules of administrative procedure, Act No. IV. of 1978 concerning the Penal Code and in the Govt. Decree No. 87/1997. (V.28.).

On the basis of Act No. IV. of 1957, the Authority, in order to enforce the requirements of the regulations in force or an inured prescription of an authority, may initiate an administrative procedure and within the framework of this may oblige the Licensee to eliminate the detected deviation. The law allows the issue of a disposition regarding the immediate fulfilment of such measures, should the measure be required to avert mortal danger or to maintain public security, or if the lack of immediate implementation would result in significant or irreversible damages. These measures can also be applied in the case of official issues concerning the use of nuclear energy and they represent the mildest form of sanctioning.

According to Govt. Decree No 87/1997. (V.28.), 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. When setting the sum of the fine, all circumstances of the event are to be taken into consideration. Fining can also be used independently as an instrument of sanctioning, but it can be also accompanied by other sanctions.

The Act on Atomic Energy also enables the Authority to revoke the licence of the nuclear power plant, or to limit the period of its validity, should it find that the safety conditions serving as the basis for issuing the licence or the degree of risks involved has changed. The licence can also be revoked or its period of validity may be limited if the modification of the nuclear power plant or its systems and components (if these modifications affect safety) has been carried out in any way deviating from those contained in the modification licence or they were performed without licence. If the approval of the specialised authority involved in the licensing procedure, which is the basis of the licence itself, becomes invalid, the competent specialised authority may initiate the revocation of the licence of the nuclear power plant.

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. According to Act No. IV. of 1978 about the Penal Code, it is a crime to operate a nuclear power plant without holding the licence prescribed in law or to operate it in a different way from that defined in the licence, and thus penalty with imprisonment can result.

2.1.7 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 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 installation.

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 supervising 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 (Safety Fundamentals, Safety Standards and INSAG-reports) set the basic principles of safety. These are the principles which the Hungarian Authority follows and applies. The Safety Policy of the Authority as a document is also based on these, but recognises the fact that each country has to follow its own practice in the actual implementation.

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 supervisory activities in order to reach these goals, and these activities comprise licensing, inspection, supervision, analysis and evaluation.

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 supervision 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 process (limited to its own professional area). Therefore, 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 reduce risks continuously. 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.

The regulation set up by the Authority reflects a non-prescriptive nature. This is put into practice by the implementation of conditions correctly defined in the licences.

One of the instruments to assess safety is the principle of defence-in-depth. Appropriate quality assurance and the operability of safety systems both serve as prevention of potential damage in the protective barriers. For the assessment of this, it is adequate to apply the principle of single failure (the deterministic approach).

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.

Human factor also plays an important role in the processes (the probabilistic approach).

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.

3.2 The safety policy of the Licensee

The Govt. Decree No. 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: "In the operation of the nuclear power plant, the complete fulfilment 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 and instructions at a lower level.

During the time elapsed since the definition of the objectives of the Safety Policy in 1993, most of those included in the policy have been fulfilled, or active improvement is going on in order to achieve its accomplishment. The Safety Policy lays great emphasis on defence-in-depth.

In order to prevent human mistakes, the following measures have been taken following the issue of the Safety Policy:

- administrative requirements have been completely revised and upgraded to meet international standards;
- independent internal supervision has been set up.

The safety status of the nuclear power plant facility is constantly being followed by both the management of the power plant and the Authority. The safety status of the power plant is analysed quarterly in a detailed manner.

A pre-requisite to any reconstruction or modification is the previous analysis of their potential effects. These analyses are the indispensable annexes of any application submitted to the Authority for a modification licence.

The physical protection system of the power plant has been revised in the past both by the competent persons of the Ministry of Internal Affairs and the experts engaged by the Hungarian Atomic Energy Commission. The inspections did not reveal any significant deviations, and according to their basic statements the power plant meets all international requirements and domestic regulations concerning the physical protection of nuclear materials and installations.

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.

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 supervision 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 a supervision 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.

3.3.2 Financial resources of the Licensee

Act No. XLVIII. of 1994 regarding the generation, transportation and supply of electric energy stipulates that from 1 January 1997 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.

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. The amount payable annually by the operators of nuclear installations into the fund is defined by Parliament as part of the act concerning the annual budget. These payments should be considered when defining the price of electric energy.

Paks Nuclear Power Plant 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, set against the depreciation generated and through taking loans.

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 Technical University of Budapest, students obtain significant knowledge regarding power plants and nuclear power plants within the framework of subjects related to energetics. An affiliated college of the Technical University of Budapest operates in Paks providing a three-year engineering degree course. The knowledge obtained in these higher education institutions can be well utilised in jobs both at the Authority and the power plant itself.

3.4.1 Human resources of the Authority

The Authority employs a total of 82 individuals, 66 of which are experts holding a higher education degree (university or college), 50% of whom have two degrees (the second degree usually being in the area of nuclear technical disciplines). Nine individuals have an academic degree, and 33 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).

The training of the staff of the Authority 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.

In the Centre for Emergency Response, Training and Analysis (CERTA) of the Authority regular preparatory training was started in the spring 1998 for the employees of the Authority. In the second half of this year an education programme approved by the Governmental Committee for Nuclear Emergency Preparedness is scheduled to start at the same place within the framework of the "Accident Prevention Harmonisation Project" co-ordinated by the International Atomic Energy Agency.

The representatives of the Authority take part in international technical affairs.

3.4.2 Human resources of the Licensee

As of 31 December 1997, the number of individuals employed by Paks Nuclear Power Plant Ltd. was 2,895; 104 persons of which are heads of divisions or executives of a higher level. The number of persons engaged in operation is 1,274; the number of those in the maintenance staff is 719 and the number of others ensuring support activities is 798. The composition of employees in relation to qualifications is as follows: 742 with a higher education degree, 1,508 with a secondary school degree and 645 skilled workers or persons with other types of qualification. From among those in the operating personnel, 296 persons have a valid official licence for performing 15 types of functions.

A job description comprising the basis of a unified system and qualification requirements are laid down for all jobs. 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 expert training system consists of a series of modules ordered in hierarchic structure and it is job oriented. Theoretical and practical training is followed 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. Medical and psychological fitness is also a prerequisite.

In the case of previously defined posts of greater responsibility and vital to safety, the phases of training are concluded by an official licensing examination. The periodic renewal of the examination is also regulated.

Paks Nuclear Power Plant operates a specialised secondary school fully at its own expense and a college in order to give students a higher-level theoretical education necessary for the recruitment of experts.

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. Another area of training includes the executives.

Paks Nuclear Power Plant Ltd. executes the training of its experts at its own cost and in its own training centre. 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 centre are well equipped, audio-visual and computer controlled instruments and simulators of different types are available including a full scope simulator that has been reconstructed several times. Teachers and instructors are well prepared and in addition to being involved in education, they are also engaged in technical development.

With the assistance of the International Atomic Energy Agency, a Maintenance Training Centre has been set up which is unique in the whole region. It is used also by the experts of other countries operating WWER reactors.

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 recording and evaluating the results of the probabilistic safety analysis carried out within the framework of the AGNES project, it was clearly shown that the contribution of potential operator’s failure to the risk of core melt-downs is relatively high, 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. When evaluating 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.

Training and examinations are conducted in the training centre of the power plant and in a unified and identical way for all employees, irrespective of whether the person in question is a direct employee or engaged from outside on a contractual basis.

Medical adequacy is checked once a year, while the fulfilment of psychological criteria is checked within the prescribed frequency of the validity period of the licence. 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 experience drawn from the analysis of the causes leading to the Chernobyl accident in 1986 has been utilised by the management of the power plant through the elaboration and implementation of a detailed plan of measures. Among them the limitations concerning overtime by control room and operative personnel should be highlighted, in addition to the increase of the number of shifts from five to six.

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 keeps continuous records of the work load of employees.

The burden on operating staff has been significantly reduced following the introduction of the six shift system. The organisational framework that required the set-up of an additional shift also proved to be an effective instrument in preventing the overloading of control room personnel.

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 The feedback of experience in order to increase safety

It is an important basic principle laid down in the safety policy of the nuclear power plant that persons who commit a mistake while performing work are required to report immediately any error detected or discovered or notify the manager in control.

In the nuclear power plant all external and internal events requiring reporting should be meticulously examined according to a separate procedural order. If the investigation finds a human mistake or negligence, the psychological laboratory joins the analysis work as well and helps to detect the initial causes. The employee at fault is required to complete a form, from the analysis of which the direction of necessary changes and modifications is defined. The results of the investigations are laid down in a definite system of measures. In the case of issues related to safety culture, the forms aimed at the disclosure and review of general experience are preferred.

3.5.5 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 of the Manual of Operating Procedure on a new basis: symptom orientation instead of status orientation. (This work is being done with the co-operation of the Westinghouse company and will be completed by the year 2001.)

The requirement to keep a unit shift supervisor permanently on call also acts to retain the normal handling of unexpected situations.

A computer system that provides all substantial services to users operates within the Paks Nuclear Power Plant. The informatics background needs continuous development and modifications. The current versions of modern software are being used.

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 (e.g. the provision of hearing protection means and other supplementary measures defined in specific licences). 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 reconstructions and modifications in a way to significantly reduce the probability of the repetition of errors and mistakes. A good example of this is the activity of the

Department of Ergonomics and Psychology of the Technical University of Budapest in examining man-machine interface within the unit control room.

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

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 in the nuclear power plant. The successful accomplishment of quality assurance affects not only safety but the reliable and economical operation of the power plant as well.

Quality assurance is a common task, and so it is indispensable for everybody to be aware of its basic principles, its system and requirements.

The basic principles of the quality assurance system are as follows:
- in order to achieve their goals, the management and the *executives* of the power plant 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 *supervisors* of the quality assurance system check whether processes and individual tasks are carried out according to the requirements.

The executives of the responsible organisations have to set up basic principles that enable the integration of quality requirements into everyday work. To this end, performers should be given the appropriate information, instruments and support. It is the task of the management of the corresponding professional areas to define the requirements, organise education related to implementation, motivate staff, provide all necessary resources and evaluate its implementation.

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

3.6.2 The national quality assurance system

Subsection (2) of § 11 of Act No. 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 introduction of the quality assurance system of the nuclear power plant

The fact that Paks Nuclear Power Plant operates reliably and is among the leading WWER units is due to the continuous work that has been done since the beginning of the investment, work which has been aimed at good quality and was initially rather instinctive has become increasingly conscious over time.

The Quality Assurance Standard that was issued in 1979 as an annex to a decree by the Minister of Heavy Industry clearly summarised quality assurance requirements and significantly helped the work of organisations participating in the construction of the nuclear power plant. This standard was considered to be a first of its kind in our geographic region.

Conscious quality assurance originates from the adoption of corresponding documentation of the International Atomic Energy Agency. The establishment of organisations and the introduction of procedures were aimed at reducing the probability of defects arising, the management of such defects and the prevention of their repeated occurrence through a system of feedback. The standard items of a range of instruments were also created (documenting systems, modern tools, independent quality control, techniques to detect the causes of defects, education and upgrading training).

In the beginning, quality assurance was ensured by a well organised system of quality control, and later a system of a new approach came into existence which also defined the preventive measures needed for quality assurance. Today, the power plant has a full scope quality assurance system that includes all processes, i.e. it defines requirements in respect to every process.

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.

For the assessment of the correct functioning of the quality assurance system of the nuclear power plant an *indicator system* has been prepared. 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. No separate procedural order is prepared for the handling of non-conformance, as 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 procedural orders, instructions 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 proper control of the *maintenance* process is ensured by procedural orders, instructions and implementation documents.

The control over *technical background* activities is also performed according to 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 supervision* 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 experience obtained from such audits are widely presented. Auditors receive special training or when auditing certain professional areas, they are assisted by experts familiar with the given area.

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 supervisory activities. The valid versions of documents are handed over to the Authority, the certifying documents are partly handed over and partly presented at official inspections.

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 separate inspections are performed according to a quarterly schedule for operating units 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 improvement measure will be prescribed by the Authority in a special resolution.

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 which 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, taking national characteristics into consideration.

Govt. Decree No. 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 jointly for Units 1 and 2 of Paks Nuclear Power Plant in 1997, and this will be followed by the assessment of Units 3 and 4 in 2000, which will also be performed jointly for the two units.

3.7.2 In-service inspections and tests, material testing

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 Nuclear Power Plant, 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.

3.7.3 Handling of the ageing of equipment

In the Nuclear Safety Standards issued as annex to the Govt. Decree No. 108/1997. (VI.25.), separate sub-sections are designated to the topics of management of ageing and lifetime management.

Management of ageing in the nuclear power plant

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 licensed 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 Nuclear Power Plant 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;
- pipes of the main circulating loop;
- steam generators;
- main circulating pumps;
- main gate valves;
- the driving mechanisms of control rods;
- the containment;
- cables and connections;
- feed-water pipeline;
- diesel aggregates;
- reactor internals.

Procedural order

The power plant set up a so called Lifetime Management Committee, the tasks of which are as follows: to examine and deal with technical problems related to the ageing of components of distinct importance, to allocate tasks related to ageing management and to co-ordinate the accomplishment thereof, and to create the technical prerequisites necessary for the preparation of a strategy aimed at the safe operation of the units beyond their scheduled lifetime.

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.

3.7.4 Seismic safety

The issue of the earthquake resistance of Paks Nuclear Power Plant 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 when the nuclear power plant was designed.

The key issue of the programme is to assess the seismicity of the site and to demonstrate the existence and activity of the presumed fault line underneath the site. The president of the Hungarian Atomic Energy Commission set up an expert body, the Scientific Co-ordinating Committee, in order to assess the seismicity of the site and to supervise all related research. The report issued in February 1993 by the Scientific Co-ordinating Committee gave a rather conservative estimate for the intensity of the maximum design basis earthquake and the related horizontal acceleration. The review performed on the matter by the experts of the International Atomic Energy Agency also found that the seismicity of the site is greater than the value considered in the designs, and recommended the performance of further tests.

Upon this recommendation, the Authority issued a disposition in June 1993, and Paks Nuclear Power Plant elaborated a safety improvement programme aimed at the assessment of the site and the evaluation and improvement of earthquake resistance.

As a result of the comprehensive revision and reassessment of the seismicity of the site, the obtained value of the maximum free-field horizontal acceleration caused by design basis earthquake is 0.25g.

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 omitted, and all existing safety margins should be exploited; the redundancy level of the process equipment is 200%, according to international practice.

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 implementation of earthquake resistance

The programme is based on the description of a technology that fulfils the requirements, that being the Seismic Safety Technological Concept. Structures and systems can be classified into two groups:

- systems listed in the Seismic Safety Technological Concept and which are earthquake resistant to design earthquakes (SL-2 level or one earthquake in 10.000 years);
- systems belonging to safety classes 1-3 but not listed in the Seismic Safety Technological Concept. When modifying or reconstructing these, they should be qualified for the SL-1 level (one earthquake in 100 years).

There is no need to consider the earthquake resistance of other, non-classified systems and structures, etc.

Earthquakes are differentiated by input groups. Generally the seismic design considered is characterised by a maximum horizontal acceleration and by response spectra. In the case of components, pipelines, devices, etc. the floor spectrum related to the installation location is considered. The simultaneous but independent occurrence of failures and off-normal events belonging to the design base concurrently with the design basis earthquake need not be considered in the Seismic Safety Technological Concept. Applicable qualification procedures may be analytical or empirical methods, or tests based on standards, but qualification may take place in an experimental way as well. The major part of this qualifying work has already been completed by the power plant.

The seismic resistance of the nuclear power plant increased significantly between 1993 and 1997 thanks to „easy-fix" reinforcements. The majority of the reinforced equipment are instrumentation and control equipment, electrical frames, boxes and cable channels; and a smaller part of them contain technological equipment and dividing brick walls. The „easy-fix" reinforcement has also been performed on diesels and unit batteries, the latter have been replaced by earthquake resistant ones. Some 120 types of „easy-fix" design concepts have been prepared. These reinforcements actually fasten equipment to the load bearing structure of the building by simple supports and anchors. A total of 5,507 „easy-fix" design concepts have been installed for the four units, following the inspection of 10,184 items. The Authority was continuously notified in detail about the reinforcements.

The most important further elements of the seismic safety programme are as follows:

- earthquake resistance calculations of the buildings for the final input, with the least conservative procedure;
- assessments concerning the stability of the foundation;
- complex calculations related to the primary circuit pipeline system and equipment, for supports and suspensions.

The phase of analysis and qualification is followed by the construction design of necessary reinforcements and the implementation thereof.

Earthquake alarm and protection system

In addition to free-field measurements, several triaxial acceleration gauges are located within each twin-unit: three of them on the base plate and three additional pieces at different locations of the reactor building. This is important from both structural and mechanical point of view. The currently installed earthquake monitoring system supplied by the Swiss company SIG SA provides sufficient measurement data for the evaluation procedure.

As a result of the conclusions made by a 1995 meeting of experts at the International Atomic Energy Agency, the Authority (in order to prevent unit shutdowns triggered by erroneous signals) changed its original requirements regarding automatic unit shutdowns, thus the earthquake alarm and protection system presently operates in an off-line operational state. The operator in the control room is also assisted by audio alarms. 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. The setting value of the signal within the designated frequency range is given by considering the maximum spectral amplification generated from the standardised response spectra multiplied by a safety factor of 1.5.

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 Decree No. 4/1993. (VI.15.) TNM of the Minister without portfolio prescribed the performance of such reviews and the renewal of the nuclear safety operation licence. In August 1995, the Authority issued a disposition and a Guideline about Periodic Safety Reviews. The guideline set the objectives, principles of accomplishment, legal regulation, technical background of the review and related documents.

For Units 1 and 2 of Paks Nuclear Power Plant, the Periodic Safety Review is comprised of nine basic areas, as follows:

- the actual technical condition of the installation,
- the classification of equipment,
- safety analyses,
- ageing management,
- the evaluation of the characteristics of safe operation,
- the utilisation of experience, feedback,
- procedures,
- organisational and administrative factors,
- human factor.

Those preparing the review paid special attention to quality assurance, informatics support (the material was prepared on a computer network) and archiving. In addition to the hard copy, the entire documentation prepared was made available on CD-ROM and on the Intranet of the nuclear power plant as well.

In the official disposition concluding the review (14 March 1997), the Authority extended the validity of the long-term safety operation licence of Units 1 and 2 of Paks Nuclear Power Plant up to 31 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.

The deadline of the accomplishment of the measures falls before the year 2000 in almost all cases, but a few further deadlines do exist in more complex cases.

A part of the review was accomplished at a deferred date due to lack of time. With the previous approval of the Authority, the probabilistic safety analyses for the reactor operating at low power or completely shut down were submitted by the operator only on 18 December 1997. The analysis in question increased the number of improving measures by four.

The new Act on Atomic Energy and the related regulations already contain the obligation of performing Periodic Safety Reviews, along with the main circumstances of accomplishment.

In accordance with this, by the end of 1997 the operator embarked on the performance of the Periodic Safety Review of Units 3 and 4 of Paks Nuclear Power Plant. An important novel addition in comparison to previous approaches is that the scope of the review is supplemented by two additional areas: the analysis of environmental radiological effects and the preventing of nuclear accidents.

3.7.6 Measures to improve safety

The evolution and sources of measures to improve safety

Paks Nuclear Power Plant embarked on an activity aimed at improving safety back in 1986, well before the commissioning of the fourth Unit. 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 supplemented with the factors below:

- the correction of inadequate solutions detected during the operation of the units;
- the utilisation of operational experiences provided by power plants abroad;
- the recommendations of international reviews carried out in the power plant;
- the analytical processing of the results of WWER-440/230 and 213 tests performed by GRS (Gesellschaft für Anlagen und Reaktorsicherheit);
- the utilisation of the experience of international programmes organised by the International Atomic Energy Agency;
- asks originating from the results of the AGNES project.

Setting of priorities

The revision of the list was helped by the recommendations of the AGNES project, whose recommendations were considered by the power plant when defining highlighted tasks. One of the most important results of the project was that it provided effective assistance to the correct prioritising of tasks.

In 1996 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.

Major measures taken to improve safety

During the time elapsed 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 following modifications will have been completed on all units by the end of 1998:

- 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).

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 $4 \div 5 \times 10^{-5}$/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.

While this report was being produced, a temporary regulatory situation was in evolution in the field of the application of nuclear energy: the Act on Atomic Energy has been in force since 1 July 1997, but some of the decrees concerning its implementation have yet to be prepared. In these situations the former regulation is used.

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 No. 7/1988 SZEM of the Minister of Public Health lays down the radiation protection requirements that should be applied to all activities where nuclear energy and ionising radiation are used.
- The Govt. Decree No. 108/1997 focuses on the technical part of radiation protection in nuclear power plants.
- The Decree No. 1/1980 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 Nuclear Power Plant by the regionally competent environmental and water affairs administration during the licensing procedure of the nuclear power plant.

- The MSZ 62 standard deals with special radiation protection issues, such as secondary limits, annual uptake limits, values related to accidents, etc.

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 present Hungarian system of radiation protection regulations is based on ICRP 26, a new regulatory framework is under consideration, however, which will be based on ICRP 60 instead.

The Decree No. 7/1988 SZEM 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 No. 7/1988 SZEM deal with the limits of the doses of workers and members of the public; the radiation safety principles of workplaces, 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, the special radiation protection requirements for nuclear power plants and the disposal of radioactive waste. Annex 10 of the Decree deals with special issues of the nuclear power plant, such as the division into controlled and free zones, the measurement of the radiation parameters of certain areas and the main radiation protection criteria.

The Govt. Decree No. 108/1997 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 which 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 (mSv/year) [1]

dosimetric quantities	subjects of exposures		
	workers [2]	students and apprentices [3]	members of the public [4]
effective dose equivalent	50	5	5
dose equivalent in the lens of eye	150	50	50
dose equivalent in any other organ or tissue	500	50	50

Remarks:

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

(2) For female workers of reproductive age, any exposure should be distributed in time as uniformly as practicable.
Pregnant women are not permitted to be occupationally exposed.
Breast-feeding mothers are not allowed to work with unsealed sources.
Planned special exposures may be permitted for a few workers, provided that the doses received do not exceed twice the relevant annual limit in any single event, and five times this limit in a lifetime. Planned special exposures shall not be permitted for women of reproductive capacity.

(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, however, the contribution to the dose that is related to their instruction shall not exceed 1/10 of these limits.

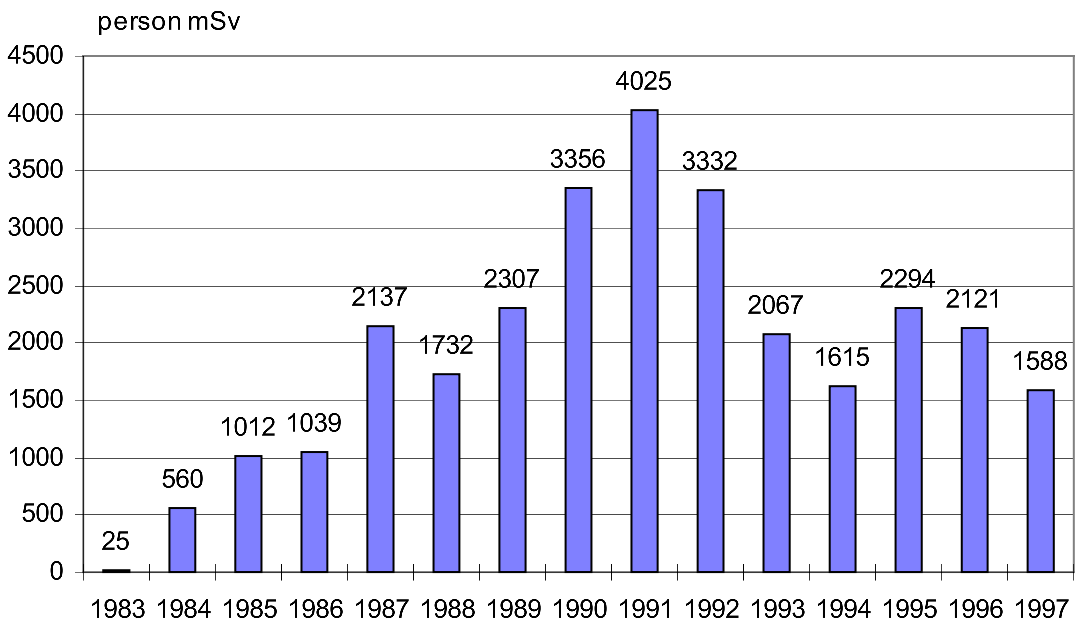
(4) In case of repeated or continuing, long-term exposure, the effective dose equivalent limit is 1 mSv/year.

3.8.3 Occupational exposure at Paks Nuclear Power Plant

The patterns of annual exposures

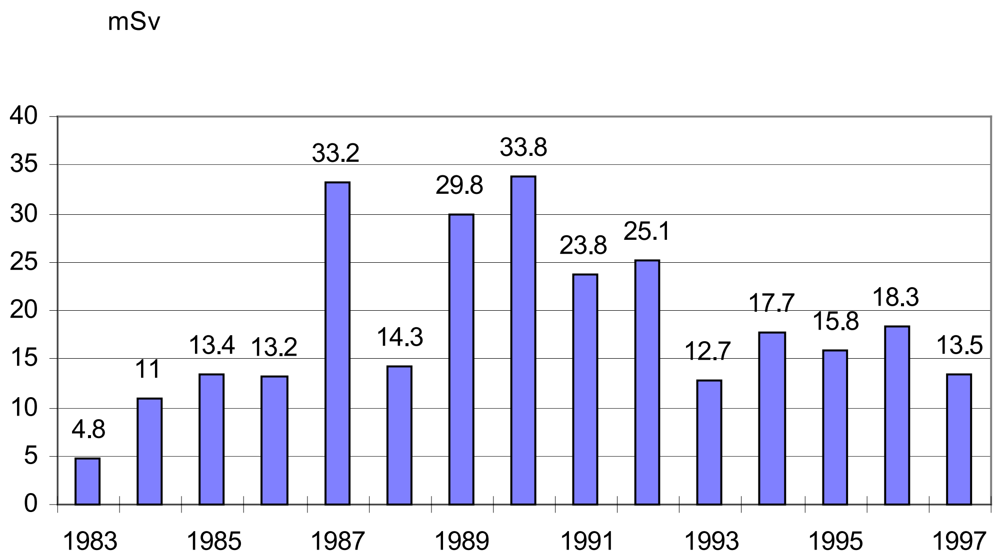
A unified central film-dosimetric service is operating in Hungary for the tracing of external radiation exposure of workers. This service is operated by the National Research Institute for Radiobiology and Radiation Hygiene.

The monitoring of exposure of nuclear power plant personnel includes all workers working in controlled zones and thus monitoring is manifold as it includes the wearing of an official film dosimeter badge, the TLD system (with a neutron track detector) and, in the case of those activities which can only be executed by holding a dosimetric permit, an operative dosimetric control performed by an electronic dosimeter. The following charts demonstrate the patterns of annual collective and maximum individual doses of workers, based on the measurements of the film dosimeters by the authority.



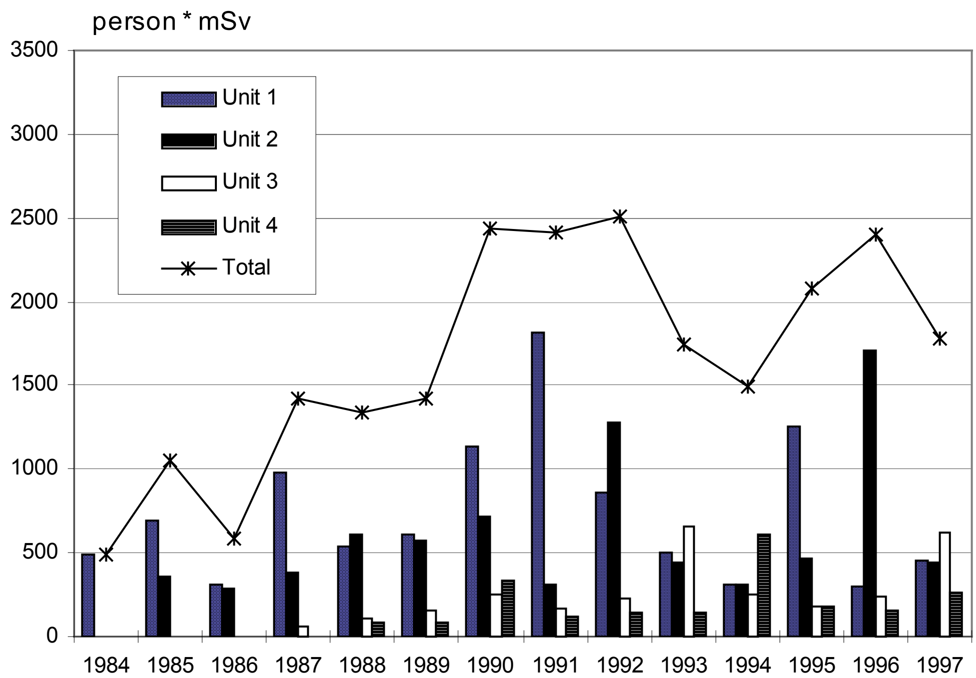
Annual collective doses according to official film dosimeter readings

Figure 3.8.3-1



Maximum annual individual doses according to official film-dosimeter readings

Figure 3.8.3-2



Collective doses during overhauls based on operative dosimetric measurements

Figure 3.8.3-3

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 1997, radioactive incorporation caused by corrosive products (^{58}Co, ^{60}Co and ^{110m}Ag) and exceeding the recording level (0.15 mSv) were found (by whole body measurements) in 16 employees, with a maximum committed effective dose equivalent of 1.2 mSv.

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

The application of the ALARA principle

At Paks Nuclear Power Plant, 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. Special attention is paid to the dissemination and control of the information concerning the optimisation of radiation protection. The structure of the radiation protection organisation of Paks NPP Ltd. also serves as optimal radiation protection, since in addition to a professional body providing radiation protection measurements during all hours of operation it also includes the Radiation Protection Service. The Radiation Protection Service consists of employees and appointees of the operating and maintenance organisations, who are familiar with all aspects of radiation protection as well as their own professional areas.

Technical standards comprise measures aimed at providing protection through distancing, the limitation of the radiation field and the 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 practices related to major maintenance works). During unit overhauls, a technical measure used is the shutdown cooling schedule, which is aimed at positively influencing the deposition of corrosive products during cool-down.

Dose scheduling, the radiation protection licensing of certain overhaul works and the definition of necessary radiation protection measures are all included in the wide-ranging radiation protection measurement programme. This programme is performed by radiation protection experts within the vicinity of the main components and in the rooms affected by overhaul activities, at the beginning of overhauls immediately after the shutdown of the unit. Thus data concerning radiation can also be used in the dose schedules of the overhaul in the following year.

The power plant applies the above administrative and technical measures in the form of procedures. Some of the most important procedures aimed at the achievement of optimal radiation protection is the scheduling and planning of overhaul doses, the radiation protection preparations made before works with specially high radiation exposure, and the evaluation of the radiation protection related experiences of the overhaul. All these procedures play a significant role in the reduction of collective and individual exposures.

When making preparations for works that are particularly exposed to radiation, a qualitative ALARA programme is proposed for all activities where this is justified by the radiation dose of the working area (>4 mSv/h) or the expected collective dose (>4 person.mSv). The programmes contain all technical and administrative measures that are needed to achieve the optimal radiation protection of the activity in question.

The ALARA principle is only applied qualitatively in Hungary, no definite calculations can be made, as the monetary equivalent of the reduction of one unit of collective dose has not yet been defined.

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

Atmospheric and liquid release

The official limit of additional radiation dose caused by any releases is 250 μSv/year/GWe in respect to the most affected group of the public. This exposure limit consists of two parts: the dose caused by atmospheric emission can equate to 2/3 of the total dose, while the dose coming from liquid discharges may reach 1/3 of the value. 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 power plants of 1000Mwe performance

Radioactive substance	Emission limit Bq/day (1)
Sr-89 and Sr-90	$5.6x10^{4}$
Radioiodine isotopes, in I-131 equivalent	$1.1x10^{9}$
Total radioactive aerosols (with a half-life over 24 hours)	$1.1x10^{9}$
Radioactive noble gases (2)	$1.9x10^{13}$

Remarks:

(1) values are for the average of emission over a 30-day period
(2) at the simultaneous shutdown of two reactors using boric acid, this value may achieve a maximum of $6.5x10^{13}$ Bq/day once a week.

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

Table 3.8.4-2

The limits of annual liquid discharges for the four units

Radioactive component	Activity limit (GBq)
Total beta	14.8
Sr-90 from the total beta	0.148
H-3	30×10^3
Total alpha	Around background (at 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 as a percentage of official 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	$^{89, 90}Sr$	Total 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 The 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), the water sampling stations (total gamma activity, temperature, water flow measurement), the meteorological tower (measurement of wind direction, wind speed, temperature and wind fluctuations at different altitudes) and at the environmental monitoring stations set up within 1.5 km surrounding of the power plant (air iodine activity, dose rate). Data are transmitted to the above mentioned Dosimetry Control Room;
- *off-line* laboratory measurements serve to compare the sampling and release data. The stations perform off-line measurements related to 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 oublic from the emissions is less than nSv/year.

When the Interim Storage of Irradiated Fuel Assemblies was commissioned in September 1997, radiation protection monitoring was also commenced including both the location and the surroundings of the facility. During the short time elapsed, radiation levels have been found 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 protection-related 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 authority 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 an annual report since 1984. As it is generally not possible to trace radioactive substances released by the plant into the environment, or 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. These doses constitute 0.03 to 0.2 and 0.004 to 0.01 % of the annual dose limits for gaseous and liquid releases respectively.

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 No. 135/1989 (XII.22.) of the Council of Ministers. This Decree has been amended several times since.

The new Act on Atomic Energy introduced the necessity to re-regulate the scopes of duty and competence of the organs of the National System for Nuclear Emergency Preparedness, the Hungarian Atomic Energy Commission and the Authority. The Govt. Decree No. 87/1997. (V.28.) dealing with this matter came into force concurrently with the Act. The new regulation considered the obligations generated by international contracts, the recommendations of international organisations and the regulations of the European Union to the greatest possible extent.

Govt. Decree No. 248/1997. (XII.20.) prescribes the organisation and tasks of the National System for Nuclear Emergency Preparedness in agreement with modern public administration structure and with Govt. Decree No. 87/1997.

3.9.2 The operation of the national system for nuclear emergency preparedness

According to the Govt. Decree No. 248/1997 (XII.20), the National System for Nuclear Emergency Preparedness is managed by the Governmental Committee for Nuclear Emergency Preparedness.

The composition of the Governmental Committee is as follows:

- president: the Minister of Internal Affairs;
- vice presidents: the Minister of Defence and the Director General of the Hungarian Atomic Energy Authority;
- secretary: the deputy state secretary of the Ministry of Internal Affairs in charge of local authorities;
- members: ministers and the heads of bodies of national competence

The organs of the Governmental Committee are the Secretariat, the Operative Staff and the Technical and Scientific Council.

In order to enforce their own professional requirements, Ministries issue directives and guidelines for the use of the County (Capital) Local Committees for Nuclear Emergency Preparedness. The presidents of the County (Capital) Local Committees for Nuclear Emergency Preparedness enforce the requirements laid down by the Governmental Committee and different ministries within their own competence and responsibility.

Under normal circumstances, the organisations of the National System for Nuclear Emergency Preparedness carry out works and tasks related to preparedness (monitoring, signalling, etc.), planning, organisation, providing information and co-operation.

The state of a nuclear emergency is declared or withdrawn by the president of the Governmental 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. This declaration activates the organs of the National System for Nuclear Emergency Preparedness. In the case of a nuclear emergency, the Secretariat of the Government Committee is supplemented by experts of the corresponding Ministries and institutions. The employment of intervention forces is to be recommended by the head of the Operative Staff. After such a decision has been taken he manages the accident response activity on a national scale and ensures its proper implementation.

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.

The operation of the organs of the Governmental Committee

The *Operative Staff* consists of the delegates of ministries and organs of national competence. Its head is the national commander of Civil Defence. He obtains information to support his decisions from the Emergency Information Centre of the National Radiation Monitoring, Warning and Surveillance System, the Centre for Emergency Response, Training and Analysis (CERTA) of the Authority, the International Relations Centre of the Authority and the Information Centre of the National Environmental Radiation Protection Monitoring System. The most important function of the Centre for Emergency Response, Training and Analysis (CERTA) is to give an independent estimate about the assumed progress of the accident having occurred in a nuclear installation either in the country or abroad, and to forecast the expected patterns of emission (source term) at an early phase of the nuclear accident.

The duty of the *Technical and Scientific Council* is to give technical and scientific aid to support the decisions taken by the Governmental Committee in order to raise emergency preparedness and to handle the consequences of an emergency. In case of a nuclear emergency, the Governmental Committee, in justifying its decisions, can invite experts from the scientific research and other organisations involved in accident consequence mitigation.

It is the task of the *National Radiation Monitoring, Signalling and Control System* to continuously monitor, signal and control the radiation situation.

The *Secretariat*, in addition to its usual administrative activities, co-ordinates the activities of the Operative Body, the Technical and Scientific Council and other organs participating in the response to the nuclear emergency. The Secretariat operates within the organisation of the Ministry of Internal Affairs. If a nuclear emergency occurs, the Secretariat is supplemented with experts from the corresponding Ministries and experts from organisations of national competence. In the event of a nuclear emergency, the Secretariat establishes a *Public Information Group* in order to co-ordinate the task of the Governmental Committee in providing adequate information to the public.

The nuclear emergency preparedness organisations of various sectors

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 National Emergency Action Plan consists of a charter and several annexes.

The first chapter of the charter contains basic information, while the second deals with the implementation of control, management and co-operation and the tasks needed for this in relation to alarms and communication. Chapter three rates the different regions of the country and the different sectors from the aspect of the degree of being prone to nuclear accidents. Chapter four contains the draft action plan of the president of the Governmental Committee.

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 actually measured or forecasted radiation levels in the environment.

The basis for emergency intervention levels is the children inhalation dose from radioactive iodine, at the limit of the exclusion zone. This is determined by computers using the data collected by real-time on-line environmental monitoring system of the power plant concerning meteorology, releases and environmental radiation. The revision of accident categories and the introduction of a system of categories depending on the state of the power plant is presently in progress within the framework of an International Atomic Energy Agency project.

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 treatment of a nuclear emergency.

Based on the assessment of emergencies, it lays down emergency categories, defines the order of emergency management and control, the operation of the Emergency Organisation of the nuclear power plant, and the emergency responsibilities of certain persons. The tasks to be accomplished in an emergency situation are given in a table form. In order to ensure the rapid response of an Emergency Organisation, the power plant established a duty system.

The plan prescribes the order of internal and external alarms and communication and the method of operation and control of the telecommunication devices necessary. The protection of personnel, such as checking their number, their rescue and release is regulated in detail. The plan also includes the materials and technical instruments for accident handling and the method of operation and maintenance thereof. The detailed regulation of the prescribed tasks is contained in the annexes 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. Therefore, the power plant regularly provides information to the public through its relations established with the local media. The settlements of the area founded a Social Monitoring and Information Association with the assistance of the power plant. This Association is one of the organisations the power plant uses for providing the public with the appropriate information and for the preparation of their emergency response. The power plant is represented in the Public Information Group as well.

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. The equipment and tests of this system are also used for the proper preparation of the public. 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 statements and to notify local public through local radio, television and press.

The order of preparation and exercises

On-site and off-site exercises, including national and international exercises, are regularly organised 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.

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 1989:

- the Convention on early notification about nuclear accidents;
- the Convention on providing assistance in the event of nuclear accidents or radiological emergencies.

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

In 1996, Hungary became the member of the Nuclear Energy Agency of the OECD, thus participation in nuclear accident prevention exercises (INEX-2 CH, INEX-2 FIN) organised by them became possible. The exercise to be held in November 1998 will be organised by Hungary, and Paks Nuclear Power Plant will be the accident site of the closing exercise of the international series of practices (INEX-2 HUN).

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 have been started concerning our joining the ECURIE, the early notification system operated by the European Union.

Bilateral inter-governmental agreements

Both the Convention on early notification about nuclear accidents and the Convention on providing assistance in the event of nuclear accidents or radiological emergencies recommend the conclusion of bilateral agreements in order to increase co-operation between neighbouring countries.

Based on this recommendation bilateral inter-governmental 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) and Ukraine (1997).

A similar agreement with Croatia is planned for conclusion in the near future.

Great importance is given to the regional harmonisation project related to the prevention and handling of nuclear accidents launched by the International Atomic Energy Agency. Hungary is an active participant of this project.

4. THE SAFETY OF INSTALLATIONS

4.1 On-site and off-site factors

4.1.1 The methodology and scope of the site investigations

When the site was selected, it was investigated and its adequacy was assessed in line with Soviet practices and regulations then prevailing. These primarily considered the analysis of the technical and economic aspects of installation. As far as safety was concerned, the basic principles were the positioning of the plant far enough from major cities and the creation of an exclusion zone around it. During the past ten years, the site has been systematically reassessed using the guidelines of the International Atomic Energy Agency (No. 50-C-S and those related thereto) and the regulations of developed western countries, primarily the USA, on certain issues. Most of the site characteristics described below are the results of the reassessment of the site or data verified within the framework thereof.

The location and surroundings of the site

Paks Nuclear Power Plant is situated about 115 km south of Budapest. The broader vicinity of the installation is divided into two parts by the most prominent river of the country, the Danube: its western part lies on the Dunántúl, while its eastern part lies on the “Duna-Tisza köze”. 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^{o}34’24” (northern latitude) and 18^{o}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. Reactor tanks and steam generators were transported to the site 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. 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} 1/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 considering local navigability, release of substances and meteorological characteristics resulted in a risk in the order of 10^{-6} events/year.

4.1.2 Population

The 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 25 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 was 213,000 in 1980, 199,000 in 1990 and is expected to drop by another 3 % by the year 2000. The population patterns of the Paks area were greatly influenced by the construction of the power plant, which led to a significant change in the dynamics of population growth in certain sectors. The modifications of the principles of regional development caused by the recent political changes had also influenced demographic situation. The population of Paks rose steeply after 1970 (particularly the young male population), while population numbers dropped in most other settlements of the region. A significant migration could be observed into the settlements of Szekszárd and Paks.

4.1.3 Meteorology

According to the measurements performed in Paks during the last 15 years, the annual mean temperature is rising slightly. The same trend can also be observed at two neighbouring meteorological stations. 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, extreme rain or snow loads) 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 major characteristics of the Danube in the region:

	minimum	average	maximum
yield [m^3/s]	770	2350	8500
water speed [m/s]	0.75	1.0	1.2
water-level [mB]	84.69 (November 1983)	88.00	94.95 (February 1876, icy) 93.61 (June 1965, ice-free)
temperature, [^oC]	0-1		25 (August 1971)

Extremely low water levels were experienced when the nuclear power plant was already in operation. According to analyses, this took place because the river bed became 40 to 60 cm deeper as a result of industrial excavations. Thus the excavations were suspended in the summer of 1985, except for the crossover (ford) excavations necessary for the maintenance of the international passage. Resulting measurements showed that this measure was successful and the bed maintains a dynamic equilibrium with a tendency to a slight build-up.

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 has 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 ^oC, or 14 ^oC if the temperature of the water is below 4 ^oC. 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 ^oC, 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 significantly 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.

Seismicity is low in Hungary as a whole, though strong 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 19^{th} 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.

Seismo-tectonic characteristics

The seismicity of the site was the subject of scientific disputes. The final evaluation 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 earthquakes in Hungary and the isoseistic map that can be drawn from this.

Geological, geophysical and seismological tests aimed at the reassessment of the seismicity of the site were embarked on in 1986 and completed in 1995. The final evaluation was made by the Ove Arup company within the framework of the PHARE project of the European Union. The review included the assessment of the possibility of a surface fault and the definition of the characteristics of an earthquake which could jeopardise safety. The review primarily followed the guidelines issued by the International Atomic Energy Agency (50-SG-S1). The work of the authorities was assisted by the International Atomic Energy Agency through regular assessments.

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. More information is given by the microseismic monitoring that has been going on here since 1995. No Quaternary faults can be found in the loess to the west of the site either. Thus it can be concluded that structures within the Pannon layers at and around the Paks site are most probably inactive. Deterministic analyses showed no faults reaching the surface. Probabilistic risk assessments resulted in a probability exceeding 99 % that faults do not reach the surface within 10,000 years.

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 frequency of 10^{-4}/year, no soil liquefaction can be expected.

4.1.6 Reassessments of the site

Following the commissioning of the fourth unit of Paks Nuclear Power Plant in 1987, the issue of the further extension (first by WWER-440, later by WWER-1000 units) of the plant along with the related technical design and investment was on the agenda for several years. This also led to the execution of partial reassessments.

For the installation of the Interim Storage of Irradiated Fuel Assemblies at the power plant site, the authorities required the submission of a complete site review and a study of environmental effects, a preliminary version of these was submitted in 1993 and a final one in 1994. The assessment of the site characteristics was based on American standards, which were slightly modified to meet local criteria.

At the same time the Authority issued a disposition regarding the reassessment of the seismicity of the site and the earthquake resistance of the units. In order to accomplish these, Paks NPP Ltd. set up its own strategy and elaborated a comprehensive programme.
The Periodic Safety Review executed in 1995 and 1996 for Units 1 and 2 also analysed in detail the changes having taken place related to the site.

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

Multilevel protection

Volume 3 of the Nuclear Safety Standards issued as Schedule 3 to Govt. Decree No. 108/1997 (VI.25) contains the general nuclear safety-related requirements concerning the design of nuclear power plants. It lays down safety objectives and the principle of defence-in-depth as a basic principle of the implementation of objectives.

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 first level of protection is aimed at preventing the occurrence of deviations from the normal state of operation. The aim of the second level is to detect any deviation from normal operation and to stop anticipated operational occurrences from becoming real accidents. When designing the third level, it should be presumed, though with a very low level of probability, that the preceding protection levels can not stop operational events from developing into accidents. Additional systems, components and related operational procedures should be provided in order to limit the consequences of emerging design basis accidents. The further aim of the third protection level is to attain and maintain stable and acceptable conditions after the accident was contained.

Beyond the third level of protection, 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

In order to meet the requirements concerning the application of proven and verified technologies, the following instruments should be made available:

- to shut down the reactor safely and to maintain it in a safe shutdown condition during and after anticipated operational occurrences and design basis accidents;
- to remove residual heat after the shutdown, including both anticipated operational occurrences and design basis accidents;
- to reduce the emission of radioactive substances and to ensure that all emissions remain below the prescribed limits during anticipated operational occurrences and design basis accidents.

Safety functions and the systems and components executing these functions should be classified into safety classes according to their influence on safety. Based on this classification, the basic quality assurance requirements should be defined in respect to the safety systems, components and the related activities (e.g. maintenance, material tests, welding). According to the weighting used in the safety classification, the safety systems and components should meet the strictest applicable manufacturing, structural, inspection, maintenance and operational standards. Where no adequate requirements exist, the adequacy of the applied design procedure and construction should be verified.

Only newly designed constructions based on adequate research and development can be used. 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.

If the failure of a safety-related system or component can not be evaluated on a probability basis, then that system or component may only be accepted after the application of a special case procedure. Such a procedure should thoroughly examine all relevant scientific and technical issues, taking into account where appropriate of precedents set under comparable circumstances in the past.

The structural elements of the safety-related systems and components should be faultless and fail in a safe manner as far as possible. In order to meet these requirements the following aspects should be taken into consideration:

- application of proven design methods and perfect design concept;
- application of proven structural materials;
- application of standards setting high requirements in all phases of design, in the procurement, manufacture, installation and operation alike;
- performance of pre-commissioning and in-service tests to identify all faults that can develop into, or might cause an accident;
- preparation of equipment and material examination:
- taking into account, in justified cases, the leak-before-break principle.

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. Special attention should be paid to operational parameters, systems and components that may influence fission processes, the cooling of the reactor core, the removal of residual heat, the integrity of the fuel element, the primary circuit and the containment, or the items of information which are required for the safe and reliable operation of the power plant.

- An adequate communication system should be established between different locations. Sufficient communication should also be ensured with external organisations, the activities of which may be needed during normal operation, anticipated operational occurrences and design basis accidents.
- Through the establishment and application of instrumentation and control engineering systems, 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.
- A minimum level of safety related instrumentation should be defined for the operation of the reactor unit, and the adequacy of this should be verified. Control systems should respond to problems emerging in the operation of the reactor unit on time and in a stable manner, but without triggering protection functions.

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. Concerning the installation of the unit control room, the following requirements, among others, are allocated:

- Such control and measuring instruments and monitors that provide the operating staff with a full and clear picture of the condition and operation of the power plant should be installed.
- Indicators should be installed in the unit control room that indicate all deviations from normal operation and adequate displays are to be made available for the reliable collection, processing and display of data. These display devices should assist the operator in case of anticipated operational occurrences and accidents.
- The display instruments of process variables that are functionally related and the status indications of the control room should be grouped and positioned in such a way as to consider ergonomic requirements and ensure easy and reliable control.
- Working conditions should be adequate in the unit control room. Measures should be taken for the protection of the personnel working in the control room.

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 Nuclear Power Plant 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.

With the establishment of a dose limitation system, Soviet standards obviously endeavoured to meet the radiation protection objective, according to which, processes accompanied by greater amounts of release can only take place occasionally, and more common processes may only lead to a moderate radioactive release.

When preparing the design bases, a strictly conservative engineering practice was used; Soviet standards contain safety requirements and criteria that are even stricter than the principle of defence-in-depth. In spite of this, not all of the protection levels were given enough attention, e.g.:

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

The fulfilment of up-to-date safety requirements

The Pre-commissioning Safety Analysis Report of Paks Nuclear Power Plant contains the fulfilment of technical safety requirements considered and achieved when the units were designed. The main feature of these is that during normal operation and in case of failures occurring relatively often, the first three physical protective barriers may not be breached (thus the fourth barrier inhibiting the release of radioactive substances has 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 minimal was not directly taken into account among the design principles of the units.

The basic safety principles of design stipulate the existence of all four barriers in serving to retain radioactive substances. Thus the containment system was graded considering the circumstances of design basis accidents. According to the practices of the 1970’s, when the containment was designed, the mitigation of severe accidents was not required. As a consequence, special emphasis was placed on the assessment of the operability of the containment, both during design basis accidents and severe accidents within the investigations of the aforementioned AGNES project.

The elements of the “defence-in-depth” principle were accomplished in the nuclear power plant according to the requirements of Soviet standards. It is self evident that the above principle played an important role in design as the V-213 unit was developed from the V-230 unit.

The analyses and investigations of the AGNES project (before the issue of the Act on Atomic Energy) and those of the Periodic Safety Review performed on Units 1 and 2 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.

Concerning the results of safety analyses, it could be stated that after the consistent accomplishment of the improvement measures the safety of the assessed units is in line with modern design requirements and international expectations.

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.

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 Nuclear Power Plant was established and commissioned, Hungarian practices followed those approved in the West. 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.

Thus the way of proceeding when constructing and licensing Paks Nuclear power plant was formally in line with standards approved in other countries in the second half of the 70's. Issues related to the content of reports are far more complex. In one respect, it can be stated that the above mentioned reports convincingly proved to the experts the safety of the power plant, and specified that safety can be maintained using the available equipment in the case of the occurrence of numerous types of off-normal events or accidents. In other respects, however, 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 with the following objectives:

- to prepare a report reassessing the safety of Paks NPP to the standards of the 90's;
- to prepare deterministic analyses concerning off-normal events and severe accidents, along with probabilistic analyses;
- to set the priorities of safety improvement measures;
- to make preparations for the elaboration of an upgraded safety analysis report.

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 AGNES project. The previous concerns that the approach applied in the Pre-Commissioning Safety Analysis Report was inconsistent, were found to be justified. In spite of this, the AGNES project finally concluded that the power plant can be safely operated.

The analyses of the Periodic Safety Review performed for Units 1 and 2 were based on the above results of the AGNES project with the addition of some other elements.

The Periodic Safety Review 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 tests of the containment and issues related to the subcriticality of fuel storage systems. Systems and components related to safety have been qualified (the required environment-tolerance during and following accidents has been defined).

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 frequency was calculated and sensitivity and uncertainty analyses were performed. It should be emphasized that in addition to a rated performance operation of the reactor, the analysis included cases when the reactor runs at low or reduced power or is shut down.

All probable external effects jeopardising safety were assessed. In respect to the assessment of the consequences of external effects, a more detailed analysis was required only in the case of seismic activity and aeroplane crashes, as the safety risk of other hazards is extremely low according to calculations.

Within the framework of the review, accident analyses were prepared for the entire scope of design. Analyses included the full scale examination of pressurised heat shock and certain transients, with the hypothesis of the reactor protection being out of order. 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 specially characteristic for WWER reactors. The most sophisticated and modern computer programmes were used for the analyses. In those cases when system-specific validation was necessary (to ensure the quality of results or to assess the uncertainty thereof), analyses were performed. The applied system of criteria was established according to the guidelines of the Periodic Safety Review and was also in line with international standards. The system of criteria sets different requirements for more frequently anticipated operational transients, which are subject to stricter requirements, and for postulated accidents not likely to occur.

The aim of the severe accident analyses was to assess the way they would take place at Paks, based on the deterministic analysis of the basic accident processes. From this, 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. This task is scheduled by the Authority for the period following the completion of the Periodic Safety Review for Units 3 and 4 in 1999. The Authority also prescribed that the safety analysis report would have to be annually updated in the future. Related works have been embarked upon.

The major improvement measures necessary and considered to be the most important by the Authority (based on the Periodic Safety Review) are contained in Table 4.3.1-1. Items 1 to 8 and item 21/1 have already been accomplished.

Table 4.3.1-1.

Major upgrading measures taken as a result of the Periodic Safety Review
(two deadlines mean separate deadlines for Unit 1 and Unit 2)

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 handling 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" through the potential re-qualification and reconstruction of the equipment	1999 2000
14.	The protection of the reactor against overpressure in the cold state through modifications made in the accident prevention and management instructions and through the installation of protection equipment	1999 2000
15.	The possibility of control system equipment (transducers) becoming flooded at accidents accompanied by an internal flooding should be eliminated, or its risk should be reduced to an adequate level, and the same applies to the phenomenon that water coming into the rooms of the electric gallery during extinguishing of fires 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 experiments, 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

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 superinspection 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 an operational equipment.

4.3.2 The Manual of Operating Procedure

Paks Nuclear Power Plant 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. The standard laid down all general requirements, basic rules and limit parameters which determined the safe operation of the nuclear power plant units in the operational states and in other modes considered in the design.

The Authority licensed the application of the Manual of Operating Procedure in 1990 for a given period of time. Through the licensing of the manual, the basic document of operation came into existence, the application of which is authorised by the current Authority exercising nuclear supervision. Independent experts, who were also approved by the Authority, prepared the full scale review of the Manual in 1991 at the request of the power plant.

In 1992, the Safety Directorate of Paks NPP (which was established in the same year) took over the tasks related to the maintenance of the Manual of Operating Procedure. 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 establishment of the regulatory system

When the first unit was commissioned in 1982, Paks NPP had regulations which were in line with expectations then prevailing and which ensured the conditions for a well organised operation. In 1990, a deregulatory programme was launched within the framework of which several instructions were eliminated and a complete revision of internal dispositions was embarked upon. The power plant was transformed into a shareholders' company in 1992, as a result of which all regulations had to be reformed.

The power plant increasingly endeavoured to consider the safety series documents of the International Atomic Energy Agency (50-C-QA and series 50-SG-QA). Accordingly, the Director General issued an instruction in 1993 concerning the method of elaborating the internal regulations of the plant. The number of dispositions was reduced by a half by the time the organisation was transformed in 1995.

The present situation of regulations, directions of development

As a result of the work done since the first two units became active, it can be stated that the present power plant has a modern system of regulations which are able to ensure efficient and safe operation through a chain of regulations, instructions and procedural orders. However, a complete reform of standards and procedural orders has been initiated since 1995 in line with the set of requirements laid down in the Quality Assurance Manual. The result is a unified system of regulations which is a prerequisite to safe operation. Standards and implementation instructions have started to be processed on the power plant's Intranet as well.

Based on the results of the audit performed in 1995 concerning procedural orders, it can be stated that valid procedural orders are available at all levels, the users clearly comprehend all requirements and are able to put them into practice in their work correctly. At the same time, the audit highlighted that certain areas are characterised by over-regulation and are too complicated.

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. From 1995, the feedback of experiences of accident handling exercises was implemented. A task yet to be solved is the elaboration of a status-oriented system of accident management instructions that is comparable to international practices. This is to be done in co-operation with power plants of similar types.

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.

The operator revised the valid operating instructions in the years 1985 and 1986. A new algorithmic system of operating instructions was introduced to supersede the former instructions of a descriptive nature. New instructions were better structured, more transparent and easily managed, but the parts concerning accident management remained occurrence-oriented.

In the meantime, it became internationally accepted that in the case of unanticipated off-normal events or if several occurrences arise concurrently, it may be necessary to execute interventions that are not related to the triggering occurrence itself (which may not be identifiable) but to the state that has evolved as a result. Since 1993, Paks NPP Ltd. has 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.

For the direct preparation and validation of the new system of instructions, a bilateral contract was concluded in December 1996 with the American company Westinghouse. Work was embarked upon and has been ongoing according to previous schedules. According to the contract the preparation will be completed by the end of 1999, with the new instructions coming into use by the end of 2001.

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 efficiency of the plant.

The maintenance organisation of Paks Nuclear Power Plant should be professionally diverse and complex, taking into consideration that only one nuclear power plant is in operation in Hungary and the economic environment concerning its maintenance is not always sufficient in every respect.

Initially, the power plant had to cover the whole range of maintenance tasks itself. Recently, external contractors have been involved increasingly in the maintenance of the power plant. The maintenance body of the power plant has different professional divisions (mechanical engineering, electrical, I & C and civil engineering), but operates according to unified principles.

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 data base 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

The production policy of Paks Nuclear Power Plant states that “the key task is to maintain the availability of the power plant at the highest technical and economical level possible”. 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 new overhaul strategy is the introduction of three basic types of overhauls instead of the present two. 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 transmission of work instructions is regulated in procedural orders and this ensures 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 supervision exercised by the executives of the given professional area. The proportion of contractors hired of the latter type has risen during recent years.

4.3.6 Technical support

Technical and preparatory bodies

In the present organisation of Paks Nuclear Power Plant, 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 in order to make use of their accumulated experience. Some of these companies are: IVO, Siemens, Westinghouse, EdF, FRAMATOME and Nuclear Electric.

After the commissioning of the power plant was completed, the competent institutions of the Soviet Union made technical recommendations for its improvement in the late 80's. These recommendations were integrated into the safety improvement programme of the power plant.

Later, the professional level of assistance received from former Soviet institutes declined, and at the same time Hungarian research institutes gained significant competence and as a consequence, could assume the relevant tasks. This situation was also accepted by the Authority, in connection to such important issues as the preparation of analyses related to safety improvement measures, the whole AGNES project or the evaluation of the Manual of Operating Procedure.

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 and, to a certain extent, maintenance), 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.

The analysis of reliability and availability indicators may lead to the replacement, modernisation or modification of certain components. 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.

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. Investigations are divided into two groups: those related to events affecting safety and those to events affecting quality. From 1992 onwards, events are classified according to the INES scale, and previous events were also classified retrospectively.

On the four units of Paks Nuclear Power Plant 535 INES-0, 61 INES-1, 11 INES-2 and 1 INES-3 events took place between 1982 and the end of 1997:

Table 4.3.8-1.

year	INES 0	INES 1	INES 2	INES 3
1982	0	1	0	0
1983	20	4	2	0
1984	33	7	0	0
1985	13	4	1	0
1986	14	2	2	0
1987	21	9	1	0
1988	22	5	0	0
1989	24	13	3	1
1990	37	2	0	0
1991	34	5	0	0
1992	39	1	0	0
1993	41	2	0	0
1994	56	3	0	0
1995	51	2	1	0
1996	64	0	0	0
1997	66	1	1	0

The results of investigations and the corrective measures are presented to a wide circle. Measures are always marked by deadlines and responsible personnel, thus they are traceable. Not only single events but trends are monitored as well, including the changes occurring in the reliability of safety systems. Trends disclosed lead to modifications and reconstructions if needed. Experiences are used in education through simulator training. The constant and periodic 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 takes decisions upon consent, prepares disputed issues for consideration and brings them before the Director General for decision.

The utilisation of the experiences of other power plants

It is of vital interest to Paks Nuclear Power Plant to learn and make use of the operating experiences of other installations. This fact was acknowledged at the very beginning of the installation phase and has always been given special attention. In accordance with this, numerous forms of relations and methods of exchange of experience came into existence. The fields of activities aimed at the utilisation of experiences and the forms of implementation are contained in Tables 4.3.8-1 and 4.3.8-2:

Table 4.3.8-1.

Organisation	Nature	Topic	Time	Comments
International Atomic Energy Agency	Co-ordinated research programmes Working groups Regional programmes Technical co-operation IRS event reports INES reports Assessments Training courses, conferences Fellowships Databases Documents	Covers the entire activity of the nuclear power plant	from the period of designing of the power plant	
World Association of Nuclear Operators (WANO)	Event reports Questions and answers on computer network Production and safety indicators Exchange of positive experiences Technical exchange visits Power plant assessments Seminars, experts' meetings	Covers the entire activity of the nuclear power plant	1989	
WWER-440 Club	Directors' meetings Professional meetings	Current power plant problems reconstructions, events, projects	1989	
Users' Group	International conferences Studies	Modifications, Safety improvement measures, Reconstruction, Co-ordination of international aids	1993	Observer status

Table 4.3.8-1. (continued)

International Nuclear Safety Programme (Lisbon initiative)	Professional conferences Elaboration of procedural orders and instructions	Power plant documentation, Accident management instructions	1991	Observer status
Nuclear Maintenance Experience Exchange (NUMEX)	Conferences Questions – answers	Maintenance	1992	
Nuclear Maintenance Application Centre (NMAC)	NMAC Memo – monthly review Conferences	Maintenance	1993	
Nuclear power plants abroad	Professional exchange visits Exchange of experts for work Exchange of documents	Different for all power plants, Issues related to certain professional areas and current power plant problems	From the construction of the power plant	
Design, manufacturing, implementing companies	Design Modifications Reconstruction Expert assistance	Covers the entire activity of the nuclear power plant	From the period of designing of the plant	
Research institutes	Analyses Research and development Expert assistance	Covers the entire activity of the nuclear power plant	From the construction of the plant	
OECD NEA	Information system Data bank Professional work commissions	Radiation protection Safety programmes Safety of nuclear installations	1992 1992 1996	
INTERATOMENERGO	Professional working committees	Operation, maintenance safety indicator registration system of operation and equipment	1989	Membership terminated in 1994

Table 4.3.8-1. (continued)

Hagler & Bailly Consulting Inc.	Database	Event reports	1995	
European Nuclear Society	Conferences NucNet network	Current issues related to nuclear power plants Informative newsletters	1991	

Reviews by external entities

Since operation commenced, Paks Nuclear Power Plant has paid great emphasis on international assessments and reviews, which are important factors in the endeavours of the plant to increase safety and reliability. The preparation and execution of such reviews forces the operator to consistently evaluate usual practices. 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 Nuclear Power Plant:

Table 4.3.8-2.

Year	Subject of the review	Review performed by	Man.days
Between 1984-1987 yearly	Operation, maintenance	Experts invited by the Soviet supplier	20-20
1988	OSART (full scope)	IAEA	195
1990	Operation, maintenance	Experts invited by the power plant from 4 countries	80
1991	Design for safety	IVO	30
1991	Post-OSART review	IAEA	15
1992	Peer Review	WANO	156
1992	ASSET	IAEA	144
1993-1996	Site seismicity - 6 occasions; seismic safety programme – 2 occasions	IAEA	total 120, total 60
1995	Post-ASSET review	IAEA	50
1995	Peer Review follow-up	WANO	40
1996	The assessment of the accomplishment of safety improvement measures	IAEA	80
1997	Nuclear Liability Insurance Engineer’s Inspection	International experts of the insurance pool	35

The first reviews took place in 1984 within the framework of an agreement concluded between the power plant and its Soviet suppliers. The power plant quickly realised that the professional level of these assessments was not sufficient. As a result and in order to utilise the experiences accumulated from around the world, the power plant applied for an assessment to be performed by international experts within the framework of the OSART (Operational Safety Review Team) programme launched by the International Atomic Energy Agency with the goal to increase the safety of nuclear power plants. The review took place in November 1988. Hungary was the first former CMEA (Council for Mutual Economic Assistance) country to apply for this review. The review disclosed all the major differences existing between the West and the East as far as the evaluation of key issues related to the operation of nuclear power plants are concerned. Substantial differences were found, for instance, in the field of administrative regulations, where the practices followed by the West were based on significantly more detailed and fully described regulations with no significant role given to individual decisions.

The WANO Peer Review inspection, an analysing review similar to that of OSART but performed by experts of operating companies, was of similarly great importance.

Based on the reviews performed to date, it can be stated that they became integral parts of the plant's life. The reviews are normally concluded with positive evaluations and the steps taken so far to eliminate the identified deficiencies clearly demonstrate the process of continual development of 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 international reviews in the future, every 2 or 3 years.

4.3.9 Radioactive wastes

The safe handling of radioactive wastes 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)	$< 5.10^4$	5.10^4-5.10^8	$> 5.10^8$
dose rate (at 10 cm from surface) (μGy/h)	< 300	300-10 000	> 10 000

According to the Hungarian regulations, disposal is to be regarded as final if its safety is ensured for a period of 20-times the longest half-life in the waste disposed of. In the case of low and medium level wastes this period amounts to several hundred years.Deposited hihg level wastes should be isolated from the environment for a very long time. The length of this period, that depends on the actual technology of sealing and on the way of back end of the fuel cycle, cannot be determined now. There are low and medium level wastes containing long-lived radionuclides that should be handled in the class of high level wastes.

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 liquid technological waste streams make up the major part of low and medium level radioactive waste.

During the operation so far, 2,964 m^3 of evaporation residue was generated, 1,754 m^3 of which is stored in tanks located in auxiliary building No. I., while 1,210 m^3 is stored in the tanks of auxiliary building No. II. The amount of spent ion-exchange resins discharged from water treatment systems and accumulated during the operation so far is about 30 m^3 and is stored in the two auxiliary buildings.

Used protective devices, tools, parts, cleaning tools, debris from reconstructions, metal waste and scrap generated in maintenance workshops and contaminated with radioactivity constitute a further element of low and medium level wastes. During the operation so far, 1,736 m^3 of processed (compressed or solidified) waste has been generated, 1,580 m^3 thereof was transported to Püspökszilágy for final disposal at the Radioactive Waste Processing and Disposal Facility. The average amount of solid and processed radioactive waste generated during the 52 reactor years elapsed is 110 m^3/year in a compressed state.

In the auxiliary building of Paks Nuclear Power Plant a limited capacity is available for the interim storage of drums containing solid waste. This interim storage provides sufficient capacity for about 8 years for the storage of waste on the premises of the plant.

Final disposal

The Radioactive Waste Processing and Disposal Facility was opened in 1976 in Püspökszilágy (some 30 km from Budapest). This site receives the radioactive wastes generated in the research, medical and industrial institutions of the country. This is a near-surface, concrete-pool storage facility. As there was no separate disposal site available for the disposal of low and medium level radioactive wastes generated by the power plant, such low level solid wastes were transported to the above mentioned site, within the framework of a contract concluded with the approval of the Authority, between the years 1983 and 1997. From 1997, the power plant no longer transports solid radioactive wastes 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.

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. Such waste is categorised as high level waste (according to the related Hungarian standard and the regulations of the company itself) if the surface dose rate exceeds 10 mGy/h.

Concerning the operation of Paks Nuclear Power Plant, 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 pre-prepared waste packages can be put into the pits. The radioactive waste to be disposed is put into uniform containers, so that they can be removed at any time. Only solid waste can be put into the pits.

The Interim storage of spent fuel was already discussed in Section 1.1.4.

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

In February 1992, the Hungarian Atomic Energy Commission reviewed the issues related to the handling and disposal of low and medium level wastes generated by Paks NPP Ltd., and issued a resolution stating that an acceptable method of handling and safe storage of radioactive waste generated in the nuclear power plant should be found within the framework of a National Project.

The first phase of the National Project was launched in 1993 and completed in 1996. The chief organiser and one of the executors of the geological research was the Hungarian State Institute of Geology, under the supervision of which several dozen institutions have participated in the work.

The Governing Board of the Project took resolutions on 8 December 1996 regarding further research activities.

In the initial phase the National Project identified all potential geological formations for the safe final disposal of low and medium level radioactive waste generated by the power plant, when considering all circumstances known to date. The wide-scale national survey, in line with international practices, considered the possibilities of both surface and underground disposal. In each case, such technology was considered that ensures the retrievability of waste.

Considering the geological research and safety analyses performed within the framework of the Project, along with the attitude of the population, the region of Udvari proved to be the best for surface disposal, while the region of Üveghuta was declared to be the most suitable for underground disposal.

Based on the comprehensive evaluation of the results obtained in the first phase of the project, detailed geological analyses are to be conducted in the region of Üveghuta in the second phase of the Project. If the results of these analyses do not verify the previous geological assessments, surveys should be embarked on in Udvari, or in one of the regions already surveyed and supported by the population.

In the second phase of the Project, which will be concluded with the commissioning of the facility meant for the final disposal of low and medium level radioactive waste, it is still a task of key importance to provide the public with adequate information, along with the elaboration and implementation of a communication programme aimed at this task.

Geological works have been carried out in 1997 and 1998 according to the above described resolutions. Professional opinion about the adequacy of the Üveghuta site will be issued in 1998. If a positive decision is taken, the next phase (a detailed geological survey) may be embarked upon. According to preliminary plans, the storage facility could be put into operation by 2003.

Preparatory works for the final disposal of high level radioactive wastes

While searching for uranium-ore fields, the Mecsek Ore Mining Company discovered a geological formation (siltstone of Boda), which seems to be adequate for the disposal of high level radioactive waste.

The Hungarian Atomic Energy Commission issued a resolution in 1995 for the launch of a national programme aimed at the final disposal of high level long-lived radioactive wastes in Hungary. Within the framework of this and upon the request of the nuclear power plant, the Mecsek Ore Mining Company prepared a detailed short-term programme for the period of June 1995 to June 1998. The programme aims to examine whether the siltstone rock of the Western Mecsek mountains is adequate for the disposal of high level radioactive waste. During the implementation of the programme, existing and new information has had to be collected, analysed and interpreted so that a decision can be taken regarding the implementation of long-term surveys. The research programme, based on investigations from the surface, set minimal objectives only, i.e. to assess the extension and characteristics of the rock.

Within the framework of the research programme for the high level radioactive wastes, the Mecsek Ore Mining Company conducted research through open-cut test borings and started to survey the siltstone rock through an exploration from the mining level (1,050 m). Based on the findings of international research, it was obvious that the information presently available is not sufficient to assess the adequacy of the siltstone formation. That is why a long-term concept and a short term research programme has been prepared in co-operation with the Canadian company AECL acting as consultant.

In the meantime, the production of uranium ore was stopped (at the end of September 1997), and, as a consequence, research activities had to be rescheduled. The decision is expected to be taken soon about the continuation of work and the potential establishment of an underground research laboratory.

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 the national report 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.

The review of Units 3 and 4 of Paks Nuclear Power Plant was started at the end of 1997, and is expected to be completed by 1999. The scope of the review was supplemented by two professional areas, as follows:

- environmental radiological effects; and
- nuclear emergency preparedness.

Safety Improvement Measures were already in existence at Paks Nuclear Power Plant in 1986 and have been continuing since then.

Priorities are revised periodically. As a result of the safety improvement modifications completed in 1998, the risk of a core melt-down in the power plant was reduced by a whole magnitude.

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

An important element of safety improvement is the modernisation of the system of *accident management instructions*. The preparation of status-oriented accident management instructions was started in 1996 and is expected to be concluded in 1999. The new instructions will be utilised from 2001.

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