WESTERN EUROPEAN NUCLEAR REGULATORS' ASSOCIATION

Report on nuclear safety in EU applicant countries

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INTRODUCTION

Nuclear safety in the candidate countries to the European Union is a major issue which needs to be addressed in the frame of the enlargement process.

The Heads of the nuclear safety Regulatory Bodies of the European Union member States having nuclear power plants, i.e. Belgium, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom, together with their national Technical Support Organisations, thought it was their duty to offer their assistance to the European Union Institutions at a moment when the expansion of the Union is being considered. As a consequence, they decided to issue a report giving their collective opinion on nuclear safety in those applicant countries having at least one nuclear power reactor (Bulgaria, Czech Republic, Hungary, Lithuania, Romania, Slovak Republic, Slovenia) and covering :

- the status of the regulatory regime and regulatory body,
- the nuclear power plant safety status.

This report is based on the knowledge they gained through multilateral assistance programmes, in particular the Phare programmes, and also through bilateral contacts. It must be stressed that in some cases, they recognised that their current knowledge was not sufficient to express a clear and exhaustive opinion. Also, it should be pointed out that the judgements are based on widely applied Western European design standards for the defence-in-depth and associated barriers. Quantitative comparisons of Probabilistic Safety Assessments have not been used as the available results are of widely different depth and quality.

They also recognised that such a report could only present the situation at a given moment and they intend to periodically update it so as to reflect the changes which may occur in these countries. At this stage, the report does not cover radioactive waste or radiation protection issues in any detail.

After they had taken the decision to issue this report, they decided to create an association, the Western European Nuclear Regulators Association (WENRA) in order to increase the co-operation between them. Switzerland has been invited to join WENRA and has accepted. WENRA has the following objectives :

- to develop a common approach to nuclear safety and regulation, in particular within the European Union,
- to provide European Union with an independent capability to examine nuclear safety and regulation in applicant countries,
- to evaluate and achieve a common approach to nuclear safety and regulatory issues which arise.

The present report is produced by WENRA, although it should be mentioned that Switzerland did not participate in it.

Executive summaries

BULGARIA

Status of the regulatory regime and regulatory body

1. There have been improvements in the capabilities of the nuclear regulatory body (the Committee on the Use of Atomic Energy for Peaceful Purposes - CUAEPP) and in the legislative basis over the last 7 years.

2. However, much remains to be done to bring the regulatory regime up to Western European standards. The main needs are:

- the budget and salaries for the CUAEPP should be improved to allow it to recruit and retain adequate staff, and obtain independent technical support when needed;
- the number of regulatory staff should be increased, with adequate training and experience in safety assessments and in site inspection duties;
- resources should be committed to the drafting and introduction of necessary new and revised legislation;
- the independence of the CUAEPP from bodies concerned with the promotion of nuclear power should be made explicit.

Nuclear power plant safety status

3. Since the early 1990s, a substantial amount of assistance has been provided to the Kozloduy site by international organisations and through bilateral assistance agreements. The utility has also invested considerable funds in safety improvement programmes. In particular, with the completion of further planned safety upgrades, it should be possible to achieve a level of safety for Units 5 and 6 which is in line with reactors of the same vintage in Western Europe.

4. The short term upgrading measures implemented at units 1-4 have improved the safety of these units. Further safety improvements are being implemented or planned. However, on the evidence available, the existing and planned safety upgrading programmes will not be sufficient to bring these units up to acceptable safety standards in Western Europe for older reactors.

5. There have been considerable improvements in the standards of operational safety at all the units and staff awareness of safety issues has definitely increased. However, continuous and long term improvements are necessary to bring the operational safety at the plant up to a level comparable with good practice in Western Europe.

CZECH REPUBLIC

Status of the regulatory regime and regulatory body

1. The Czech Republic has taken the appropriate steps to establish a regulatory regime and regulatory body according to the principles adopted in Western Europe. Nevertheless, some improvements are still necessary.

2. It is recommended that the Government of the Czech Republic consider the following issues:
   - the budget and salary conditions of the SÚJB should be improved so that it can obtain the necessary technical support and retain highly qualified staff;
   - the working relations between the SÚJB and other governmental organisations and administrative departments should be clarified. In particular, the organisation for emergency preparedness and planning should be tested in national emergency exercise.

3. The SÚJB should establish a strong management line, in particular to ensure the rapid implementation of the necessary regulations under the Atomic Act.

Nuclear power plant safety status

Dukovany

4. The overall safety status of Dukovany can be summarised as follows:
   - in the early years of operation, a backfitting programme was introduced to remove some of the safety deficiencies of the original design;
   - further upgrading measures are underway or planned as part of an extensive modernisation programme. Due to burdens from the construction of Temelin NPP however, this programme will be implemented in stages depending on annual budgets;
   - Dukovany NPP appears to be well operated, and the plant safety culture has been continuously improved. Several IAEA missions, and co-operation with WANO, have contributed substantially to the enhancement of safety; safety assessments are being conducted in a manner similar to Western practices;
   - the current level of safety at the plant cannot be fully assessed due to lack of detailed information. However, subject to a detailed analysis of the fully modified plant and an experimental verification of the containment function, Dukovany NPP should be able to reach a safety level comparable to plants of the same vintage in Western European countries.

Temelin

5. Due to a lack of information the current status and prospects of the Temelin programme cannot be fully assessed.

6. However, there are concerns that the ambitious safety improvement programme might not be successfully implemented. Due to the complexity of repeated design changes, long construction time and the necessity to integrate technologies of very different origins, a major effort is necessary to prepare and assess a comprehensive safety case. This is a challenge for both the operator and the regulator.

HUNGARY

Status of the regulatory regime and regulatory body

1. There is no doubt that the Hungarian approach to licensing, regulating and controlling nuclear facilities is an advanced one. Legislation and other regulations are up-to-date, and compare favourably with the principles applied in Western countries. HAEA is also sufficiently independent from the organisations promoting nuclear energy.

2. There are some issues that need to be improved or clarified:

- to continue to maintain a stable, competent staff, the Hungarian Government should ensure that the salary level of the regulators more closely matches that of the utility;
- the HAEA should further develop the role of the site inspection department in order to avoid undermining the safety responsibilities of the operating organisation, and to ensure that all operational safety issues are sufficiently covered.

Nuclear power plant safety status

3. The following conclusions can be drawn:

- the safety characteristics of the Paks units have been evaluated in an in-depth, systematic manner;
- the basic technical structure of the plant is good from the safety point of view, and the key safety systems are comparable to Western plants of the same vintage. There are no major shortcomings in the present safety systems, but some minor issues remain to be resolved;
- Paks containment structures are among the best for this reactor type, and meet their original design targets by providing protection against all sizes of loss of coolant accidents. However, their leaktightness is not as good as the leaktightness of containments in Western Europe. This would have some influence in the progress and consequences of potential severe accident scenarios;
- Paks has taken actions to mitigate beyond design basis accidents and severe accidents. These measures are in compliance with good Western European practice, but additional work is needed to ensure containment integrity following a severe accident;
- operational safety aspects are generally at a level comparable to Western plants of the same vintage. Some concern is caused by the experience from management changes related to the political changes in the Government;
- periodic safety reviews are conducted similar to Western practices, and have already led to an increase in safety;
- it is expected that after the implementation of planned safety improvements, which are in the design and preparation phase, the plant will be able to reach a level of safety which compares well with plants of the same vintage in Western European countries.

LITHUANIA

Status of the regulatory regime and regulatory body

1. The legal and regulatory system in Lithuania has developed substantially over a short period.

2. However, in some areas the system needs further improvement in order to be comparable with good practice in Western Europe. In particular:

- the nuclear law should be clearer about the interfaces between different authorities, and the co-ordination between these authorities needs to be improved;
- the organisational structure of the Ignalina NPP should be changed in such a way that the head of the operating organisation/utility is authorised under the Board to handle all safety relevant issues and is provided with the means to take full responsibility for safety;
- the resources of the regulator need to be strengthened to enable it to handle all regulatory issues without foreign assistance;
- technical support and access to nuclear safety research should be strengthened in order to provide the regulator with an adequate assessment capability;
- the responsibility for auditing and approving vendors and suppliers should rest with the operating organisation and not with the regulatory body;
- the work of the resident site inspectors should shift from detailed inspection to a system in which they audit the activities of the licensee.

Nuclear power plant safety status

3. The Ignalina reactors belong to the more advanced design generation of RBMK reactors and much has been achieved in the ongoing safety improvement programme. From the independent safety assessments completed so far, it appears that most of the deviations from Western European requirements could be reasonably addressed or compensated for by a continued safety improvement programme.

4. However, there remain fundamental weaknesses with respect to the type of accidents and transient events that the plant can handle with high reliability and without unacceptable environmental consequences. In particular, there are ongoing concerns regarding the lack of an adequate containment and the reliability of the reactor shut down systems. Although it is likely that many of the plant's safety deficiencies could be addressed by means of a further safety improvement programme, the lack of an adequate reactor containment remains a major problem which cannot realistically be solved.

5. This design weakness prevents the Ignalina reactors from being able to achieve standards of safety which are comparable to those required for older reactors in Western Europe.

6. Much has been achieved with respect to improvements in operational safety and safety management. However, further efforts are required on issues such as :

- the financial situation of Ignalina NPP should be improved to provide for all of the necessary safety improvement measures required for the remaining plant lifetime;
- issues relating to safety culture have been addressed but need stronger implementation. Thus, the management structure of Ignalina NPP needs further clarification, amongst other things, to ensure the necessary quality and safety culture at all levels;
- the internal communication and experience feedback procedures should be improved in parallel with the implementation of the new Quality Assurance system;

- accident management strategies and procedures should be evaluated and further developed.

7. The national technical support infrastructure is improving but will not be sufficient in the near term. For supply and services, the Ignalina NPP will remain dependent on foreign companies. In addition, further Western assistance and Russian consultation will be needed for engineering work.

ROMANIA

Status of the regulatory regime and regulatory body

1. The regulatory regime and the regulatory body have both improved during the licensing process of the Cernavoda NPP. The roles, duties and responsibilities of organisations involved in nuclear safety are in line with those of similar organisations in Western Europe. In addition, the regulator is sufficiently independent of the organisations involved in the use and promotion of nuclear energy.

2. However, some improvements are necessary in order to reach a level comparable with good practice within Western Europe. In particular:

- the resources of the regulator need to be strengthened to ensure it can accomplish all its regulatory duties effectively. Further staff need to be recruited and trained. Staff working conditions should be improved and salaries increased in order to retain qualified personnel;
- the responsibility for auditing and approving vendors and suppliers should rest with the operating organisation and not with the regulator;
- nuclear emergency preparedness needs to be improved. Specifically, the regulator should assign more staff to this area and an emergency response centre should be established. In addition, national organisations should improve their emergency procedures and lines of communications.

Nuclear power plant safety status

3. The Cernavoda NPP has a Canadian designed CANDU 600 constructed and commissioned under the responsibility of a Western consortium. The safety design philosophy is similar to that of reactors in operation in Western Europe. However, the Western European regulators and their technical safety organisations have little experience of this design and no in-depth knowledge of the plant. Based on the information available, it is apparent that additional assessments are needed to confirm design safety margins against seismic events and the adequacy of fire protection. Also, a validated probabilistic safety assessment should be performed.

4. The Cernavoda plant managers and operators have a solid professional attitude and have assimilated a western safety approach and culture. However, this safety culture needs to be extended to all plant personnel and to the national service and support organisations. There is a need for improvement in some areas of plant operation such as accident management, emergency preparedness, training and operational experience feedback.

5. It is important that the Romanian government ensures that the current financial problems of the utility do not affect the ability of the management to maintain an adequate level of safety at the plant. Western support (especially from Canadian experts) should be made available when it is needed in the future.

SLOVAK REPUBLIC

Status of the regulatory regime and regulatory body

1. The Slovak Republic has taken the appropriate steps to establish a regulatory regime and regulatory body (the ÚJD) according to the principles adopted in Western Europe. Nevertheless, some improvements are still necessary.

2. It is recommended that the Government of the Slovak Republic consider the following issues:
   - clarifying the relations between the ÚJD and the Authority in charge of radiological protection;
   - clarifying the relations between the different governmental organisations involved in emergency preparedness and planning;
   - increasing the budget of the ÚJD, in particular to allow full independent technical assessment capability;
   - increasing the salaries of the ÚJD to allow the retention of expert staff.

3. The ÚJD should:
   - devote necessary resources and priorities to the continued development of regulations under the Atomic Act and appropriate guidance;
   - enhance independent safety assessment capabilities.

4. The first unit of the Mochovce plant has recently started operation and a number of modifications to upgrade it to Western standards for reactors of the same generation still need to be implemented. The ÚJD will have to continue to demonstrate its independence and credibility through the requirements it will impose on the operator for the completion of all safety modifications.

Nuclear power plant safety status

Bohunice V1

5. The following conclusions can be made for Bohunice V1 (units 1 and 2):
   - compared with the original design, the safety of Bohunice V1 has been greatly improved and further improvements are to be made. Many of the major shortcomings of the plant should eventually be corrected. However, some safety concerns still remain, for instance the adequacy of the confinement remains a key issue and the confinement would probably not mitigate the consequences of large LOCAs and severe accidents consistently with current Western practices for plants of the same vintage;
   - operational practices are consistent with those in Western Europe;
   - due to a lack of information, the current and planned level of safety of the Bohunice V1 units cannot be fully assessed.

Bohunice V2

6. The safety of the V2 units seems generally adequate, although some safety issues still need to be addressed. Once the safety upgrades have been implemented (within about 3 years), the safety level of these units would probably be comparable with that in units of the same vintage in Western European countries, although, due to a lack of information, the current and planned level of safety of the Bohunice V2 units cannot be fully assessed.

Mochovce

7. Once the planned improvements are complete, the safety of Mochovce units will be comparable with that of Western plants of the same vintage.

SLOVENIA

Status of the regulatory regime and regulatory body

1. Since its creation in 1987, the Slovenian Nuclear Safety Administration (SNSA) has evolved and matured as a regulator, and there is a clear separation between regulation and promotion of nuclear energy.

2. In general, SNSA operates according to Western practice and methodologies, but there are some issues that need to be improved or clarified. In particular:

- SNSA needs to continue the revision of the existing legislation to ensure it is brought in line with current Western European practice. The current right of the licensee to appeal to the Minister on regulatory decisions may constrain and undermine the SNSA and this should be reviewed;
- an increase in SNSA salaries and an improvement in its financial stability would help to retain staff, increase assessment capability and allow speedier approval of safety improvements;
- the use of the same technical institute as a main contractor for both the regulator and the utility may lead to a conflict of interest and this needs to be guarded against;
- special attention needs to be paid to the interface with the Croatian authorities with regard to cross-border emergency arrangements.

Nuclear power plant safety status

3. Kr_ko is a Western designed facility and in general, the safety of the plant compares well with nuclear power plants operating in Western Europe. The NPP has a continuous backfitting and upgrading programme and many safety improvements have been completed. A few safety issues, for instance the seismic characterisation of the site, remain to be fully addressed. A key challenge for the near future is the replacement of both steam generators, coupled with a reactor power uprating. This will require an in-depth safety assessment. There is also a need for the utility to carry out a formal periodic safety review of the plant.

4. The site organisation, staff numbers, qualification and training are similar to those in Western Europe and the utility appears to show proper regard for safety. However, the utility is small and needs sufficient financial resources to allow it to continue to obtain adequate technical advice and support from outside organisations. The Slovenian Government needs to address the long term financial stability of the utility to ensure an adequate priority for nuclear safety can be maintained.

Detailed reports

BULGARIA

Chapter 1: Status of the regulatory regime and regulatory body

Status of legislative framework

1. The primary legislation for nuclear safety was enacted in 1985, and amended in 1995. Enforcing regulations, which give interpretation and meaning to the primary legislation came into force in 1985, but have not yet been revised to reflect the 1995 amendments. There are no significant gaps in the regulatory basis for nuclear and radiation safety. However, some of the legislation still in force is based on, or strongly influenced by, the rules and regulations of the former Soviet Union. The regulatory approach therefore remains primarily of a prescriptive nature. There is a three year programme agreed by the nuclear regulator and relevant Ministries for the development and revision of much of the present regulatory basis, which should lead to greater consistency and facilitate the adoption of a less prescriptive approach. However, the high workload of the regulatory body means that this legislative programme is late, and is likely to be delayed considerably.

2. Existing legislation adequately defines the legal obligations of the National Electricity Company (NEC - the operating organisation) with regard to safe control of the plant and civil liabilities under the Vienna Convention. The primary legislation also requires the operating company to make payments into funds for dealing with radioactive waste and for decommissioning. These funds have not been adequately maintained, and although Bulgaria has claimed that regulations to address this will come into force in early 1999, this seems likely to be delayed. The Bulgarian Government is reported to be considering eventual privatisation of NEC, but at the moment the company is wholly owned by the State.

3. All the key international conventions have been ratified and included in the national legislation.

Status of regulatory body

4. The current legislation places a dual role on the regulatory body (the Committee on the Safe Use of Atomic Energy for Peaceful Purposes - CUAEPP), as a State Body with membership from organisations concerned with the promotion of nuclear power and the operation of the power stations, and as a legal entity charged with regulation of safety. This implies a lack of independence of CUAEPP as a safety regulator. The proposed changes to the legislative basis should remove this apparent lack of independence, although it is not clear when, or even if, this will take place.

5. Funding for the CUAEPP is controlled by Ministry of Finance, and is currently inadequate. Budget restrictions imposed since 1996 have reduced the CUAEPP staff by about 25% to the present 77. Of these, 50 posts are allocated to the Inspectorate on the Safe Use of Atomic Energy (ISUAE), the enforcement and inspection arm of the CUAEPP. CUAEPP salaries are typically 20% of salaries staff can earn working for the nuclear industry, and this makes recruitment and retention of well qualified staff difficult. The CUAEPP Chairman stated at the June 1998 CONCERT meeting that proposed legislation will fix the regulators salaries at a minimum 80% of the equivalent industry level. This legislation is not yet in place and CUAEPP continue to lose good staff. The 1997 IRRT concluded that there are not enough staff to adequately carry out safety assessment and site inspection duties. Staff shortages make the CUAEPP vulnerable to the loss of experienced personnel. The IRRT review also found the training for site inspectors to be inadequate

and that there was poor succession planning. This was highlighted by the loss in early 1998 of the only Kozloduy site inspector with significant nuclear safety expertise. It is worth noting that the site inspection staff devotes much of its efforts to carrying out routine, qualification inspections of pressure parts and lifting equipment. With such limited resources, CUAEPP would benefit from adopting a Western approach in which the licensees carry out such inspections, with independent routine inspections carried out by specialist inspection agencies.

6. At a recent RAMG co-ordination meeting in Sofia, the Western Regulators were informed that the Council of Ministers are considering whether CUAEPP should be made an independent Agency of the Government or whether it should be housed within an existing Ministry. If the Bulgarian Government decides that the CUAEPP should become part of a Ministry, it is vital that the Ministry is completely separate from any part of the bureaucracy that promotes nuclear power in order to ensure the independence of the CUAEPP.

7. Frequent changes in senior management positions, especially the Chairman, has put additional strain on CUAEPP over the last few years. The CUAEPP would benefit from greater organisational stability if it is to be able to continue its improvement process in an effective way.

Status of regulatory activities

8. The CUAEPP issued an Improvement Plan in 1998 which set out the status of the current legislation and regulations and a strategy for future developments. The stated aim is to create a strong and independent regulatory body with sufficient funding to carry out its functions of reviewing and assessing safety submissions, licensing nuclear safety activities, establishing regulations and criteria, inspecting nuclear installations and enforcing the national legislation. The Improvement Plan set out an ambitious programme for codifying the CUAEPP's nuclear safety and licensing requirements, which will gradually replace the prescriptive legacy of the former Soviet Union and bring the Bulgarian regulator in line with a Western European approach. Some good progress has already been made, but unfortunately, because the CUAEPP is unable to devote sufficient resources to that programme, it is already falling behind schedule.

9. In general, the CUAEPP appears to be staffed by technically competent personnel. However, since 1992, due to the limited resources available to it, the CUAEPP has relied on external independent technical assessments in carrying out licensing of plant modifications and improvements. Much of this has been provided under assistance projects funded by the EC, the IAEA and through bilateral programmes. In the absence of significant increases in CUAEPP resources, such assistance will need to continue, at least until the completion of the upgrading programme of Units 5 & 6.

Emergency preparedness on governmental side

10. CUAEPP has recently stated that there are too many regulatory documents, produced over a number of years, to provide for an effective, consistent emergency response. A comprehensive regulation has been drafted, which should clarify and strengthen the regulatory basis for the national nuclear emergency response, and has been submitted for consideration by the Council of Ministers. A decision on this is still awaited. It is noted that Bulgaria is a participant in the IAEA Regional Assistance Project to promote harmonisation of emergency planning of Central and Eastern Europe. In addition, CUAEPP are receiving assistance in the development of its Emergency Preparedness Manual via a current PHARE RAMG contract. It is assumed that the CUAEPP emergency response centre, established at the Sofia headquarters with international assistance a few years ago, is still adequate for its intended purposes, although this needs to be confirmed.

11. A welcome improvement introduced in the proposed emergency planning regulation is the requirement for a full, national nuclear emergency exercise every 5 years. Currently, there are annual communications-only exercises involving all relevant national authorities, and there is a site emergency exercise

each year. Bulgaria has also participated in the last three INEX-2 international exercises organised by the OECD.

Status of supporting national infrastructure

12. In the last few years, local technical support organisations have developed in number and expertise. However, there are still only a limited number of Technical Safety Organisations (TSOs) in the country, which means they are sometimes contracted to work for both regulator and the utility. A considerable proportion of technical support to the regulator continues to be provided by Western TSOs, funded by international assistance programmes. This is unlikely to change in the near future.

13. The funds available to CUAEPP for nuclear safety research and support are provided by charges levied from the licensees. Compared with equivalent funds typically available to Western regulators, this is at a fairly low level.

Conclusions

14. Since the original PHARE mission in 1992, there have been some significant improvements in legislation, organisation and operation of the CUAEPP. However, many of the weaknesses identified in 1992 remain. Lack of progress in many areas is no doubt due to the severe economic problems which the country faces. Low wages, combined with a high workload and poor working conditions, have a negative effect on staff morale and the loss of further valuable staff is likely.

15. It is recommended that the Government of Bulgaria consider the following issues:

- there is no substitute for a strong, independent and competent regulator. Over recent years, the technical competence, strength and continuity of the Bulgarian regulator has been strongly supported by Western experts. Major efforts are still needed by both the Bulgarian Government and by the CUAEPP management to ensure that the regulatory authority achieves a status which is comparable with that considered acceptable in Western European countries.
- the independence of the CUAEPP from bodies concerned with the promotion and supply of nuclear power needs to be made explicit. The CUAEPP would also benefit from a period of managerial and organisational stability;
- the budget and salaries for the CUAEPP are too low to allow it to recruit and retain sufficient numbers of competent staff, and to obtain independent technical support when required; in addition, the CUAEPP funds for supporting independent nuclear safety research and support are very low when compared with typical Western European regulators;
- there is a shortage of competent technical support organisations within the country and the same organisations may be used by the CUAEPP and the utility. This could mean a possible conflict of interest and needs to be guarded against.

16. In addition the CUAEPP should ensure that sufficient resources are committed to the drafting and introduction of new and revised legislation identified in the CUAEPP Improvement Plan, and to the programme for codifying CUAEPP's basic nuclear safety and licensing requirements. This should gradually replace the prescriptive legacy of the former Soviet Union in order to bring Bulgaria in line with a Western European approach to regulating nuclear safety.

Chapter 2: Nuclear power plant safety status

Data

1. Kozloduy has six operating VVER-reactors owned by the National Electric Company (NEC); four units (Kozloduy 1-4) of type VVER-440/V-230 and two units (Kozloduy 5-6) of type VVER-1000/V-320. On the Belene site the erection of two VVER1000/V-320 units was started in the 1980's but frozen at different stages of completeness in 1990.

NPP Unit	Reactor Type	Start of Operation	End of design life
Kozloduy 1	VVER 440/230	October 1974	2004
Kozloduy 2	VVER 440/230	November 1975	2005
Kozloduy 3	VVER 440/230	December 1980	2010
Kozloduy 4	VVER 440/230	June 1982	2012
Kozloduy 5	VVER 1000/320	November 1987	2017
Kozloduy 6	VVER 1000/320	August 1991	2021

Basic technical characteristics

(i) Kozloduy, units 1-4

2. Units 1-4 are characterised by the significant design safety deficiencies which are common to all V-230 reactors. Units 3 and 4 are more advanced type V-230 reactors, having some, but not all, of the design improvements of the V-213 type, e.g. better segregation of safety systems.

Embrittlement, NDT verification

3. In the early 1990's units 1-3 reactor pressure vessels (RPVs) were annealed, and recent experimental results on irradiated samples taken from unit 1 RPV indicate that embrittlement should not be a problem for the next few years of operation. However, further investigation of additional samples is required to confirm this. For unit 4, lower impurity contents in the affected weld means that RPV embrittlement should not be a life-limiting factor.

Primary pressure boundary integrity

4. For large primary circuit breaks, a case for leak-before-break has been confirmed theoretically. Based on these calculations, new supports and hangers for primary circuit components have been introduced on all four units.

Safety systems

5. By 1997, with assistance from the EU (Phare) and EBRD, substantial short term safety improvements had been implemented on all four units, e.g. improvements to reactivity control and additional reactor protection signals, installation of an independent emergency feedwater system, measures to ensure the integrity of pressurised components, measures for improving the leaktightness of the confinement, measures for improving protection against hazards in general (e.g. fire protection), improvements to Instrumentation & Control. Additional thermalhydraulic analyses show that the emergency core cooling system can cope with leaks somewhat larger than assumed in the original design basis.

Confinement function

6. The reactor and the primary circuit is housed within a pressure suppression confinement system called the Accident Localisation System (ALS). Although the leaktightness of the confinement has been improved by an order of magnitude in recent years, it is still worse than would be considered acceptable for Western water reactor containments. Due to its construction, further significant improvement in the leak-

tightness is unlikely. The design load bearing capacity of the ALS system is limited to relatively small breaks in the primary circuit. Current upgrading plans seek to ensure confinement function in the event of larger breaks by installation of jet condensers.

Beyond design basis accidents (BDBA) and severe accidents

7. A series of safety improvements have been introduced in recent years in order to cope with some BDBA conditions: the installation of a new emergency feedwater system, emergency feedwater supply by mobile pumps, implementation of equipment and procedures for primary bleed and feed. With regard to severe accidents no specific measures have been implemented so far.

(ii) Kozloduy 5-6

8. In general, the main safety features of Units 5 and 6 are comparable to Western PWRs of the 1970s. They have a full-pressure containment and safety systems generally have three trains of redundancy. The utility is implementing a programme of further upgrades for these units. The main safety improvements relate to fuel and control rod optimisation, long term cooling, electrical systems, instrumentation and control, containment integrity and radiation monitoring. The programme involves major Western partners and is planned to be completed in stages over the next few years. Safety assessments by Western TSOs for similar plants in Ukraine and the Russian Federation have confirmed that, after safety upgrading, it should be possible to achieve a level of safety in line with Western nuclear power plants.

Safety assessment and programmes for future safety improvements

9. No periodic safety reviews have been performed for any of the Kozloduy units.

Safety Analysis Report:

10. The lack of Safety Analysis Reports (SAR) of Western standards for any of the units is a substantial shortcoming. For units 1 and 2, no deterministic safety documentation is available. For the other units a partial SAR exists in the form of original technical design documentation. Analyses on selected safety issues, mainly generic, are available for units 5 and 6, and also to a smaller extent for units 3 and 4. In support of CUAEPP, Western TSOs have recently developed requirements for a SAR for units 3 and 4. In the short term, CUAEPP has required the utility to present a Safety Substantiation Report describing the present safety status of units 3-4. A detailed SAR is required by the regulator with completion of the extended modernisation programme (expected in 2002).

(i) Kozloduy 1-4

11. In the early 1990's a consortium of Western Technical Safety Organisations (TSOs) assessed the safety status of units 1-2 and units 3-4 separately, and reviewed the corresponding modernisation programmes designed for safety during short term operation. The TSO consortium gave recommendations for short term safety upgrading measures, additional to those already identified by the utility. Comprehensive safety assessments of the short term modernisation programmes are still outstanding. Recently the utility has proposed a more extended modernisation programme for units 1-4 to allow these units to be operated until the end of their design life. However, on the evidence available, the existing and planned safety upgrading programmes will not be sufficient to bring these units up to internationally acceptable safety standards for older reactors.

(ii) Kozloduy 5-6

12. A plant specific safety assessment is not yet available, although some insights from assessments of similar plants (e.g. Rovno 3) may be applicable to units 5 and 6. In developing the extended modernisation programmes for the VVER- 440 and VVER-1000 reactors, the utility has performed some plant speci-

fic safety analyses, based on both deterministic and probabilistic approaches. Western TSOs have only done a safety review of the modernisation programme.

Probabilistic Safety Assessment (PSA)

13. Level 1 PSAs of varying comprehensiveness have been carried out for all six units. The PSAs for units 1-4 were performed by Bulgarian and Russian institutions, but considered only a limited number of accident sequences, mainly on the basis of generic data. The PSA for units 5 and 6 was more comprehensive and was subsequently reviewed by an IAEA expert group (IPERS). At present, it is undergoing an extended review by a Western TSO.

Decommissioning

14. Bulgarian regulations require the utility to provide documentation for decommissioning at least five years before the planned shutdown of a reactor. At present no documentation is available or under preparation. To assist the regulator, a TSO project is underway to define requirements and procedures for decommissioning units 1 and 2. Tendering for industrial assistance is underway under a Phare project.

15. The funds put aside for decommissioning are currently inadequate.

Operational safety

16. Since 1992, with Western assistance to the utility and the safety authority, plant operational management has improved continuously. There is a significant number of competent staff at the plant dedicated to the ongoing safety upgrading process. The management structure was reorganised, responsibilities clearly defined, a Quality Assurance (QA) programme established and a systematic analysis of operational experience feedback has been started. However there are still a number of significant shortcomings and concerns:

- training of new operating and maintenance personnel to replace experienced staff as they retire from the company;
- the Novovoronezh simulator is not of modern design and does not correspond to design features of Kozloduy 1-4. Multifunctional simulators which are under development for units 1-4 will have only a limited capacity for accident simulation;
- there is an absence of modern technical specifications for operation;
- the development of symptom-oriented accident procedures for units 1-4 has been halted because of the lack of a full-scope simulator;
- recently, an increasing number of failures and abnormal events have been reported at all units. These may be due to a growing uncertainty and demotivation of the plant personnel coupled with instability caused by Government imposed changes, and frequent reorganisations of the operating company and plant management.

When known, the results of the recent OSART mission of the IAEA to Kozloduy will provide insight into the current status of operational safety.

17. In Bulgaria there are several national and private organisations providing high quality technical and scientific support to Kozloduy such as Energoproject Sofia, several institutes of the Academy of Science, Riskengineering, ENPROconsult and BEQE. These are sometimes used by CUAEPP as well, which could lead to a possible conflict of interest.

Spent fuel and waste management (technical and economical status)

18. Spent fuel of the VVER-440 reactors is stored in an on-site fuel store, erected in the 1980's but which has certain design deficiencies. There is currently an agreement that this fuel will be transported back to Russia for reprocessing. Presently the spent fuel store is being modified to accept VVER 1000 fuel from units 5 & 6. At the moment this is stored in pools within the containment and the capacities are nearly exhausted.

19. In general, the Bulgarian approach to waste storage complies with Western practices. Radioactive wastes originating at Kozloduy are stored in interim storage facilities and an on-site cementation plant for liquid wastes is being built, but with considerable delay.

20. The construction of a repository for radioactive wastes is required by a decision of the Council of Ministers dating from 1991. However, a decision on the siting and design of the repository has not yet been taken.

Conclusions

(i) Kozloduy 1-4

21. The short term upgrading measures implemented at units 1-4 have improved the safety of these units. Further safety improvements are being implemented or planned. However, on the evidence available, the existing and planned safety upgrading programmes will not be sufficient to bring these units up to internationally acceptable safety standards for older reactors.

(ii) Kozloduy 5, 6

22. In general, the main safety features of these units are comparable to Western PWRs. Safety assessments by Western TSOs for similar plants in Ukraine and Russia indicate that after upgrading it should be possible to achieve a safety level in line with Western standards. An industrial programme for upgrading these units is underway and has been reviewed by Western TSOs.

General remarks

23. In all nuclear units the staff awareness of nuclear safety issues has definitely increased. In particular, significant improvements in operational safety have been achieved since 1992 and technical improvements to the safety of the units are underway or planned.

24. Some concerns remain however:

- a continuous and long term process of operational safety improvement is needed to reach a level comparable with good international practice. At the moment this process is faltering. Increased stability of senior plant staff is necessary in order to ensure that an appropriate level of attention is paid to safety management;
- every unit lacks adequate technical specifications for operation. Safety documentation of Western standard is not available for any of the units and is urgently needed; work on this is planned by the utility;
- inadequate financial provisions are being made for decommissioning any of the units at Kozloduy;
- there is a heavy dependence on Western TSO support.

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CZECH REPUBLIC

Chapter 1: Status of the Regulatory Regime and Regulatory Body

Status of the legislative framework

1. A new Atomic Act (law on peaceful utilisation of nuclear energy and ionising radiation) entered into force in 1997. It establishes the SÚJB as the administrative department responsible for supervising the utilisation of nuclear energy and ionising radiation (licensing, assessment, inspection and enforcement activities).

2. The nuclear legislative framework is considered to be comparable with current Western European practice.

Status of the Regulatory Body

3. The SÚJB is a central agency of the State Administration reporting to the Prime Minister via the Vice Prime Minister in charge of economy and finance, and is funded from the State budget. The authority and responsibilities of the SÚJB are clearly and legally defined to conform with good international practices.

4. After a substantial staff and budget increase, the budget of the SÚJB has recently been decreased by 25% and the current SÚJB salaries do not allow it to retain highly qualified staff. The salaries are distinctly lower than those of nuclear operators and the difference is increasing. Also, the SÚJB budget does not enable it to obtain the external technical support necessary for substantiating its regulatory decisions. The SÚJB seems to have particular difficulties in financing the work of the two advisory groups recently established for nuclear safety and radiation protection.

5. The SÚJB is responsible for nuclear safety, emergency preparedness and planning, transport of nuclear and radioactive material, international notification of incidents and accidents, radiological protection, information to the public, nuclear material accountancy, and import and export of dual purpose equipment. Several of these duties are carried out in conjunction with other administrative departments. This can lead to complicated interrelations, in particular with regard to emergency preparedness and planning.

6. The Atomic Act authorises the SÚJB to restrict or suspend a licensed activity if the licensee ceases to fulfil its obligations. For a violation of a legal obligation under the Atomic Act, the SÚJB may impose a penalty.

7. It is considered that, in general, the SÚJB has a status comparable to Western European regulatory bodies. However, further improvements are needed and these could be implemented more rapidly if a stronger line is taken by the SÚJB management. It is acknowledged that the allocation of SÚJB staff resources was not helped by the insistence of the Parliament that revised regulations be developed before the Atomic Act was adopted.

Status of regulatory activities

8. The Atomic Act authorises the SÚJB to draft subordinate regulations which, after approval by a legal advisory group of the Government, are signed by the SÚJB Chairman. The existing set of regulations needs to be revised in order to comply with the Atomic Act and the SÚJB has started work on this. Some revised regulations are currently being reviewed in the framework of the RAMG assistance programme

(e.g. quality assurance, design of NPP, siting of nuclear installations, commissioning and operation of NPP). The SÚJB should consider developing guidance on the application of these regulations.

9. A licence for a nuclear installation is not issued by the SÚJB but by the District authorities of the region where the installation is located. Nevertheless, a licence cannot be granted if the SÚJB issues a negative opinion.

10. SÚJB inspection activities derive from US NRC practices. They are based on an annual inspection plan which is revised after 6 months in order to identify additional inspection needs. The methodology for assessment of safety related documentation is also derived from US NRC practice.

11. In summary, the SÚJB has developed a series of regulatory practices which compare favourably with those of Western European nuclear regulators. However, further work is needed in the development of revised regulations for basic nuclear safety and licensing requirements.

Status of Emergency Preparedness on the Government side

12. A new Act in the field of emergency preparedness and planning is being prepared under the responsibility of the Ministry for the Interior. In case of a radiation accident, the co-ordination of all activities is the responsibility of the Governmental Commission for Radiation Accidents, chaired by the Minister for the Environment. The chairman of the SÚJB is the deputy chair of this commission. The SÚJB is responsible for ensuring the availability of the background information necessary to take decisions aimed at averting or reducing radiation exposure.

13. The national organisation for emergency preparedness needs to be tested in emergency exercises.

Status of supporting national infrastructure

14. For radiological protection, the SÚJB relies on the Radiological Protection Institute which is under its direct supervision. For nuclear safety, the SÚJB can obtain technical support from the Nuclear Research Institute (ÚJV), which has a separate team of staff working independently for the SÚJB. However, budget limitations allow only 5 ÚJV staff to work for the SÚJB which estimates that it currently needs about 15 staff to provide adequate technical support.

Conclusions

15. It is recommended that the Government of the Czech Republic consider the following issues:

- the budget and salary conditions of the SÚJB should be improved so that it can obtain the necessary technical support and retain highly qualified staff;
- the working relations between the SÚJB and other Governmental organisations and administrative departments should be clarified. In particular, the organisation for emergency preparedness and planning should be tested in national emergency exercises.

16. The SÚJB should establish a strong management line, in particular to ensure the rapid implementation of the necessary regulations under the Atomic Act.

Chapter 2: Nuclear power plant safety status

Data

1. The Czech Republic has two nuclear power plants (NPP) at Dukovany and Temelin:

NPP unit	Reactor type	Electrical power (MW)		Start of construction	First grid connection	End of design life
		gross	net			
Dukovany (in operation):						
Unit 1	VVER-440/V-213	442	411	1974	02/1985	2015
Unit 2	VVER-440/V-213	440	413	1978	01/1986	2016
Unit 3	VVER-440/V-213	452	425	1978	11/1986	2016
Unit 4	VVER-440/V-213	448	421	1978	06/1987	2017
Temelin (under construction):						
Unit 1	VVER-1000/V-320	981	912	1982	(05/2001?)	?
Unit 2	VVER-1000/V-320	981	912	1985	(07/2002?)	?

2. The plants are operated by CEZ (Ceske Energeticke Zavody, Czech Power Company).

(i) Dukovany NPP

3. Although background information on Dukovany is available from various international sources, the Western Regulators and their TSOs have had only limited access to detailed analysis and technical information.

Basic technical characteristics

4. All units of Dukovany NPP are second generation VVER-440 reactors of type V-213. However, since 1991, on the basis of safety analyses and supporting programmes of the IAEA and WANO, a backfitting programme has been carried out on all of the units. Major safety upgrading measures should, by now, have been implemented (e.g. improvements to fire protection, electrical power supply systems, the installation of an emergency response centre).

Safety assessments and programmes for future safety improvements

Operational Safety Analysis Report (OSAR)

5. Due to the modifications and safety improvements implemented at Dukovany, the original Pre-Operational Safety Analysis Report (required to get a permanent operating license) is of only limited value. In addition, since the plant was commissioned, methods for safety assessment have been improved and significant experience of plant operation has become available.

6. In 1991 the former Czechoslovak Atomic Energy Commission, CSKAE, established conditions for licensing unit 1 to operate beyond 10 years. In particular, this required the operator to provide a revised SAR, the so called Operational Safety Analysis Report (OSAR). On the basis of the OSAR, the now responsible

Czech State Office for Nuclear Safety, SÚJB, issued a licence for continued operation of unit 1 in 1995. This was conditional on the fulfilment of 97 regulatory requirements. Since then, OSARs have also been prepared for units 2-4. Depending on the SÚJB's assessment of how the respective regulatory requirements are being complied with, units will be licensed for up to 10 more years of operation (up to a total of 20 years).

7. In general the content of the OSAR is in line with Western practice for periodic safety reviews.

Probabilistic Safety Assessment (PSA)

8. In 1993 a Government sponsored level 1 PSA was carried out for Dukovany by several Czech organisations under the leadership of the Czech Republic's Nuclear Research Institute. The PSA is considered as a "living PSA" involving a permanent programme of updating plant specific data, modelling of plant modifications etc., and incorporating more accurate analyses, as well as extending the scope of the study. The results of the PSA can serve as a starting point for further plant improvements and for setting priorities for safety upgrading measures.

Future safety improvement

9. A comprehensive modernisation programme for Dukovany has recently been initiated by CEZ. Major upgrading measures include:

- Reconstruction of the Instrumentation & Control system;
- Protection of the suction inlets of the spray pumps;
- Modifications on the emergency feed-water system;
- Modification of equipment on the 14.7 m floor;
- Partial reconstruction of diesel generator stations.

However, the current status of, and prospects for, this programme are not fully known.

10. Due to the financial burden resulting from delays in the construction of Temelin, this modernisation programme is not scheduled for completion until 2005.

Operational safety

11. Staff responsibilities within the NPP are clearly defined. Nuclear Safety and Production are separate divisions within the management organisation. The head of the nuclear safety division is a deputy director and thus a member of the plant's senior management.

12. Dukovany has implemented three basic programmes for monitoring and maintaining the level of nuclear safety: a preventive maintenance programme, an in-service inspection programme and a components ageing monitoring programme.

13. The operational performance of Dukovany NPP is reasonably good. Except during initial commissioning, over the last ten years the average number of unplanned shutdowns (scrams) per unit has been about 1 per year or less.

14. Furthermore, the NPP is pursuing an extensive exchange of operational information with WANO and participates in common activities with other VVER-440/V-213 operators. In particular there is direct co-operation with the Slovakian NPPs of Bohunice and Mochovce.

(ii) Temelin NPP

15. Originally, it was planned to build 4 VVER-1000 type units at Temelin. Construction of the first two units started 1987, but due to the political and economic conditions of the Czechoslovak Republic in the early 1990s, the original plan was revised. In 1993 a final decision was made to complete only units 1 and 2.

16. Although background information on Temelin is available from various international sources, the Western Regulators and their TSOs have had only limited access to detailed analysis and technical information.

Basic technical characteristics

Design basis aspects

17. Both units of Temelin NPP are of the standard VVER-1000/V-320 type as designed in the 1970s. However, the construction permits, which were not issued until 1985/86, contained additional conditions, e.g. a re-analysis of all design basis accidents using qualified calculational methods.

18. The design of Temelin has been subject to continuous improvements and modifications. Numerous individual improvements, e.g. modified construction of pressure vessel nozzles and modifications in the electrical systems, were implemented before 1990. Recent safety design changes at Temelin have been strongly influenced by international co-operation, e.g. the NUS Halliburton audit, the GRS/IPSN safety assessment for the Stendal NPP, and results from IAEA safety missions. These include:

- Reactor control system and accident instrumentation;
- Changes to the core design and fuel;
- Substitution of the original Instrumentation & Control for a digital one of Western design;
- Replacement of original cables for non-combustible ones;
- Design of a full scope simulator.

In 1993 CEZ contracted Westinghouse for the supply of the most important design modifications (replacement Instrumentation & Control, core design and fuel).

19. The safety improvement programme for Temelin will be the most comprehensive to be applied to any VVER-1000/V-320 plant. However, in implementing this programme there have been serious difficulties due to combining technologies based on very different safety design concepts from different countries of origin. This has led to technical problems and delays during construction which seem to have worsened during recent years. Besides delayed or incomplete delivery of technical specifications and licensing documentation, major difficulties have arisen from:

- routing the non-combustible cables which have larger diameter than the original design, combined with requirements for better separation and segregation;
- interfacing the new digital I&C with safety equipment which had already been installed.

Safety assessments and programmes for future safety improvements

Operational Safety Analysis Report (OSAR)

20. Since Temelin is still under construction, only the Pre-Operational Safety Analysis Report is available. This has been produced in accordance with the US NRC Regulatory Guide 1.70. There are concerns, however, as to whether this approach is really applicable, as the NPP design process and its construction do not comply with the original concept of the US NRC regulatory guide.

Probabilistic Safety Assessment (PSA)

21. On behalf of the utility a PSA (level 1 and 2) has been performed by a US consultant. The first results of this study have been presented to the utility, but a detailed review of this work is not available.

Safety missions and further assessments

22. During construction of Temelin a series of IAEA missions have taken place covering various safety aspects: plant construction practice, safety systems evaluation and safety analyses, fire protection, quality assurance, resolution of safety issues etc.

23. Some preliminary Western assessments of the plant safety have been performed within bilateral co-operation programmes. However, these assessments were based on limited technical information and further investigations using more detailed information are desirable.

Operational safety

24. A license for commissioning the conventional parts of unit 1 was issued in 1997.

25. The training of the operating staff of Temelin will basically follow the same scheme as that of Dukovany. Plant operators will be trained on a modern full scope VVER-1000 simulator at the site. This simulator is at an advanced stage of development.

26. A Quality Assurance Programme has been set up in compliance with regulations of the former CSKAE and has been approved by the SÚJB. This establishes the main principles for operation, inspection and maintenance activities.

27. Recent regulatory inspections of installation work on the plant revealed some non-compliances with the QA programmes and relevant documentation (mainly due to the complex supplier-customer relationships).

Spent fuel and waste management

28. In the early years of operation spent fuel was transferred (via interim storage at Bohunice) to Russia for reprocessing. Today spent nuclear fuel is stored for 6 years in the reactor storage pool and subsequently transferred into CASTOR casks. An interim storage facility, currently with a capacity for 60 CASTOR casks, has been built at the Dukovany site, and was commissioned in 1997. Plans for final waste disposal in the Czech Republic are under discussion.

(i) Dukovany NPP

29. The overall safety status of Dukovany can be summarised as follows:

- in the early years of operation, a backfitting programme was introduced to remove some of the safety deficiencies of the original design;
- further upgrading measures are underway or planned as part of an extensive modernisation programme. Due to burdens from the construction of Temelin NPP however, this programme will be implemented in stages depending on annual budgets;
- Dukovany NPP appears to be well operated, and the plant safety culture has been continuously improved. Several IAEA missions, and co-operation with WANO, have contributed substantially to the enhancement of safety; safety assessments are being conducted in a manner similar to Western practices;
- the current level of safety at the plant cannot be fully assessed due to lack of detailed information. However, subject to a detailed analysis of the fully modified plant and an experimental verification

of the containment function, Dukovany NPP should be able to reach a safety level comparable to plants of the same vintage in Western European countries.

(ii) Temelin NPP

30. It is not possible to fully assess the safety status and prospects for Temelin because of a lack of detailed information. However, there are concerns that the ambitious safety improvement programme might not be fully implemented. Due to the complexity of repeated design changes, long construction time and the necessity to integrate technologies of very different origins, a major effort is necessary to prepare and assess a comprehensive safety case. This is a challenge for both the operator and the regulator.

HUNGARY

Chapter 1: Status of the regulatory regime and the regulatory body

Status of Legislative framework

1. The first Hungarian regulations on nuclear safety issues, in the form of ministerial decrees, were issued in 1979, when the first Unit at Paks was partially built. These gave a framework for nuclear power plant licensing and safety inspections and also contained technical requirements for nuclear safety. The first Atomic Energy Act was issued in 1980.

2. Active revision of the nuclear legislation and the regulatory framework started in the early 1990s. As well as using IAEA safety guidance to help with this process, the Hungarian authorities and experts became thoroughly acquainted with the legislation and regulatory practices in a number of Western European countries. This international experience was reflected in the new legislation. The new Act on Atomic Energy was adopted by the Parliament of Hungary in December 1996, and the revised legislation came into force in June 1997.

3. The Government decrees issued under the Atomic Energy Act specify the duties and the scope of authority of the Hungarian Atomic Energy Commission (HAEC) and the Hungarian Atomic Energy Authority (HAEA). The Government decrees also mandate the Nuclear Safety Directorate (NSD) of the HAEA to act as the nuclear safety regulatory body.

4. The responsibilities of the regulatory body are well separated from the responsibilities of the operating organisation. It is clearly stated in the legislation that the operating organisation carries full responsibility for safety. The role of the regulatory body is to verify that necessary actions to ensure nuclear safety are taken by the operating organisation. The legal status of the utility is also defined in the legislation.

5. All the key international conventions have been included in national regulations (Convention on Nuclear Safety, Convention on Early Notification of a Nuclear Accident, Vienna Convention and the Joint Protocol on Third Party Liability, etc.).

6. Peer evaluations of the Hungarian legislation and regulatory framework have been carried out by EU experts within the RAMG programme. It can be concluded that the legislative framework in Hungary compares favourably with those Western European countries that have a nuclear programme. The legislation and other regulatory documentation is modern and comprehensive.

Status of the Regulatory Body

7. Under the Act on Atomic Energy, Parliamentary approval is required for the construction of a new nuclear facility or radioactive waste disposal facility. Following that, the Government controls and supervises the safety of the installation through the HAEC, the HAEA, and the Ministers concerned.

8. The HAEC is composed of senior officials of the ministries and the heads of the central public administrative organisations that perform regulatory tasks under the Act on Atomic Energy. The President of the HAEC is nominated by the Prime Minister from the members of the Government. The role of the HAEC is to supervise safety activities and to report on them to the Government. The Government exercises supervision over HAEA through the President of the HAEC.

9. The HAEA is an executive body for regulation of nuclear safety and the control of nuclear materials. In 1997 its work scope was extended to new areas which were previously the responsibility of different authorities: civil structures, radiation protection, emergency preparedness, fire safety and physical protection. These authorities still play a role in regulatory control of nuclear facilities, but the HAEA is authorised to co-ordinate their joint activities. Similarly, the HAEA works in co-operation with authorities which regulate regional planning and environmental issues.

10. The HAEA has two main parts, each headed by a deputy of the Director General. The Nuclear Safety Directorate has responsibility for licensing, safety assessment and inspection of nuclear facilities, while the General Nuclear Directorate has responsibilities regarding the safeguarding of nuclear and radioactive material, and also for external relations and co-ordination of R&D activities. The Director General of the HAEA, and his deputies, are appointed and dismissed by the Prime Minister.

11. From the administrative arrangements described above, it can be concluded that the Nuclear Safety Directorate of the HAEA is sufficiently independent from those bodies with an interest in the promotion of nuclear energy.

12. The total number of HAEA staff is currently about 90. Of this total, there are about 40 technical experts within the NSD. Compared with some Western European countries, and taking into account the number and variety of nuclear plants, this number is quite reasonable. Current NSD staff have a high level of technical competence.

13. Funds for the NSD are specified in the Government budget (primarily from the licensee fees), and it seems that the availability of funds has not been a limiting factor in the daily work performed by the Directorate. To ensure long term stability, it would be more satisfactory, however, if the NSD salaries could more closely match the level paid by the utility. Nevertheless, the current NSD staffing situation appears to be stable.

14. The NSD is authorised to take appropriately strong enforcement measures to ensure safety, such as ordering the shut down of a reactor. It can also oblige the licensee to pay a fine for a violation of rules, although a need for such enforcement measure has not yet been necessary.

15. The NSD participates actively in international regulatory co-operation.

Status of Regulatory activities

16. The Organisational and Operational Code of the HAEA is issued by the Director General and describes in detail the regulatory regime, organisational matters, and the ways of working within HAEA. Another document issued by the Head of the NSD establishes the regulatory strategy and serves as a basis for internal Quality Assurance. However, the written procedures and guidelines for internal QA, and the planning processes for management of regulatory activities, are still being developed.

17. In addition to mandatory regulations, the regulatory documents include a set of safety guidelines which are issued by the Director General of the HAEA. There is an active programme for developing new safety guidelines and for upgrading the existing ones, as the need arises from experience. More than 30 guidelines were issued by HAEA during 1997-98.

18. In connection with the Periodic Safety Reviews and the related Paks NPP operating license renewal, the NSD has developed a systematic safety assessment process. In addition, the NSD carries out an extensive inspection programme. Mostly, this is done by an inspection department of nine experts who are permanently stationed at the Paks site. In the past, the main task of the site inspectors was to verify in great detail the compliance with rules and regulations, especially regarding the structural integrity of vessels and piping. This obscured the absolute responsibility for safety of the operating organisation. In the recent years, a new approach has been developed and some of the HAEA inspectors have been transferred to the QA staff of the operating organisation. The remaining ones are increasingly focussing on the work processes of the operating organisation, operating experience feedback, and team inspections that cover a whole area. The inspection department is supported by other NSD staff from the main office.

19. Since 1992, a number of national and international evaluations of the HAEA have taken place. Among

them are reviews by the IAEA, by the EU's RAMG, and by the United States Nuclear Regulatory Commission. Expert support for development of the regulatory body has been provided by RAMG with PHARE financing. The first phase of this support programme took place from 1994 to 1996 and the second phase started in February 1998.

20. The recommendations of the various missions and support programmes were used effectively in developing the current Hungarian regulations. In addition, the active exchange of information with international organisations (IAEA, OECD/NEA, NRWG of the EU), and many bilateral contacts, helped to facilitate the rapid development of these regulations.

21. HAEA's system for the analysis and feedback of operating experience from domestic events is satisfactory but improvements are needed to maximise the benefits to be gained from international experience.

Emergency preparedness on the Government side

22. The Governmental Committee for emergency planning and preparedness is chaired by the Minister of the Interior, with the Director General of HAEA as its vice-chairman. Under this committee, there is an extensive national system for planning rescue measures, radiation monitoring, and providing information to the general public. HAEA is responsible for early notification in case of a nuclear accident, under international and bilateral agreements. HAEA has established a dedicated centre for emergency response, training and analysis.

23. The national system for nuclear emergency preparedness has improved significantly over the past year. This was tested in a large international exercise (INEX-2 HU) in November 1998 and the international observers were positive in their assessment of the HAEA/NSD performance. The INEX-2 exercises and associated workshops have provided a good stimulus for recent improvements.

Supporting national infrastructure

24. The technical know-how and manpower within the NSD permits in-depth assessment of key safety issues, and support for this work is available from the national institutes such as KFKI AEKI (Atomic Energy Research Institute) and VEIKI (Institute for Electric Power Research), which together possess an independent, advanced safety analysis capability. The technical support available to the regulatory organisation is competent and sufficient. The regulator has good access to the results of both national and international research programmes.

25. The current regulatory policy of the NSD strongly emphasises its reliance on national resources and tools. Foreign assistance is welcome, but is not planned as a necessary condition for successful conduct of the NSD duties.

Conclusions

26. There is no doubt that the Hungarian approach to licensing, regulating and controlling nuclear facilities is an advanced one. Legislation and other regulations are up-to-date, and compare favourably with the principles applied in Western countries. HAEA is also sufficiently independent from the organisations promoting nuclear energy.

27. There are some issues that need to be improved or clarified:

- to continue to maintain a stable and competent staff, the salary level of the regulators should more closely match the level of the utility;
- the role of the site inspection department needs further development in order to avoid undermining the safety responsibilities of the operating organisation, and ensure that all operational safety issues are covered jointly with experts from the main office.

Chapter 2: Nuclear power plant safety status

Data

1. Hungary has one nuclear power plant at Paks with four units:

Paks unit	Reactor type	Electrical power (MW)		Start of construction	First grid connection	End of design life
		gross	net			
Unit 1	VVER 440/213	430	460	1974	12/82	2012
Unit 2	VVER 440/213	433	460	1974	08/84	2014
Unit 3	VVER 440/213	433	460	1979	09/86	2016
Unit 4	VVER 440/213	433	460	1979	08/87	2017

2. The plant is owned by the Paks Nuclear Power Plant Ltd., which is 99.92% owned by the Hungarian Power Companies Ltd. The latter is owned by the state.

Basic technical characteristics of Paks NPP

Design basis aspects

3. Each unit has a design lifetime of 30 years from first criticality. There are no official plans to extend the lifetime, but it is thought likely that this will eventually be considered. Operating licenses have no final date of expiration, but are subject to renewal by the regulators every 10 years, based on a periodic safety review.

4. All units in Paks are second generation VVER type 440 model 213. Generic safety characteristics of this type of plant are discussed in a separate annex.

5. The quality of the main equipment was controlled by the Hungarian experts during construction as well as they could, but independent quality verification during manufacturing, such as required in the West, was not possible. However, no major quality concerns have been identified in tests and inspections carried out since the plant began operating. Also the high reliability of plant operation since its first start-up is an indication of the good quality of the equipment.

6. Since the start up of the plant, many safety improvements have been made and this will continue as a matter of policy throughout the plant lifetime. Among the early improvements was a Hungarian designed core monitoring system which was installed in 1988, and has since then been extended to provide plant operators with information on other important safety parameters.

7. Following a thorough safety evaluation project (called AGNES), a systematic safety enhancement programme was launched in mid-1994. Among the measures already implemented are:

- relocation of the emergency feed water system outside the turbine building. Relocation of this system removed a major concern about possible complete loss of decay heat removal capability as a consequence of fire and high-energy pipe break in the turbine building;
- replacement of a number of components to improve the system performance and reliability, and to ensure adequate environmental qualification;
- new systems to improve accident management capabilities;
- major upgrade of fire protection.

8. In 1996, a review of Paks against IAEA generic safety issues was carried out by the plant staff and IAEA experts, and reached generally favourable conclusions. Although some issues will require continued attention and actions in the future, they are not considered to be significant risk factors today.

Reactor pressure vessel, primary pressure boundary

9. Pressure vessel embrittlement is monitored by an adequate surveillance programme. To date, all pressure vessels have maintained their material toughness with adequate safety margins but, should annealing become necessary in the future, the required technology is available. In-service inspections of the reactor vessels and primary piping are conducted with state-of-the-art techniques. Paks is also taking measures to reduce the possibility of a large primary to secondary leak via the steam generator collector. By these means, it is considered that the integrity of the primary pressure boundary is adequately safeguarded.

Beyond design basis accidents and severe accidents

10. The station has studied beyond design basis accidents (such as Anticipated Transients Without Scram, ATWS) and has developed guidance for operators on how to avoid severe core damage. It has also considered severe accident management measures. Additional work is needed to investigate containment response to severe accident phenomena. Two Phare projects are underway to address the feasibility of filtered containment venting and hydrogen handling. Based on the results of these projects, a comprehensive strategy for managing severe accidents will be developed.

Safety systems

11. In terms of their number, type and redundancy, the Paks safety systems (diesel generators, emergency core cooling system, emergency feed water system and containment spray system) are comparable to Western reactors of the same vintage.

Containment

12. The measured leak rates for the units range from 5% to 13% volume per day, reflecting the variation in construction quality from one unit to another. These leak rates are at the smaller end among other plants of the same type and meet the Hungarian regulatory limit, although they are higher than acceptable leak rates of Western European reactor containments.

Safety assessments and programmes for future safety improvements

Safety assessment and documentation

13. A thorough safety evaluation of Paks was conducted in the AGNES project which started late in 1991 and was completed in mid-1994. Both deterministic analyses, as required in the licensing of Western plants, and a level 1 PSA study were carried out. Much attention was given to appropriate validation of the analysis tools. The results were well documented, and were used later on to prepare the technical documents of the Periodic Safety Review, and will be used in the future to update the Final Safety Analysis Report.

14. A periodic safety review (PSR) of all Paks units is required by a Ministerial Order issued in 1993. Specifications for the PSR took into account the relevant IAEA safety guidelines. The review of units 1 and 2 was completed in 1997, and that for units 3 and 4 will be completed at the end of 1999. After that, the PSR has to be repeated every 10 years. Although one goal of the initial PSR was to update the Safety Analysis Report, the regulations now require the licensees to keep the SAR continuously up to date.

15. A separate project to improve seismic capability has been underway for over five years. This has examined more than 10 000 plant items to determine their vulnerability to earthquakes. A significant part of the necessary modifications has already been done, and the entire project will be completed in 2002.

16. The only significant shortcoming related to plant safety assessment concerns the performance of the bubbler-condenser confinement pressure suppression system. There is general agreement that the performance of this system needs to be demonstrated in large scale experiments. Planning of such experiments is in progress, and the goal is to have work completed in 1999.

Programs for safety improvements

17. No single deficiencies representing dominant risk factors remain to be addressed, but a number of measures are being planned or investigated which will further reduce the remaining risk. These include:

- additional measures to reduce fire risks;
- improvements to the protection systems and engineered safety features, in order to diversify the possible responses to postulated accidents;
- replacement of ageing equipment with advanced modern equipment;
- means to protect the reactor containment in severe accident conditions;
- development of a new set of emergency operating procedures.

18. The safety of Paks is actively monitored and assessed by the operating organisation. Periodic safety reviews are conducted similar to Western practices, and have already led to an increase in safety. After the implementation of additional safety improvements which are in the design and preparation phase, it is expected that the plant will reach a safety level which compares well with plants of the same vintage in Western Europe.

Operational safety

Organisational aspects

19. According to the operating company's 1997 annual report, the financial situation of the company is healthy. An indication of that financial strength is that more than 20% of the 1997 turnover was spent on investments in safety and reliable long term operation. Although the management of the Paks plant is today characterised by a strong commitment to safety and reliability, there is some concern that political changes in the Government tend to induce changes in the station management. There have been examples of this in the past ten years.

20. Since the start of operation, the operating company has developed its competence with the aim of reaching independence from the original Russian suppliers. Today they are in a situation where the involvement of the supplier organisation and its successors is no longer a necessity, but is just one option in an open bidding process.

21. All activities are conducted under the control of the company management, which has assumed full responsibility for safety. A positive indication of safety culture is the extensive investment in local training facilities. A full scope training simulator, tailored to the Paks design, has been in use since 1988. A recent development is a maintenance-training centre where repair activities can be exercised before carrying out maintenance on real plant equipment.

22. The drive for increased safety and quality of operations is exemplified by extensive international cooperation. The plant has actively sought contacts with other utility organisations through WANO and especially with other VVER operators. A WANO team was invited to make a peer review of operating practices in 1992, with a follow-up mission in 1995. Since 1988, the plant has also received several IAEA safety missions, such as OSART, ASSET, and a safety improvement review. Also the pool of nuclear insurers inspected the plant before signing the contract on third-party liability insurance in 1997. Both WANO and IAEA missions have made recommendations for improvements to operational safety, and these have been given due attention.

Safety culture and management, Quality Assurance

23. Close contacts are being maintained with European expert organisations and companies in the nuclear field, both commercially and under the umbrella of the EU Phare programme. Support has also been received from the IAEA in development of the plant safety culture. In addition, the plant has developed a QA system based on local regulations derived from IAEA codes and guidelines. The adequacy of this QA system has not been reviewed in depth in the present context.

Operational experience

24. The reliability of plant operation and the frequency of transient events places Paks at the better end of the world's NPPs. The failure of one of the reactor protection push buttons in 1989 was an event rated as level 3 on the INES. Based on today's knowledge of ATWS, the event was less significant than thought at that time, but re-rating has not been considered. There have been no other events higher than INES level 2.

25. Accident management techniques for beyond design basis accidents have been investigated by the Hungarian research organisations, and severe accident management procedures for Paks are being developed for implementation in the near future. These will be introduced after the completion of new symptom-oriented emergency operating procedures, in parallel with some associated improvements in plant hardware.

Emergency preparedness

26. On-site emergency preparedness at Paks was developed in close co-operation with the international nuclear community. The level of emergency preparedness is comparable with that at plants in Western European countries, as demonstrated in a recent OECD INEX-2 international exercise which was based on an accident at Paks.

National industry infrastructure

27. The VEIKI and KFKI institutes have several decades of high quality experience in fundamental safety-related research, including both reactor physics and system thermal-hydraulics. They provide a sound domestic competence base and a strong technical support capability.

Spent fuel and waste management

28. Spent fuel from the early years of operation has been transported to the Mayak reprocessing facility in Russia. These shipments have now practically ceased, and spent fuel is stored on site in a recently commissioned interim storage facility. This is a modular vault type, dry store, and is being extended to be able to handle up to 10 years accumulation of spent fuel from all four units. A reference storage facility of the same type has been in operation at Wylfa NPP in the UK since 1971. Plans for final disposal of high level waste are still at an early stage.

29. There is sufficient interim storage space for low and intermediate level radioactive waste available at the plant site for several more years of operation. A national project for providing an ultimate repository for these wastes started in 1993, and is currently focusing on four prospective areas, three for near surface and one for underground disposal. The objective is to have an ultimate repository in operation by around 2003.

Conclusions

30. The following conclusions can be drawn:

- The safety characteristics of the Paks units have been evaluated in an in-depth, systematic manner;
- The basic technical structure of the plant is good from the safety point of view, and the key safety systems are comparable to Western plants of the same vintage. There are no major shortcomings in the present safety systems, but some minor issues remain to be resolved;
- Paks containment structures are among the best for this reactor type and they meet their original design targets by providing protection against all sizes of loss of coolant accidents. However their leaktightness is not as good as the leaktightness of containments in Western Europe. This would have some influence in the progress and consequences of potential severe accident scenarios. Also the performance of the containment structures still has to be demonstrated through large scale tests;
- Paks has taken actions to mitigate beyond design basis accidents and severe accidents. These measures are in compliance with good Western European practice, but additional work is needed to ensure containment integrity following a severe accident;
- Operational safety aspects are generally at a level comparable to Western plants of the same vintage. Some concern is caused by the experience from management changes resulting from political changes in the Government;
- Periodic safety reviews are conducted in line with Western practices and have already led to an increase in safety;
- It is expected that after the implementation of planned safety improvements, which are in the design and preparation phase, the plant will be able to reach a level of safety which compares well with plants of the same vintage in Western Europe.

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LITHUANIA

Chapter 1: Status of the regulatory regime and the regulatory body

Status of legislative framework

1. Lithuania has acceded to all essential international conventions with regard to nuclear safety. Also the basic laws and safety regulations have been established are undergoing further development. The legislation defines a licensing system under which the responsibility for safety is assigned to the licensee. This licensing system is gradually being implemented.

2. The regulatory body, VATESI, was established in 1991 under the Law on Nuclear Energy, and developed from the small site inspection group that was part of the former Soviet system.

3. Besides VATESI, the Law establishes the responsibilities of other Ministries and departments in licensing nuclear activities. However, the interfaces between these different bodies is not clearly stated in the law and the co-ordination between them needs to be more fully developed.

4. The Ignalina NPP (INPP), the only nuclear power plant in Lithuania, is owned by the state under the Ministry of Economy. A bill to make INPP a company under a Board has been under consideration by the parliament for over a year. At present the plant director is restricted by the Ministry to act in certain matters, for instance financing and personnel issues, and in practice this means that he can not assume full responsibility for plant safety.

Status of regulatory body and regulatory activities

5. VATESI is headed by a Board appointed by the Government. It reports directly to the Prime Minister and is independent of the part of the state with responsibilities for the ownership of Ignalina. VATESI is financed through the state budget and although its resources allow it to carry out its duties, the budget needs to be strengthened.

6. The VATESI head office in Vilnius has 25 staff and a Resident Supervision Group with 5 staff at the NPP. At present, there is a mismatch between the regulatory approaches of the main office and the resident group. The resident group is still too closely involved in plant activities, working more like a plant safety department, and seems to be too little involved in the standard setting and safety assessment activities of the head office.

7. Although in general the VATESI staff are competent for their tasks, more staff are needed to be able to adequately handle all normal regulatory tasks, as well developing internal Quality Assurance (QA). The salary level, although about 20% lower than at INPP, is good enough to recruit qualified new staff, and staff turnover is low.

8. At an early stage, VATESI introduced a system of annual permits for the operation of Ignalina. This practice enables VATESI to exercise strict regulatory control of the plant. As a result of the agreement between Lithuania and the Nuclear Safety Account managed by EBRD, Unit 1 is currently undergoing formal licensing. VATESI has adequate control over this licensing process but lacks the resources to carry out a Western style in-depth assessment of safety cases without foreign assistance.

9. Contrary to usual Western practice, the regulations also require the licensing of organisations which perform services and produce goods for nuclear facilities. To date VATESI has issued 8 such licenses, and another 30 applications are under review.

10. There is a need for the development and implementation of new methods of inspection which will lead to a more integrated regulatory control process. In line with the implementation of a new quality assurance system at the plant, the work of the resident group should shift from detailed inspection to a system in which they audit the activities of the licensee. This will more clearly separate the resident group from the plant internal safety management organisation. VATESI also needs to develop its system for dealing with operational experience analysis and feedback.

Status of emergency preparedness on governmental side

11. Lithuania has adopted a national emergency preparedness plan that has been internationally reviewed. In addition to its role in the national plan, VATESI has developed its own emergency preparedness plan. This has not yet been fully exercised. An on-duty, decision maker system operates around the clock.

Status of supporting national infrastructure

12. The national expertise that is available to VATESI from Technical Safety Organisations (TSO) is rapidly increasing in strength. This expertise comes mainly from the Lithuanian Energy Institute in Kaunas but also from the technical universities in Vilnius and Kaunas and from other organisations. A special TSO Council co-ordinates this, and considers, among other things, whether the TSO involved in any specific matter is sufficiently independent from the interests of the nuclear operator. The ongoing licensing of Ignalina unit 1 engages these TSOs in a broad co-operation with Western TSOs, which is of great value for the transfer of Western methods and practices to Lithuania. However the national TSO resources can not yet be regarded as sufficient to support VATESI. For instance, no national resources are available to support VATESI in human factors assessments.

13. Although VATESI has access to research results through the Lithuanian Energy Institute and through bilateral contacts, this is still insufficient when compared with Western practice.

Conclusions

14. The legal and regulatory system has developed substantially over a short period. However, in some areas the system needs to be further developed in order to be comparable with good practice within Western countries. The Government of Lithuania should address the following points:

- the Nuclear law should be clearer about the interfaces between different authorities. Also, the co-ordination between these authorities needs to be improved;
- the head of the operating organisation/utility is authorised under a Board to handle all safety relevant issues, and be provided with the means to take full responsibility for safety;
- the responsibility for auditing and approving vendors and suppliers should rest with the operating organisation and not with the regulatory body.

15. With regard to regulatory activities, the Government should consider the following:

- the resources of VATESI need to be strengthened both with regard to number of staff and to the budget necessary to handle all regulatory issues, without foreign assistance, and to participate in international regulatory activities;

- the TSO structure and access to nuclear safety research should be further strengthened in order to provide the regulatory body with the necessary competence to review all major safety issues.

16. VATESI should develop its regulatory supervision of INPP in a more system and process oriented way. This particularly applies to the activities of VATESI's resident inspection group, where there needs to be a clearer separation between regulatory supervision and the NPP's responsibilities for safety management.

Chapter 2: Nuclear power plant safety status

Data

1. Lithuania has one nuclear power plant with two units in operation at Ignalina (INPP). These are second generation design (Soviet OPB 73 standards, see annex 1) and have the highest power rating of any RBMK:

Unit	Type	Present power level		Start of construction	First grid connection	End of design life
		MWth	MWe			
INPP-1	RBMK 1500	4200	1300	1977	12/1983	?
INPP-2	RBMK 1500	4200	1300	1978	08/1987	?

2. The plant is owned and operated by the state.

Basic technical characteristics

Design basis aspects

3. INPP has some additional safety features compared to other RBMK units of the same generation. For instance a larger pipe break (900 mm header) is included in the design basis. In addition the plant has well diversified emergency core cooling systems. As a result of backfitting, the plant is now capable of tolerating 9 simultaneous fuel channel breaks without any significant environmental consequences. The design basis for emergency core cooling is roughly comparable to Western plants of the same vintage with regard to loss of coolant accidents (LOCA) and operational transients. Anticipated Transients Without Scram (ATWS) and events such as fires, station blackout and seismic events are not, however, fully covered in the design basis. There is not much in the design to allow the plant to cope with severe core damage.

4. Transients dominate the risk from the plant rather than loss of coolant accidents. Furthermore it is the long term failure to cool the core that gives dominating risk contribution. The low power density and large heat capacity of the core enables it to withstand about two hours total loss of electrical power supply without core damage. Long-term lack of cooling could lead to environmental consequences because the core damage is assumed to cause primary circuit failure at high pressure. Human factors contribute significantly to the core damage frequency and work is going on to implement symptom based Emergency Operating Procedures. These have not been accounted for in the current Probabilistic Safety Assessment (PSA).

5. A reactor scram signal based on low flow from any of the 40 group distribution headers has been installed to reduce the probability of core damage due to blockage events.

Status of fuel channels

6. The top welds of the fuel channels have been thoroughly examined and found to be in good condition. All the pressure tubes have been fitted with new seals. Irradiated parts of fuels channels are at present being examined in Western Europe to further verify the material condition and ageing process.

Material verification

7. The INPP units have suffered from material defects and leakages, although less than other RBMK units. The material problems and degradation mechanisms are of the same types as have been found in Western

BWRs, especially intergranular stress corrosion cracking. Since 1992, the primary system has been examined with modern methods and equipment, and the detailed knowledge of its material status increases every year. Up to now, not all of the reasonably accessible parts of the primary circuit have been thoroughly examined. The INPP non-destructive testing (NDT) staff is certified to a European Standard.

Status and capabilities of safety systems

8. As in most older Soviet designs, inadequate physical and functional separation of some safety systems makes them vulnerable to common cause failures. At INPP the fire protection has been improved to protect vital electrical, and control and protection systems, as well as the emergency core cooling pumps. Further improvements are being implemented. Although environmental qualification of the safety related components has not been considered very much so far, this is included in the ongoing licensing project.

Reactivity control

9. Additional logic lines have recently been installed in the shut down system. For unit 2, a new completely independent shut-down system has been designed to further improve the reliability of the protection function, and will shortly be installed. Since 1995, a new type of fuel with higher enrichment and burnable absorber has been loaded into both units, improving fuel economy and having much improved safety characteristics.

Status and capability of the containment

10. The reactor and part of the primary circuit are protected by a pressure suppression type of partial containment called the Accident Localisation System (ALS). This containment has the following features:

- only about 65% of the water volume of the primary system is enclosed within the containment;
- the containment is made up of a large number of semi-interconnected, reinforced, leaktight compartments;
- condensation of steam occurs in ten water pools which are separated in two groups of five each;
- spray nozzles for steam condensation are installed in several compartments;
- a controlled venting system serves to reduce both the peak and the long term pressure.

11. The design basis for the ALS is the isolation of the steam resulting from a LOCA after the largest pipe break. The condensation capacity of the INPP ALS system is larger than in other RBMK units.

12. As discussed in annex 1, there are generic deficiencies in the design of the containment system. Its performance has not been fully validated and independently reviewed, and the ongoing safety programme addresses some aspects of this. The leaktightness and structural stability of the ALS is a licensing issue for unit 1. Measurements indicate no serious problems so far, although the leak rate is higher than Western requirements. However, it has been concluded that the design pressure margins are small. The capacity of ALS to handle a severe accident is being analysed in an ongoing level 2 PSA.

Ageing and lifetime assessments

13. Gas gap closure (see annex 1) is an ageing issue with implications for the plant lifetime. During the 1998 outage about 500 channels of unit 1 were measured with Western designed equipment, and 48 tubes were removed for detailed analysis. The date for gap closure is estimated to be between 2000 and 2005. However, a more exact gap closure date, as well as its safety significance, will be determined by ongoing analysis which will be subjected to international review. In a 1994 agreement with the EBRD, the Lithuanian Government declared that re-tubing of the INPP units will not be performed and that they will be shut down permanently at the date major re-tubing would be necessary.

Safety assessments and programmes for future safety improvement

Safety assessments and documentation

14. The International RBMK Safety Review 1992-94, used INPP unit 2 as one of its reference plants. This review considered the safety of RBMK reactors in nine technical areas and resulted in about 300 recommendations and extensive documentation.

15. Under an agreement with EBRD, in 1994-96 Unit 1 was subjected to a comprehensive safety assessment (SAR). The assessment was made to IAEA standards, but only considered the limited remaining operating time before re-tubing, and was also limited due to financial and time restraints. This safety assessment report was reviewed by an independent international team (RSR) and an independent group of experts (ISP) evaluated and drew conclusions based on both the safety assessment and the review.

16. A fairly complete PSA of unit 2, covering full power operation, has been available since 1994. The quantitative results are based partly on plant specific data and partly on generic data. Compared to Western PSAs, the level of detail is good. Based on this study, a level 2 study is being prepared, and key results are expected in 1999.

17. Within the present safety programme, a number of analyses are being carried out in order to complete the safety assessment, e.g. a Fire Hazards Analysis, a single failure analysis of the Control and Protection System (CPS), safety cases for ALS and the structural integrity of the primary system.

Programmes for future safety improvements

18. Following the SAR, RSR and ISP recommendations, the Lithuanian Government committed itself to financing a new safety improvement programme (SIP-2). The programme contains design modifications, management and organisational developments and safety analyses. The SIP-2 programme is now being implemented, albeit with financial difficulties.

19. Due to the requirement for the plant to be licensed as part of the NSA grant agreement, safety improvements on unit 1 have received priority. Most of the technical projects for unit 1 have been completed and the safety cases submitted to VATESI for approval with a target date for licensing of May 1999.

Operational safety

Organisation and procedures for operation and maintenance

20. INPP is a state enterprise under the Ministry of Economy. The Ministry controls the finances of the plant and the resources needed for operations. The plant director reports directly to the Minister.

21. As a whole, the operational and technical support staff show a high level of technical competence. A significant transfer of Western knowledge has taken place in the last few years as a result of extensive international co-operation programmes.

22. In general, operational procedures are not as developed as in Western plants. This is to some extent balanced by the high competence of the control room staff. However, new symptom based Emergency Operating Procedures (EOPs), meeting Western standards, are in the final phase of development. The accident management strategies will be internationally reviewed before the new EOPs are implemented by the end of 1999. These strategies will be further evaluated by the ongoing level 2 PSA.

23. The Technical Specifications have not been developed very much from their original form. Further development of operating procedures may result from the use of the new full scale simulator.

24. A new computerised maintenance management system is being implemented. Also, a new procedure for handling of plant modification drawings according to Western standards is being put in place.

25. The training system is undergoing modernisation according to the IAEA's Systematic Approach to Training model. Training of control room operators on the new full scale simulator began in late 1998.

26. The payment for electricity generated by INPP is just about sufficient to keep the plant operating with regard to staff salaries and operational expenses. Money for priority safety improvements is allocated by the Ministry of Economy. All the required improvements cannot however be financed without foreign support. A fund has recently been created for decommissioning and long-term handling of spent fuel and radioactive waste. This fund is dependent on the income from electricity sales.

Safety culture and safety management

27. Ignalina has been subjected to one OSART and two ASSET missions. With the support of Western experts, considerable efforts have been made since 1994 to develop management, organisation and safety culture at INPP. Several moves towards Western practice have been implemented, for instance the establishment of a Plant Safety Committee. A new Quality Assurance system based on IAEA standards is being implemented, and it is proposed to introduce a Western style staff salary structure. Achieving deeper changes to the old safety culture is a slow process and is also dependent on changes in Lithuanian laws and regulations. There are several management and organisational features that still survive from the earlier Soviet system.

Operating experience

28. The operating history of INPP shows decreasing trends for all event categories except for leaks in the primary circuit. Up to 1990, the collective dose of INPP staff was comparable to the world average. From 1990 the dose has increased a little, mainly due to the extensive safety upgrading works. The main categories of events during the 1990s have been equipment failures, leakages in the primary circuit and Control and Protection System problems. There was also a serious bomb threat in 1994, which led to an extensive project with Western support to upgrade the physical protection of the plant.

Analysis and feedback of operating experience

29. Procedures exist for the analysis of events and operational experience feedback. However the communication between the different plant departments and the internal experience feedback, needs to be improved. Regulations require the reporting of ”abnormal events” to VATESI, but a comprehensive reporting system does not exist. INES reporting is well implemented. There is a limited exchange of operating experience between INPP and the other RBMK plants.

Plant emergency preparedness

30. The on-site emergency plan has been thoroughly reviewed and modified in line with Western standards. Accident classification and alarm criteria have been developed according to IAEA RBMK guidelines, and following a final review they will be included in the plan. The new plan was exercised for the first time in 1998 and is planned to be fully exercised again in October 1999.

National industry infrastructure for technical support

31. Only a limited number of Lithuanian companies are at present licensed for work at INPP. For supplies and services Lithuania will remain dependent on foreign companies. In addition, further Western assistance and Russian consultation will be needed for engineering work.

Spent fuel and waste management

32. A new interim dry storage facility for spent fuel has been built close to the site and recently started operating. An evaluation has been made of the present facilities for storage of solid and bitumenised waste, and improvements are being implemented.

Conclusions

(i) Design issues

33. INPP belongs to the more advanced design generation of RBMK reactors and much has been achieved through the ongoing safety improvement programme. Compared with typical Western European reactors, however, there remain fundamental weaknesses with respect to the type of accidents and transient events that the plant can handle with high reliability and without unacceptable environmental consequences. Among the most important problems identified in the safety assessments are:

- the properties of the reactor core are such that the shut down system provided in the original design, plus the additional system backfitted post-Chernobyl, are not sufficiently reliable;
- the reactor core is not enclosed in a containment designed to cope with all the energy that could be released in an accident. Although the probability of simultaneous damage to tens and more channels is estimated to be low, this would be likely to lead to an accident with unacceptable consequences. In addition, there are important parts of the primary system, for instance the steam separators, which are not protected by the containment system. This represents a lack of one of the main barriers required in Western European reactors. Moreover, the performance of the partial containment is not fully validated;
- a full, in-depth, safety analysis report, based on independently validated computer models, etc., according to Western standards, still remains to be completed.

34. From the independent safety assessments completed so far, it appears that most of the deviations from Western European requirements could be reasonably addressed or compensated for by a continued safety improvement programme. However, because they have only a partial containment, it is not realistic for the INPP reactors to achieve an adequate defence in depth, and hence a safety level comparable to Western European reactors of similar vintage.

35. Therefore, it is concluded that the existing and planned upgrading measures will not be sufficient to allow these units to achieve standards of safety which are comparable to those required for older reactors in Western Europe.

(ii) Operational safety

36. Much has been achieved with respect to improvements in operational safety and safety management. However, further efforts are required on issues such as:

- the financial situation of INPP should be improved to provide for all of the necessary safety improvement measures required for the remaining plant lifetime;
- issues relating to safety culture have been addressed but need stronger implementation. Thus, the management structure of INPP needs further clarification, amongst other reasons, to ensure the necessary quality and safety culture at all levels;
- the internal communication and feedback procedures should be improved in parallel with the implementation of the new QA system;
- accident management strategies and procedures should be evaluated and further developed.

37. Prior to taking responsibility for INPP in 1991, Lithuania had little involvement in nuclear activities. To a great extent, therefore, the country lacks nuclear experience and tradition. The national technical support infrastructure is improving but will not be sufficient in the near term. For supply and services INPP will remain dependent on foreign companies. In addition, further Western assistance and Russian consultation will be needed for engineering work.

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ROMANIA

Chapter 1: Status of the Regulatory Regime and the Regulatory Body

Status of Legislative Framework

1. Legislation regulating the peaceful use of nuclear energy has existed in Romania since 1974. The current nuclear Law, in force since December 1996, defines areas of application together with role, duties and responsibilities of organisations involved in the licensing process. A 1998 amendment to the Law was intended to remove inconsistencies with other national Laws and to strengthen the status and the role of the Regulatory Body (National Commission for Nuclear Activities Control - CNCAN). The Law clearly assigns responsibility for the safe operation of NPPs to the operator. According to the Law, CNCAN is the Regulatory Body responsible for the regulation, licensing and control of all nuclear facilities in Romania.

2. The company that operates the Cernavoda NPP is the National Nuclear Company "Nuclearelectrica". It is a state company reporting to the Ministry of Industry and Trade.

3. Romania has ratified all essential international conventions, in particular those related to Nuclear Safety, Early Notification of a Nuclear Accident and Civil Liability for Nuclear Damage.

Status of the Regulatory Body

4. CNCAN is led by a President, nominated by the Prime Minister, who reports directly to the Government. He has a position similar to a Minister. CNCAN is independent from the organisations having a leading role in the use and promotion of nuclear energy.

5. In the past CNCAN organisation and staff composition has undergone several changes resulting in a significant loss of qualified personnel, who left to work elsewhere. A new organisational structure has recently been approved by the Government and is being implemented. Under the President, there are four General Divisions (NPP and Fuel Cycle, Ionising Radiation Application, Development of resources and public relations, Monitoring of the Environmental Radioactivity), all with technical units. An Advisory Committee is also envisaged. There are 80 staff allocated to the headquarters, of which 60 work in nuclear safety. In October 1998, 49 positions were filled, of which 29 are new personnel. Further recruitment of staff is currently taking place. As a result of having taken over the function of monitoring the national environmental radioactivity, 191 people have been transferred from the Ministry of Water, Forest and Environment to CNCAN. These personnel cannot, however, be used for nuclear licensing activities.

6. CNCAN is funded by the Government, but it is also allowed to retain 50% of licensing fees paid by the applicants. Personnel wages have recently been increased to 50% of that paid to equivalent NPP staff. Office facilities are currently not adequate, however, and taking into account the recruitment of additional staff, the available space in the headquarters office is insufficient.

7. In the field of NPP licensing and inspection, CNCAN has a small number of senior highly qualified experts, who have been involved in regulatory activities since the beginning of the national nuclear programme. These experts have been trained at the Atomic Energy Control Board of Canada (AECB) and have actively participated in various international activities (e.g. IAEA). They have assimilated a Western approach and safety culture, are fully aware of the duties and responsibilities of the Regulatory Body and

perform to a high standard. On the other hand, a large part of the remaining CNCAN personnel still needs to be adequately trained, as will any staff recruited in the near future.

8. Significant improvements have taken place in the regulatory management in recent years, and this needs to continue, including the further development of CNCAN's internal Quality Assurance programme.

Status of Regulatory activities

9. CNCAN has regulatory duties and responsibilities in the area of nuclear safety in line with those of regulators in Western Europe. In fulfilling its regulatory functions, CNCAN co-operates with other governmental organisations (e.g. Ministry of Health, Interior, Defence, etc.).

10. According to the nuclear Law, any activity related to a nuclear installation (i.e. siting, construction, commissioning, operation, modifications etc.) must be licensed by CNCAN. The licence is issued by CNCAN on the basis of an application plus supporting documentation.

11. The legislation requires CNCAN to license not only the operator but also its subcontractors. This approach has the potential to obscure the operator's perception of its absolute responsibility for safety at the plant.

12. The Romanian licensing practice has been developed during the construction, commissioning and initial operational phases of Cernavoda Unit 1 and is defined in a recently revised regulation. The basic format of the safety documentation is based on the requirements of US Regulatory Guide 1.70, with specific provisions derived from the AECB Canadian practice. CNCAN's licensing of Cernavoda Unit 1 was conducted on the basis of a project management approach, addressing compliance of the plant design basis with applicable regulations. CNCAN's assessments were mainly based on engineering judgement, supported by a few independent analyses.

13. CNCAN has the right to carry out inspections on the site to ensure compliance with regulatory and licence requirements, and to enforce remedial actions when violations are identified. The CNCAN site inspection practice was initially developed on the basis of the Canadian approach, and has been improved through the AECB advisory service and also through international missions organised by IAEA. Inspection during construction and commissioning has been based on an on-site inspection unit for day to day activities plus team inspections from the headquarters to address specific areas. This arrangement has shown the need for some improvements in communications between the site inspection office and headquarters. For the plant operation phase it is planned that site inspections will be performed mainly by headquarters personnel.

14. CNCAN is currently revising the Romanian regulations to bring them into line with the relevant legislative requirements of the EU.

Status of emergency preparedness on governmental side

15. An interministerial Committee has the responsibility for the control, evaluation and approval of the national emergency plan. As a member of this Committee, CNCAN has the role of providing technical support and advice, and notifying the public about nuclear emergencies. CNCAN also has the responsibility for approving the on-site emergency plans of nuclear facilities. Romania has participated in a number of INEX international exercises. At present, however, CNCAN does not have enough staff with expertise in emergency preparedness and there is no dedicated emergency centre available.

Status of supporting national infrastructure

16. In addition to insufficient internal technical assessment capabilities, CNCAN currently has no qualified external technical support. There are organisations like the Technical University of Bucharest, the Institute of Nuclear Physics and Engineering and some private companies that could provide TSO support, but their technical expertise in the field of support needs to be verified. Part of the new CNCAN organisation includes a National Institute for Nuclear Safety, which will perform technical analyses and independent reviews.

Conclusions

17. The nuclear Law is the basic element of the Romanian regulatory pyramid. Roles, duties and responsibilities of organisations involved in nuclear safety are in line with those assigned to similar organisations in Western Europe. The Regulatory Body is sufficiently independent of the organisations involved in the use and promotion of nuclear energy. The regulatory regime and the regulatory body have both improved during the licensing process of Cernavoda NPP.

18. However, some improvements are necessary to reach a situation comparable with good practice within Western Europe. The following recommendations need to be addressed by the Government of Romania:

- there should be a gradual change to a regulatory system in which the responsibility for auditing and approving vendors and suppliers rests with the operating organisation and not with CNCAN;
- the funding assigned to CNCAN should be sufficient to ensure it can accomplish its regulatory duties effectively. In particular the working conditions of the staff should be improved and salaries should be sufficient to retain highly qualified personnel;
- procedures and lines of communications between national organisations involved in the response to a nuclear emergency should be improved.

19. The following recommendations are addressed to CNCAN:

- the staff recruitment programme should be completed in a reasonably short time and an adequate training programme for newcomers should be set up;
- the ongoing revision of the regulatory pyramid should be continued and completed;
- in order to be able to carry out its duties and responsibilities in the area of emergency preparedness, CNCAN should increase the number of staff with expertise in this area and establish an emergency response centre;
- additional qualified technical support is needed to strengthen the independent assessment capabilities of CNCAN, especially in view of the future licensing activities of Cernavoda Unit 2.

Chapter 2: Nuclear power plant safety status

Data and historical background

1. Construction of five CANDU 600 reactor units started at Cernavoda in 1980 and stopped at different stages of advancement (e.g. 46% for Unit 1) following the 1989 revolution. Subsequently, it was decided to concentrate on the completion of the first two units.

2. In 1991, the Romanian Electricity State Company (RENEL) signed a contract with a Western Consortium, transferring to it the responsibility to complete construction of Unit 1, to commission it and to manage initial operation. The national industry participated in the construction of conventional systems, under a qualification programme supervised by the Consortium. In June 1997, the operating responsibility was transferred from the Western Consortium to RENEL, with commercial operation starting in July 1997 under the conditions of a provisional operating licence from the regulator.

3. Work on Unit 2 had stopped with 80% of the civil work and 5% of the mechanical work completed. However, the Romanian Government is now committed to complete the construction of the Unit and the financial means for achieving this are being worked out.

4. Due to the close involvement of the Western Consortium in the construction project, Cernavoda has not benefited from EU industrial assistance programmes. Consequently, Western European knowledge of the safety characteristics of the plant is incomplete. The following statements are primarily based on information provided by the Romanian regulator and the utility.

Basic technical characteristics

5. The Cernavoda reactor uses natural uranium as fuel and heavy water as coolant and moderator. It is based on a standard CANDU 600 design developed in Canada in 1979 and is similar to NPPs in operation at Point Lepreau and Gentilly-2 in Canada.

6. In a CANDU 600 reactor the moderator and the coolant are separated by two concentric tubes, the pressure tube and the calandria tube. The pressure tubes contain the fuel bundles, and the coolant is circulated through these tubes. The calandria tubes prevent the moderator from coming into contact with the high temperature coolant. The annulus gas between the tubes is used to provide early detection of tube failure. Refuelling is made with the reactor at power.

7. A disadvantage of the CANDU reactor concept is that the reactivity void coefficient is positive. However, the adverse effects of this in transients and accident conditions are counteracted by two independent and diverse shutdown systems. An advantage of the design is that the moderator system acts as an ultimate heat sink in the case of loss of coolant and emergency cooling failure. The pressure tubes of the Cernavoda NPP have been manufactured from a new type of material (Zirconium-Niobium 2.5%) following a tube rupture at the Pickering 2 NPP in Canada. The pressure boundary surveillance programme is based on the ASME Code.

8. Plant systems are divided into process systems and special safety systems. The special safety systems are the two shutdown systems (shut-off rods and liquid poison), the emergency core cooling system, the containment system and the related supporting systems. They are divided into two groups, physically and functionally separated.

9. CANDU reactors are designed against a set of postulated events based on the concept of single/dual failure. Single failure is a failure of any process system which is required for the normal operation of the plant and dual failure is a combination of a single failure event and the simultaneous failure or impairment of one of the special safety systems. In a bounding double failure event, limits are set on the fission

product release and not on the peak cladding temperature of the fuel. Plant design bases include external events such as earthquake, flooding, missiles and, for the containment, a reference aircraft impact. Additional assessment is necessary to confirm the plant design margins against seismic events and the adequacy of fire protection.

10. The containment provides a complete enclosure of the reactor primary circuit. It is a pre-stressed structure, equipped with a spray system to reduce any pressure increase after an accident. The design leak rate of the containment is 0.5% volume/day, which is comparable with reactors in operation in Western Europe.

11. The basic safety features of the CANDU 600 concept have not developed very much over the years. When construction of Unit 1 restarted in 1991, design improvements were introduced similar to those already implemented in the twin plants of Wolsung (South Korea), Point Lepreau and Gentilly -2 as a result of their operating experience and PSA studies. The main improvements include better separation between control and shutdown system, modification of control room design, provision for post LOCA sampling capability in the containment, etc.

12. The standard CANDU safety philosophy is based on the defence-in-depth principle, but its implementation presents some differences compared to the design of NPPs operating in Western European countries. An independent in-depth safety review of the Cernavoda NPP has not been performed by any Western European safety organisation.

Safety assessments and safety improvements programmes

13. The basic safety assessment of the plant is provided in the Final Safety Analysis Report, whose content is in line with the standard content of US NRC Regulatory Guide 1.70 and based on Canadian safety assessment documents. The probabilistic basis of a standard CANDU design is derived from a reliability analysis performed at system level to show compliance with established reliability targets. A level 1 PSA has been developed by national organisations and peer reviewed by the IAEA. A validated PSA does not, however, currently exist. Providing resources are available, the Cernavoda NPP is committed to further develop and validate the existing level 1 PSA to optimise plant operational activities.

14. There is no specific safety improvement programme, although there is a continuous programme of plant modifications based on operational feedback. However, this modification programme may be affected by the critical financial situation at the NPP.

Operational safety

Organisation, Plant safety management and culture

15. The utility has developed a nuclear safety policy document which covers both the corporate and the plant level. It clearly states the overriding priority given to nuclear safety and the objective of the utility to promote a nuclear safety culture at Cernavoda NPP. It also sets out a number of policies for the achievement of good performance. On a yearly basis the Cernavoda management communicates strategic objectives of the NPP to its staff.

16. Cernavoda received an IAEA pre-OSART mission in 1994 and a WANO mission in August 1997. The WANO mission noted some positive points in the management processes, and some areas to be improved, such as maintenance, configuration control, training and feedback from operating experience. Action has been taken to implement some of the recommendations, while others are either ongoing or planned.

17. Following the transfer of operating responsibility to the Romanian utility, the on-site technical support from the Western Consortium was significantly reduced. In view of this, the current plant managers were selected from professional experts who had been working for the Cernavoda Project for several years. These received initial training in Canada and then on-the-job while acting as deputies of the Consortium managers during the construction and commissioning phases. The plant management is aware

that additional efforts are necessary to ensure that an adequate safety culture extends from the senior staff to all levels of plant personnel.

18. In Canada in 1997, an Independent Integrated Performance Assessment (IIPA) identified deficiencies in human performance and management at a number of Ontario Hydro stations. At the request of CNCAN, a systematic review of the IIPA recommendations was performed by the utility to ascertain their applicability to Cernavoda. The above mentioned WANO Peer Review also covered safety management aspects. It is planned to implement those recommendations that are applicable, but this will depend on budget availability. However, both the utility and CNCAN are of the opinion that the most critical IIPA findings that led to the temporary shutdown of some Ontario Hydro units are already addressed or not applicable to Cernavoda, but this could not be confirmed by Western experts.

19. A Plant Quality Assurance manual was issued in 1993. A revised version, based on current Canadian, Romanian, IAEA and ISO standards, is under evaluation by CNCAN.

Procedures for operation and maintenance

20. Plant operational documents are based on the Canadian approach and culture. The document which replaces the traditional Technical Specifications for Operation, is the Operating Policies & Principles (OP&P). This is a Canadian reference document which defines the envelope for safe operation and also includes items related to the plant organisational structure. As a result of an agreement between CNCAN and the Utility, the OP&P now used in Cernavoda are more detailed than those used for similar Canadian plants.

21. The plant Human Resources Development Unit reports directly to the Station Manager. There is a systematic approach to training and training programmes have been established both for general topics and for specific job types. A training centre is available on the site, with a full scope plant simulator, which is currently being adapted to the specific details of the Cernavoda plant.

22. Due to the general economic difficulties of the country, the Utility does not receive a large part of the payments due to it for the production of electricity. A large part of the income that is received goes to pay off the credit for plant construction, which is leading the NPP into financial difficulties.

Operating Experience and Event Reporting

23. A plant event database has been kept since start of commercial operation. Most of these events are classified as below scale or level 0 on INES. Eight are classified at level 1. These events led to a total of 5 unplanned shutdowns.

24. A new procedure is being finalised which will allow the systematic analysis of operational events with ASSET methodology and the assessment of external operating experience.

Plant Emergency Preparedness

25. There is an on-site emergency plan approved by CNCAN. Around the plant there is an exclusion zone out to 1 km and a low population zone out to 2 km. In order to improve the evacuation routes from Cernavoda, a bridge is under construction on the Danube, although work on this has stopped due to financial problems. Periodic emergency drills and annual exercises are carried out at the plant.

26. At present there is no dedicated emergency centre available on-site or outside the NPP. This is contrary to normal Western European practice.

National industry infrastructure for technical support

27. In Romania, engineering support for the nuclear programme is provided by the Centre of Technology and Engineering for Nuclear Objects (CITON), and research is carried out by the Institute for Nuclear Research (ICN). Both organisations have been supporting the national nuclear programme since the early 1970s. However, Western support and Canadian consulting services are still necessary, particularly for engineering activities involving safety related equipment.

Spent fuel and waste management

28. A draft Law, currently under Ministerial review, establishes the level of contribution to a fund for the management of radioactive waste and decommissioning for all categories of users. It also covers the setting up of a Radwaste Management Agency which will establish strategy and co-ordinate activities. Cernavoda NPP fuel is currently stored in the plant spent fuel pool whose capacity is about 9 years.

Conclusions

29. The Cernavoda NPP has a CANDU 600 reactor similar to those in operation at Point Lepreau and Gentilly-2 in Canada. The plant was designed and constructed under the responsibility of a Western Consortium. The standard CANDU safety philosophy is based on the defence-in-depth principle common to the design of NPPs in operation in Western Europe, but some differences exist in the way it is implemented.

30. The Western European regulators and their Technical Safety organisations have little experience of this design and no in-depth knowledge of the plant. Consequently, the statements in this report are primarily based on information provided by the Romanian regulator and the utility.

31. The NPP managers and the plant operators have a solid professional attitude and have assimilated a Western safety approach and culture.

32. Future challenges and necessary improvements include:

- additional assessment is needed to confirm design safety margins against seismic events and the adequacy of fire protection. A validated PSA (level 1 & 2) should also be performed;
- there is a need to maintain the current good level of safety culture and qualification at the plant management level. This safety culture should be extended to all plant personnel and to the necessary service and support interfaces existing in the country;
- it is important that Cernavoda NPP maintains all necessary international contacts and co-operation. The plant management should implement any applicable recommendations from WANO and IIPA and carefully monitor the evolution of events concerning the safety and the operation of CANDU reactors in Canada. In particular, there is a need to improve some areas of plant operation such as accident management, emergency preparedness, training activity and feedback from operational experience;
- the national infrastructure for technical support and research should be improved;
- at the moment the Cernavoda Utility is running into financial problems, reflecting the general economic difficulties of Romania. It is clear that these difficulties, if not overcome, could seriously affect activities that are necessary to ensure and maintain an adequate level of safe operation;
- it is important that Western support (especially from Canadian experts) is made available when it is needed in the future.

References

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2. CNCAN Improvement Plan - Concert meeting - December 1997.
3. IAEA IRRT Mission Report - February 1998.
4. Cernavoda NPP Unit 1 Final Safety Analysis Report.
5. ANPA Expert Mission Report - November 1998.

SLOVAK REPUBLIC

Chapter 1: Status of the regulatory regime and regulatory body

Status of legislative framework

1. A new Atomic Act on the peaceful use of nuclear energy entered into force on 1 July 1998. It establishes the ÚJD as the Nuclear Regulatory Authority for state supervision of nuclear installations, radioactive waste and spent fuel management, nuclear materials, special materials and equipment, physical protection, emergency preparedness and planning. The ÚJD is not responsible for radiation protection nor for transportation of radioactive materials or spent fuel. The Atomic Act states that the operator is responsible for the safety of its installations.

2. Compared with current Western European practice, the nuclear legislative framework is considered to be sufficient.

Status of the regulatory body

3. The ÚJD reports to the Prime Minister. Following recommendations from the RAMG exploratory mission, the ÚJD's staff and budget were increased significantly. However, taking into account Slovakia's present nuclear programme, the ÚJD's current financial resources are still not sufficient. This may cause a particular problem in the area of technical assessment, where the ÚJD have benefited from foreign assistance programmes for several years. Also, the ÚJD salaries, which are lower than those of the NPP operators, do not allow the retention of highly qualified staff.

4. The ÚJD has the power to issue and withdraw authorisations. It also has the power to impose penalties on the utilities for any violation of the conditions of an authorisation.

5. The ÚJD also approves the qualifications required for selected personnel of nuclear installations, reviews the proposals for technical standards, and carries out inspections to ensure that the Slovak Republic is complying with international agreements and conventions.

6. It is considered that, in general, the ÚJD has a status comparable to regulatory bodies in Western European countries. However, further improvements are needed, in particular in the area of internal quality assurance.

Status of regulatory activities

7. Work remains to be done in the development of regulations under the new Atomic Act. According to the current programme, by the year 2000 the ÚJD will produce 10 such regulations, plus explanatory guidance for the operating organisations.

8. A licence for a nuclear installation is not issued by the ÚJD but by the District authorities of the region where the installation is located. Nevertheless, a licence cannot be issued without the approval of the ÚJD.

9. The ÚJD has developed an inspection plan based on the recommendations of Western nuclear regulatory authorities. Further improvements in inspection practices should result from the ongoing RAMG programme.

10. Through a bilateral assistance programme with Switzerland, the ÚJD was able to establish an internal nuclear safety advisory group. The ÚJD should now be given the financial means to allow the activities of this group to continue.

11. The Ministry of Health is the Authority for radiological protection. Some regulatory issues in the field of nuclear safety have implications in terms of radiological protection and vice-versa. Both Authorities should establish close links so as to harmonise their respective regulations.

Status of Emergency Preparedness on Government side

12. The ÚJD has taken the appropriate steps to fulfil its duties in case of an emergency. The adequacy of the national and regional provisions for emergency preparedness should be tested in national emergency exercises involving all organisations concerned.

Status of supporting national infrastructure

13. The ÚJD places contracts with the Nuclear Research Institute (VUJE) for necessary technical support. The independence of the recommendations provided by VUJE may be questioned as it also performs studies for the utility.

Conclusions

14. It is recommended that the Government of the Slovak Republic consider the following issues:

- clarifying the relations between the ÚJD and the Authority in charge of radiological protection;
- clarifying the relations between the different governmental organisations involved in emergency preparedness and planning;
- increasing the budget of the ÚJD to allow full independent technical assessment capability;
- increasing the salaries of the ÚJD to allow the retention of expert staff.

15. The ÚJD should:

- devote necessary resources and priorities to the continued development of regulations under the Atomic Act and appropriate guidance;
- enhance independent safety assessment.

16. The first unit of the Mochovce plant recently began operating and a number of modifications are needed to upgrade it to Western standards for reactors of the same generation. The ÚJD will have to continue to demonstrate its independence and credibility by requiring that these modifications are completed by the licensee in a timely and satisfactory manner.

Chapter 2: Nuclear power plant safety status

Data

1. On its two nuclear sites at Bohunice and Mochovce, the Slovak Republic has the following nuclear power plants:

Site / NPP / Unit		Reactor type	Start of construction	First grid connection	End of design life
Bohunice A1		KS 150 Prototype gas cooled reactor	1958	1972	Shutdown in 1977
Bohunice V1	Unit 1	VVER 440/230	1974	1978	2008
	Unit 2	VVER 440/230	1974	1980	2010
Bohunice V2	Unit 3	VVER 440/213	1976	1984	2014
	Unit 4	VVER 440/213	1976	1985	2015
Mochovce	Unit 1	VVER 440/213	1983	1998	2028
	Unit 2	VVER 440/213	1983	1999 ?	2029 ?

2. At Mochovce, construction of two more units of the same type has been suspended (40 - 50% complete), and currently there is no schedule for their completion.

3. Note: The statements presented in this Chapter regarding the safety of the Bohunice plant are based primarily on information provided by Slovak organisations (utility and safety authority). An independent evaluation performed by a Western European organisation is not available.

(i) Bohunice V1 NPP, units 1 and 2

Basic technical characteristics

Design basis aspects

4. The first two units on the Bohunice site are typical VVER 440/V230 reactors. Generic safety characteristics and safety issues of such plants are presented in annex 2. Improvements have been carried out on the two units continuously since the plant was commissioned. So far, more than 1000 modifications have been implemented, and this improvement process is still underway.

5. Based on the findings of a safety assessment in 1990-1991, the Czechoslovak Atomic Energy Commission issued a list of urgent safety upgrading measures. During the same period, a safety report for a large «gradual reconstruction» was completed for Units 1 & 2. The aim of these two programmes was :

- to establish the Reactor Pressure Vessel status;
- to improve the behaviour of the confinement system;
- to demonstrate the ability of the plant to cope with Loss of Coolant Accidents larger than the Design Basis using conservative analysis;
- to demonstrate the ability of the plant to cope with the complete rupture of a main primary coolant pipe (a Beyond Design Basis Accident) using best estimate analysis;
- to improve the plant behaviour in case of internal or external hazards;

- to improve systems and equipment reliability;
- to improve organisation and operational safety.

6. Completion of the long term improvement programme is expected by the end of 1999. By then, compared to the standard VVER 440/230, the safety level of the plants will have been significantly improved. However, weak points will still remain, as explained in the following sections.

Reactor pressure vessel, primary pressure boundary

7. The current condition and the surveillance programme of the reactor pressure vessels appear to be adequate. Both reactor pressure vessels were annealed in 1993. and measurements of weld impurity concentrations indicate that further annealing will not be needed up to end of the expected lifetime of the units. Bohunice V1 has also implemented measures to reduce the probability of a large primary break. The risk of a large primary to secondary leak due to a steam generator collector head lift, has been reduced by use of a new sealing technology and specific in-service inspection. Further improvements (e.g. fitting a new collector head) may be implemented in the future. It is considered that the integrity of the primary pressure boundary is safeguarded to an adequate level.

Beyond design basis accidents and severe accidents

8. Some limited preventive measures have already been implemented, and further actions for prevention and mitigation are planned once the current plant modernisation process has finished. Therefore, with regard to beyond design basis and severe accidents, the situation has been improved, but further actions are still necessary.

Safety systems

9. Original deficiencies in terms of capacity and separation of safety systems have been partly corrected, and it is planned that the remaining deficiencies will be addressed soon. According to the regulator, ÚJD, qualification of safety system equipment is no longer an issue. In view of their importance, these points need further examination.

Confinement

10. Compared to the original design, the confinement capability has been improved by the installation of jet condensers. The plant is now able to withstand much larger LOCAs than the original design basis. The leaktightness has been improved. However, the leak rate remains high under accident conditions and the confinement would probably not mitigate the consequences of large LOCAs and severe accidents consistently with current Western practices for plants of the same vintage.

Operational safety

Organisational aspects and procedures

11. The good economic state of the utility has allowed it to implement the V1 plant modernisation program in addition to other necessary modernisation and maintenance activities. To ensure that maintenance is carried out efficiently, a maintenance Division has been set up with necessary workshops, laboratories, equipment and tools. For on-job training, mock-ups are also available.

12. Overall, the qualification of the plant staff appears satisfactory. A comprehensive training system is in place and a multifunction simulator is used. Numerous exchanges with Western partners are on-going either through bilateral or through multilateral co-operation programmes.

13. Technical specifications for operation have been improved, and follow a typical Western approach.

Implementation of revised Emergency Operating Procedures is planned for the end of the modernisation process. Improvements are also being made to procedures for normal operations.

14. Compared with Western European practices, it is considered that the organisational aspects and procedures used for the V1 plant are adequate.

Safety culture and management, Quality Assurance

15. Two safety committees are in place, one at the plant level, the second at the company level. Numerous contacts with Western experts have helped to promote a safety culture. A QA system is in place, covering all the main operations, including the V1 improvement activities.

Operational experience analysis

16. Systematic investigations of plant events and operational feedback are conducted by a dedicated plant department. At the national level, investigations are also conducted independently by VUJE institute and in some cases by ÚJD.

Emergency preparedness

17. The emergency plan is regularly updated and exercises are carried out periodically (quarterly and yearly, depending on the type of exercise). The level achieved is adequate.

National industry infrastructures

18. The only Slovakian commercial organisation involved at the plant is the Power Equipment Research Institute (VUEZ). This institute is involved in tests of containment sealing, condensation systems, safety system design, filtration and ventilation. The Nuclear Research Institute (VUJE) also provides technical support to the plant.

Safety assessments and programmes for further improvements

Safety assessment

19. A Safety Analysis Report was prepared for the V1 plant prior to the start of the long term improvement programme. Following completion of this programme, a full Safety Analysis Report, with a content similar to those of Western plants, will be presented to the ÚJD in 1999.

20. Due to a lack of information, the current and planned level of safety of the Bohunice V1 units cannot be fully assessed.

21. Probabilistic Safety Assessments were carried out before and after the urgent safety upgrading programme, and will be repeated after the long term improvement programme. It is claimed by the NPP that after the full modernisation process the probability of a core melt accident will have been reduced by a factor 30 and will reach a value close to Western standards.

Programme for safety improvement

22. The long term improvement programme should be complete by the end of 1999. Thereafter, modifications will be implemented on the basis of a case by case analysis.

(ii) Bohunice V2 NPP, units 3-4

Basic technical characteristics

Design basis aspects

23. Units 3 and 4 at Bohunice are typical VVER 440/213 reactors. General safety characteristics are presented in annex 2. Since 1990, significant improvements have been implemented. These include for example, the installation of in-service diagnostic systems, the renovation of instrumentation and control systems, the improvement of electrical systems, fire and seismic upgradings, and also some improvements in operational safety such as the introduction of symptom based emergency operating procedures.

Reactor pressure vessel, primary pressure boundary

24. The current condition and surveillance programme of the reactor pressure vessels appear to be adequate. Annealing will not be necessary up to the end of the expected lifetimes of the plants. Regarding primary to secondary leakage through the steam generator collector head, the same measures as for the Bohunice V1 units are either implemented or planned. Additionally a system for monitoring primary circuit leakage in the steam generators by nitrogen 16 activity in the steam has been installed. The integrity of the primary pressure boundary is thus considered to be safeguarded to an adequate level.

Beyond design basis accidents and severe accidents

25. A Phare assistance project considered the issue of Beyond Design Basis Accidents in the V2 units. Some preventive measures have been taken into consideration and mitigation measures are being implemented. However, additional work is still necessary in this area.

Safety systems

26. In terms of capacity and redundancy, the safety systems are comparable to Western ones. However, some improvements are necessary and are planned to be implemented within 2-3 years. Once these modifications are complete, the situation will be adequate.

Confinement

27. The capability of the bubble condenser system to guarantee the effective confinement of radioactive fission products in a Design Basis Accident needs further demonstration. The leaktightness values achieved on the V2 units are typical of similar reactors. To be compatible with Western practices, the corresponding leak rates should be reduced and their effect on radiological releases in case of large LOCAs and severe accidents should be investigated (see paragraph 29 below).

Operational safety

28. Information and conclusions presented above for the V1 units are generally applicable to the V2 units. Generally speaking, the improvements to operational safety are more advanced on the V2 units.

Safety assessments and programmes for further improvements

Safety assessment

29. A 10 year Safety Analysis Report was presented to the regulator in 1994 and, following comments from the ÚJD, a new version was produced in 1997. Its content corresponds to what is generally expected in Periodic Safety Reviews in Western Europe. The chapter in the report related to accident analysis was reviewed by the IAEA. In addition, a Probabilistic Safety Assessment has been carried out for the plant.

30. Due to a lack of information, the current and planned level of safety of the Bohunice V2 units cannot be fully assessed.

Programme for safety improvements

31. A further extensive modernisation programme is planned for implementation between 1999-2006, with the upgrades relating to safety being completed by 2002.

(iii) Mochovce NPP

32. The statements presented here are based on the preliminary results of an independent safety evaluation which is being carried out by a consortium of Western European Technical Safety Organisations.

Basic technical characteristics

Design basis aspects

33. The Mochovce reactors are the last of the VVER 440/213 type plants to be built (see annex 2). Compared to their predecessors, several modifications were included during the design phase. The most important of these are the use of better quality equipment (e.g. Western reactor control system, new type of pressuriser safety valves, upgraded feed water control system, use of innovative solid state technology for the reactor protection system, etc.), and also the improvement of systems used in accident situations (new design for the steam dump system, emergency feed-water system located outside the turbine hall, upgraded fire fighting water system, implementation of seismic requirements, primary circuit venting system, etc.).

34. However, some design weaknesses remained, so a nuclear safety improvement programme was developed for the Mochovce NPP in 1995 and reviewed by independent Western European Technical Safety Organisations.

35. Compared to the standard VVERs 440/213, the safety level of the Mochovce plant has been significantly improved. The remaining safety issues will be resolved during the next few years.

Reactor pressure vessel, primary pressure boundary

36. The condition and surveillance programmes of the reactor pressure vessels appear to be adequate. In addition to the measures implemented for the V1 and V2 steam generators, the collector heads have been replaced to reduce the size of possible leaks. The integrity of the primary pressure boundary is thus considered to be safeguarded to a level comparable to Western practices.

Beyond design basis accidents and severe accidents

37. The utility is planning to analyse Beyond Design Basis Accidents and severe accidents in the coming year(s) and to improve the plant if necessary. Although the situation is not yet adequate, it should be comparable to Western European practices when these improvements have been carried out.

Safety systems

38. In terms of capacity, redundancy and separation, the situation is comparable to Western European practice. The qualification of equipment for accident situations has still to be completed, however.

Confinement

39. The leaktightness of Mochovce in case of large LOCA (around 2% per day) is comparable to Western standards. However, further justification of the assumed bubble condenser efficiency is needed.

Operational safety

40. The information and conclusions presented above for the V1 and V2 plants are applicable.

Safety assessments and programmes for further improvements

Safety assessments

41. A Safety Analysis Report was prepared prior to the start-up of unit 1. Its content is consistent with the content of safety reports in Western Europe. An independent review by Western European Technical Safety Organisations is under way. In addition, a Probabilistic Safety Assessment will be completed in the coming months. An independent evaluation of this by Western European Technical Safety Organisations is planned.

Programme for safety improvements

42. An agreed safety improvement programme is being implemented.

Spent fuel and waste management in Slovakia

43. Up to 1986, spent fuel was sent back to Russia for reprocessing and final disposal. From 1987, Bohunice V1 and V2 spent fuel has been stored in an interim storage facility which is now full. An extension is being built which will allow the storage of V1 and V2 fuel up to the end of their expected operating lifetimes. On the Mochovce site, the problem has not yet been addressed (about 6 years is still available before the spent fuel pool will be full). The utility may deal with this issue by use of a dry storage facility, although no decision has been taken yet.

44. Currently, all NPP waste is treated on the Bohunice site. Additional waste treatment facilities are planned. A near surface disposal facility on the Mochovce site is in the process of being licensed.

Conclusions

(i) Bohunice V1

45. The following conclusions can be made for Bohunice V1 (units 1 and 2):

- compared with the original design, the safety of Bohunice V1 has been greatly improved and further improvements are to be made. Many of the major shortcomings of the plant should eventually be corrected. However, some safety concerns still remain, for instance the adequacy of the confinement remains a key issue;
- operational practices are consistent with those in Western Europe;
- due to a lack of information, the current and planned level of safety of the Bohunice V1 units cannot be fully assessed.

Bohunice V2

46. The safety of the V2 units seems generally adequate, although some safety issues still need to be addressed. Once the safety upgrades have been implemented (within about 3 years), the safety level of these plants would probably be comparable with that in plants of the same vintage in Western European countries, although, due to a lack of information, the current and planned level of safety of the Bohunice V2 units cannot be fully assessed.

Mochovce

47. Once the planned improvements are complete (i.e. within around 2 years), the safety of the Mochovce units will be comparable with that of Western NPPs of the same vintage.

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SLOVENIA

Chapter 1: Status of the regulatory regime and regulatory body

Status of legislative framework

1. In 1991, Slovenia became an independent sovereign state. The continuity of the legal system was ensured by adopting all relevant laws from the former federation of Yugoslavia.

2. The main nuclear act, the 1984 Federal Act on radiation protection and the safe use of nuclear energy is currently under review. Several issues have been identified and improvements are expected in a new law. Firstly, the responsibility for safety needs to be clearly assigned to the licence holder or operator. In addition, at the moment there appears to be an overlap of responsibility between different authorities in the areas of transportation and physical protection. Issues relating to early notification and information to the public also need to be addressed. It is noted that the appeal process, which currently allows the operator to appeal to the minister on both administrative and on technical decisions, may constrain the regulator and undermine his independence.

3. It is important to mention that the Kr_ko plant is owned equally by utilities from Slovenia and Croatia. Croatia is not included in the EU's Agenda 2000 process. The responsibility for nuclear safety remains in Slovenia, but shared ownership may affect the plant's financial situation, which could have an impact on safety.

Status of Regulatory body

4. The Slovenian Nuclear Safety Administration (SNSA) was established at the end of 1987 as an independent, functionally autonomous body dealing with all matters concerning nuclear safety. The SNSA reported directly to the Government and to Parliament until a change in legislation in 1991, since when the SNSA has been reporting to the Ministry of Environmental and Physical Planning. The Director of SNSA is appointed and removed by the Government and is the legal representative of the organisation.

5. There are other Governmental organisations having responsibilities for nuclear safety, the most significant being the Ministry of Health. The Health Inspectorate performs inspections, outside nuclear installations, related to the safe use, transport and storage of radioactive sources and materials. The Health Inspectorate also plays an active role in civil emergency plans for responding to nuclear and radiation accidents.

6. The staffing level of the SNSA has evolved from 5 in 1988 to the present level of 33. However, 15 of 48 permanent posts are currently vacant. The SNSA has an active training programme to increase staff skills.

7. The regulatory duties of the SNSA are well managed in accordance with Western European practice, however more effort is needed to establish an adequate system of internal quality assurance.

8. The SNSA does not have a separate and independent budget from the Ministry. Some additional income comes from fees paid to the SNSA for some of its activities, but this is not sufficient to provide financial independence. Following the recommendations of the RAMG exploratory mission, the salaries of

SNSA inspectors were raised to the same level as the utility personnel, but this did not apply to the rest of the SNSA staff. This has resulted in some SNSA staff, in particular young engineers, leaving after their initial training. The budget and financial situation of SNSA therefore needs to be improved.

Status of Regulatory activities

9. The SNSA has the powers to propose new legislation and is responsible for preparing new laws and regulations. The SNSA is currently revising the 1984 Federal Act on radiation protection and the safe use of nuclear energy. The SNSA is also responsible for issuing and amending licences for all nuclear facilities and performs regular inspections at those facilities.

10. Some of the interfaces between the different Slovenian Inspectorates are not very clearly defined, in particular with regard to the Health Inspectorate, fire protection issues, emergency preparedness and physical protection.

11. Because of its limited internal resources, in licensing plant modifications the SNSA has to rely on external independent technical assessments. According to current regulations, the licensee has to submit an independent safety assessment as part of its licensing application. If this is used as the primary basis for SNSA's licensing decision, then to guarantee a genuinely independent assessment, it should be managed/controlled by SNSA rather than by the licensee. In addition, there is no formal requirement for a periodic safety review of Kr_ko and this should be addressed in the revised legislation.

Emergency preparedness on governmental side

12. Under the present legislation, two authorities regulate and supervise emergency preparedness: the Administration for Civil Protection and Disaster Relief deals with the protection of the public off-site, and the SNSA deals with on-site matters.

13. In an emergency the SNSA acts as the independent expert governmental organisation, providing advice to the National Civil Protection Headquarters and to the nuclear facility, and acts as the co-ordinator with neighbouring countries and with the IAEA. The Kr_ko plant is close to the borders of Croatia and two bilateral agreements are in place to ensure adequate co-ordination and co-operation by the authorities of both countries. Nevertheless, there still appears to be the potential for problems with the interface with the Croatian authorities.

Status of Supporting National Infrastructure

14. As there is no unique technical support organisation, several organisations act as TSO depending on the issues being assessed. The main national TSO is the Jozef Stefan Institute (JSI) which also provides technical support for the utility. The funding for work carried out by JSI for the SNSA, is provided directly by the utility. The relationship between the JSI, SNSA and the utility needs to be clarified to ensure there are no conflicts of interest.

Conclusions

15. Since its creation in 1987, the SNSA has evolved and matured as a regulator, with a clear separation between regulation and promotion of nuclear energy. In general, it operates according to Western practice and methodologies, but there are some issues that need to be improved or clarified.

16. The responsibility for addressing the following issues, rests primarily with the Government of the

Republic of Slovenia:

- special attention should be paid to the interface with the Croatian authorities with regard to emergency preparedness arrangements;
- the existing legislation on nuclear and radiation safety is not in line with current Western European practice. The SNSA's delayed review of the existing legislation should be completed as soon as possible;
- the existing appeal process, which allows the operator to appeal to the Minister on administrative and technical decisions, may constrain the regulator and undermine his independence;
- due to relatively low SNSA salaries, there is a problem of retention of technical staff. An increase in SNSA salaries and an improvement in the financial stability of the organisation would help to retain staff, increase assessment capability and facilitate speedier approval of safety improvements;
- the use of the Josef Stefan Institute as a main contractor for both the regulator and the utility, may lead to a conflict of interest;
- the role of SNSA in an emergency situation, and its interfaces with other national organisations, needs to be more clearly defined. The interfaces between SNSA inspectors and inspectors of other Inspectorates should be clarified to avoid gaps and overlaps.

Chapter 2 - Nuclear Power Plant Safety Status

Data

1. Slovenia has one nuclear power plant located at Kr_ko, which is jointly owned with Croatia:

NPP unit	Reactor type	Electrical power (MW)		Start of construction	First grid connection	End of design life
		gross	net			
Kr_ko	Westinghouse 2-loop PWR	664	632	1974	1981	2023 (?)

Basic technical characteristics

Design basis aspects

2. The design of Kr_ko is similar to other Westinghouse PWRs of the same type in the USA, Korea and Brazil. The Angra 1 plant in Brazil was the reference plant for Kr_ko.

3. The reactor coolant system comprises two parallel loops connected to the reactor pressure vessel. Each loop contains a vertical single-stage centrifugal coolant pump and one Westinghouse vertical U-tube steam generator.

Status of the reactor coolant pressure boundary

4. The condition of the reactor pressure vessel appears to be in accordance with the design specifications. RPV surveillance seems to be carried out correctly and no operational problems have been identified. No RPV embrittlement problems are foreseen at the moment.

Status and capabilities of the safety systems

5. In general, the safety systems are based on two redundant trains. Emergency core cooling is provided by one high and one low pressure safety injection system and two pressurised accumulators. In case of a LOCA, recirculation of the safety injection cooling from the containment sump takes place. On the secondary side, the auxiliary feed-water system consists of two separate redundant loops based on electrical and steam driven pumps.

6. Heat can be removed from the containment through the heat exchangers of the low pressure injection system during sump recirculation, and also through the containment fan coolers. The Component Cooling Water System and Essential Service Water System each consist of two redundant loops.

7. The reactor protection system is based on solid state logic arranged in two redundant trains. The main plant condenser is cooled by the adjacent river water. The seismic design of Kr_ko is based on a maximum acceleration value of 0.3 g and on the design response spectrum recommended by a US regulatory guide.

Status and capabilities of the containment

8. The reactor and primary coolant system, including the steam generators, are located inside a double containment, which consists of a cylindrical steel shell with a hemispherical dome, an annulus and a surrounding reinforced concrete shield building. Leaktightness is comparable to NPPs in Western European countries. Draft operational procedures and guidelines relating to the preservation of containment integrity in severe accident conditions have been issued and are under review.

Safety assessments and envisaged improvements

Safety assessment and documentation

9. The licensing of Kr_ko was based on a Preliminary (PSAR) and a Final Safety Analysis Report (FSAR), generally following United States practice. The licence was issued in 1984 without any explicit time limitation. An implicit limit is established by the design life which is reported in the FSAR to be 35 effective full power years.

10. A PSA has been performed at levels 1 and 2. The main contributors to core damage frequency are: internal events (23%), seismic events (25%) and internal fire (42%). A PSA for shutdown conditions has also been performed, highlighting the need for some improvements in shutdown operations.

11. Since the start of operation, many requirements and recommendations affecting nuclear safety have been made by the Slovenian Nuclear Safety Authority (SNSA) and other Slovenian Regulatory Bodies, by IAEA and WANO missions, and by the ICSA International Commission (1992-93). Most of these have been resolved and some are currently being implemented. About 98% of the post-TMI safety requirements have been implemented.

12. Safety improvements have addressed many areas including: seismology, external events, safety systems, accident analysis, Instrumentation & Control, containment, fire protection, plant modifications, emergency preparedness, spent fuel and radioactive waste management.

13. The environmental and seismic qualification of safety related components is currently under review. Under a PHARE project, an investigation of the site seismicity is being carried out and a seismic monitoring network is going to be established around Kr_ko.

14. It appears that Kr_ko is undergoing a continuous process of review and safety assessment. With any plant changes, the regulator, SNSA, requires the operator to demonstrate continued compliance with the relevant US Regulatory requirements.

Programmes for future safety improvements

15. Further planned improvements include: core cooling monitoring instrumentation, reactor vessel level indication, an environment qualification program, replacement of motor operated valves, fire hazard analysis, the replacement of safety batteries, etc. It is also planned to replace both steam generators by 2000.

16. It is worth noting that financial stability of the Kr_ko plant is not helped by the long standing dispute with Croatia over the ownership of the plant. The Slovenian Government has, however, recently guaranteed to finance the current modernisation programme, including the replacement steam generators and the full scope simulator.

Operational safety

Organisation and Quality Assurance

17. The utility has established the Kr_ko Safety Committee which is under the responsibility of the General Director. The Director of the site technical division is responsible for the operation and the safety of the plant and has the authority and the duty to take any action to maintain safe plant conditions.

18. The Kr_ko Quality Assurance Program is implemented according to US requirements (10CFR50, Appendix B) and other international standards.

19. Because of the small size of the utility and the limited availability of national technical support, it is important that the NPP maintain close contact with international organisations (vendors, designers, utilities, etc.) to keep up with the state of the art and with general improvements in the field of nuclear and radiation safety.

Technical specifications

20. The plant operational limits and conditions are provided in the Technical Specifications, changes to which are subject to approval from the SNSA. The content and style of the Technical Specifications follow US practice and are similar to those used in some Western European plants.

Operating procedures

21. The operating procedures are reviewed and updated in accordance with written procedures every two years. A full set of Abnormal Operating Procedures (AOP) and Emergency Operation Procedures (EOP) has been developed and verified during simulator training. In recent years, symptom oriented EOPs have been implemented.

Plant modifications and safety assessments

22. The plant modification procedure is based on current Western practice which categorises changes according to their safety relevance. Although the utility has its own engineering and technical support for safety assessment of plant modifications, it also relies on external national and international support.

Training System

23. At the moment, training and retraining of licensed operators is performed on simulators in the USA. However, in response to a SNSA licence requirement in 1995, Kr_ko ordered a plant specific, full scope simulator. This simulator will be delivered at the end of 1999. Preparations have started to adjust the site training program and training materials in preparation for Kr_ko taking full responsibility for operator training in the year 2000.

24. In addition to the training of Kr_ko NPP personnel, specific training is provided for subcontractors, specifically in the area of site access and radiation protection.

Operational Experience Feedback and Event reporting

25. There have been no events at the plant higher than INES level 1. The average number of automatic reactor trips per year is about 2.7 and is decreasing.

26. The plant has an Operating Experience Assessment Program which analyses events and experience feedback. Plant personnel are encouraged to report all in-house deviations and to maintain a correct regard for nuclear safety.

27. It is apparent that Kr_ko NPP appreciate the high technological demands of operating the plant safely, and the site organisational structure and the training programme are designed to ensure that the staff are able to manage their duties satisfactorily.

Emergency Preparedness

28. The Kr_ko NPP is responsible for on-site emergency planning and maintaining on-site emergency preparedness. In developing its arrangements, Kr_ko has made reference to IAEA guides and standards, and also to regulations and guides from the US NRC. Slovenia has participated in all three INEX-2 international exercises organised by OECD/NEA and will participate in the forthcoming Canadian INEX-2 exercise.

National industry infrastructure for technical support

29. The utility operating Kr_ko operates just that one unit. The plant engineering department cannot provide all the necessary technical assessment and engineering services, and support is therefore provided by outside organisations. Part of the required technical support can be provided by national organisations, such as the Jozef Stefan Institute. In general, however, for supply of hardware and support services, Slovenia is dependent on foreign companies.

Spent Fuel and waste management

30. Spent fuel is temporarily stored on-site. The spent fuel pool capacity is sufficient up to the year 2002 but, by re-racking, this can be extended. Drums of low-level and intermediate level radioactive waste are stored in the on-site storage facility which will be filled in a few years. To resolve this problem, actions have been taken, including super-compaction and incineration, to modernise the waste processing and packaging system in order to reduce the rate at which the drums are being filled.

Conclusions

31. Kr_ko is a Western designed facility similar to others operating in USA and Europe. The utility operates only this single nuclear unit and, being relatively small, needs to maintain contacts with outside organisations in order to receive adequate advice and support. The utility's internal engineering department uses external support in order to be able to cover all the required technical assessments. At present, this technical support appears to be sufficient.

32. In general, the safety of the Kr_ko plant compares well with NPPs in operation in Western European countries. The NPP is subject to a continuous backfitting/upgrading process and many safety improvements have been completed. A few issues, for instance the seismic characterisation of the site, remain to be fully addressed. The site organisation, staff numbers, qualification and training are similar to Western NPPs. The utility operating Kr_ko appears to show proper regard to the requirements for safe operation of the plant. There are no major concerns in the area of operational safety.

33. Future challenges are:

- the clarification and improvement of financial issues. The Government of Slovenia needs to consider measures to address the long term financial stability of the NPP;
- resolving the problem regarding site storage capacity for spent fuel and radioactive waste;
- finalising design changes and accident management procedures to cope with severe accidents conditions;
- carrying out required assessments and improvements on a reasonable and realistic time scale. The key challenge for the near future is the replacement of the steam generators, coupled with a reactor power up-rating, which will require an in depth safety assessment;
- performing a formal periodic safety review.

ANNEX 1

Generic safety characteristics and safety issues for RBMK plants

Status of safety documentation

1. Western knowledge of the design characteristics of RBMK reactors has increased considerably since the Chernobyl accident in 1986, and especially after 1991 through participation in multilateral and bilateral safety assessment projects. However, full, in-depth, safety analysis reports, based on independently validated computer models, etc., according to Western standards have not yet been completed for any RBMK reactor, although some, e.g. Ignalina, have better safety documentation than others. Consequently, the depth of expert knowledge of these reactors is lower than with Western designs.

2. The 14 RBMK reactors in operation belong to three different design generations, built to comply with different generations of safety standards of the former Soviet Union. There are considerable differences between the different generations of RBMK reactors and even significant differences among reactors within the same generation. It was a conclusion from the International RBMK Safety Review that it is essential to perform plant-specific safety studies, including a Probabilistic Safety Assessment, of each reactor using state of the art computer codes and methodologies in order to get an accurate assessment of the safety level. However, basic features of the core design, the reactor cavity and the primary system designs are common to all RMBKs, although there are differences in the design of engineered safety systems. This fact implies that some specific safety issues are common to all units.

Containment issues

3. The most important design related safety issue is the lack of a containment or the lack of complete containment of the primary system, depending on design generation. The reactor core is enclosed in a separate cavity, designed to handle serious damage to a very limited number of the 1661 fuel channels. Unlike Western designs, the reactor vessel is not enclosed in a containment designed to cope with all the energy that could be released in an accident. Accident sequences, involving simultaneous rupture of tens and more fuel channels, would lead to unacceptable consequences. Even in the most modern RBMK designs, there are other important parts of the primary system which are not protected by a full containment. Moreover, the performance of the partial containment enclosing parts of the primary circuit in RBMK reactors of later designs has not been fully validated. Thus, RBMK reactors do not have the basic design features required in Western European reactors, because the last physical barrier, the containment, is at least partially missing.

Core characteristics

4. The general complexity of the large core, with strong spatially dependent interactions between thermal-hydraulics and neutronics, puts a particular burden on the Instrumentation & Control systems. The need for several localised core control systems requires powerful computing systems to process the necessary operational data for control and protection. Furthermore, complex 3-D codes are necessary for cal-

culation of core dynamics.

5. After the Chernobyl accident, a series of design changes were agreed by the Soviet authorities. Some of these were felt to be so urgent that they were implemented on all plants. It was planned that other changes would wait until the mid-life refurbishment of the reactors. The main design changes involved the reduction of the positive void coefficient, improvements to the reactor protection system and display of the reactivity margin. The decrease in void coefficient was to be achieved by increasing the fuel enrichment from 2% to 2.4% and by the introduction of 80-100 additional absorber rods in the core. In the technical specifications the number of effective control rods required in the core was increased from 26 to 48. These changes have reduced the void effect to less than 1 b. Furthermore the reliability and speed of the shut down system has been improved and a new fast acting scram system with 24 rods was installed.

6. These improvements as well as other safety issues have been thoroughly evaluated and monitored in the IAEA Extrabudgetary Programme on the Safety of VVER and RBMK Plants. As an example, it was established during the Programme that the two installed shut-down systems could not be regarded as fully independent and diverse. Furthermore, the fast acting scram system cannot maintain the reactor in a subcritical state in the event of a loss of coolant accident in the control and protection system channels. Such an accident was considered by the designer as a Beyond Design Basis Accident with very low probability. However, it has been concluded that in order to ensure a satisfactory reliability of the reactor shutdown function, backfitting of an additional completely independent and diverse shut down system is necessary in all RBMK reactors.

7. A new type of fuel with burnable poison has recently been introduced in most RBMK reactors, giving more stable core characteristics, without additional absorbers, and has greatly reduced the need to constantly control the power distribution in the core.

Redundancy, diversification and separation of safety systems

8. Although there is a high redundancy and diversification in most of the first line safety systems in the later RBMK designs, there is also a lack of physical and/or functional separation of some electrical systems, Control and Protection System (CPS), certain valves and the emergency core cooling pumps. This makes most of the RBMK units vulnerable to common cause failures.

Primary system characteristics

9. The specific RMBK core design, consisting of graphite bricks penetrated by 1661 fuel channels and a number of CPS channels, creates particular problems. The large mass of graphite (2 000 tons) provides a good heat absorbing capacity but has a definite disadvantage in its burnability, which was clearly demonstrated in the Chernobyl accident.

10. The primary system includes large pressure vessels distributing the coolant flow to smaller vessels and to a large number of parallel pipes connecting each core channel. The system also includes a large number of valves. This raises at least two problems:

- The possibility of blockage events, especially blockage of a group distribution header reducing the flow to about 40 fuel channels. The operating history of RBMK has shown a few blockage incidents, which fortunately did not develop into serious events. Fuel channel blockage is a major contributor to the risk of a severe accident;
- Material degradation due to the large number of pipes and welds. The RBMK pressure circuit suffers from all the expected material problems and degradation mechanisms, especially intergranular stress corrosion cracking, that have been seen in Western BWRs. A large number of defects have been found in RBMK pipework and some leakages have occurred.

11. The RBMK has certain design advantages over other reactors. For instance, there is about double the water inventory of a typical western BWR, while the fuel ratings are about 75% of those in a BWR and about 60% of those in a western PWR. These features play a significant role in determining the slow heat-up of fuel in many accident scenarios. On the other hand, the large water inventory means that there is also more stored energy to be handled by the containment and pressure relief systems.

Gap closure issues

12. A specific RBMK ageing issue is the gas gap closure. The pressure tube in each fuel channel is supported inside the channel in the graphite block by a series of graphite rings. It is arranged so that there is a gap of 3 mm between the graphite block and rings at the beginning of plant life. In this gap, a mixture of helium and nitrogen is circulated to improve the heat transfer from the graphite to the coolant and to monitor the tube integrity. Under the influence of irradiation during normal operation, this gap slowly reduces. Continued reactor operation after the gap has reduced to zero could challenge the integrity of the fuel channels and make re-tubing impossible. The average time to gap closure varies between about 15 to 20 reactor years depending on operating conditions. Mid-life re-tubing was foreseen in the RBMK design and has been carried out at Leningrad units 1-3 and Kursk unit 1.

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ANNEX 2

Generic safety characteristics and safety issues for VVER plants

1. The first VVERs were built at Rheinsberg in Germany and Novovoronezh in Russia. Rheinsberg was rated at 70 MWe and operated from 1966 to 1990. The two units at Novovoronezh were rated at 197 MWe and 336 MWe, and operated between 1964-1988 and 1970-1990, respectively.

2. The first standard series of VVER's has nominal electrical power of 440 MW, and the second standard series has a power of 1000 MW.

3. There are two generations of VVER 440 reactors which are based on different safety philosophies. Of the older generation VVER 440/230s, there are 11 units still operating, while five have been permanently closed down. Of the second generation VVER 440/213 type, there are currently 15 units operating.

4. In addition, two non-standard VVER 440 units have been in operation in Finland since 1977. In the contract for these plants, the Soviet vendor was required to meet Finnish regulations which were based on US safety rules. The original VVER design was therefore modified by incorporating safety features that provide defence-in-depth against the same type of design basis accidents that are postulated for Western designed plants. The control and protection systems were designed and supplied by Western companies. Many vital mechanical components were also purchased from Western manufacturers. Plant lay-out, civil structures (including fire protection and ventilation systems), and electrical systems were designed by the engineering staff of the owner utility. Western type QA was applied throughout the construction project, including quality control at the factories within the former USSR.

5. In the VVER 1000 series, there is a gradual design development through the five oldest plants, while the rest of the operating plants, the VVER 1000/320s are quite similar with each other. There are 20 operating VVER 1000s.

Extent and validation of VVER accident analysis

6. In-depth safety evaluation of VVER-440 plants has been done in a number of countries. This evaluation includes analysis of postulated transients and accidents with validated computer codes. Accident analysis of the Finnish VVER-440 plants has been carried out since the early 1970s by several Finnish teams and also by a German consultant.

7. The expected behaviour of the VVER-440 reactor core has been confirmed at the Finnish plants by a comprehensive instrumentation and monitoring system. Studies of Finnish irradiated fuel have confirmed the predicted fuel properties. The ability to calculate the behaviour of the nuclear steam supply system during normal operation and small transients (such as reactor trip, reactor coolant pump trip and loss of feedwater) has been verified in extensive commissioning tests and by analysing operational events.

8. The validation of accident analysis codes for VVERs, has been carried out by several organisations in different countries since the mid-1970's. This is based on integral experiments conducted at VVER-specific thermal-hydraulic test facilities such as REWET and PACTEL in Finland and PMK in Hungary.

9. The most recent comprehensive analysis of the Finnish VVER-440 plants was done in connection with periodic re-licensing in 1997, using a validated state-of-the-art computer code package. Independent calculations for verification of the analysis were done by the Finnish regulator and its consultants. Similar

analysis have been done for other VVER-440s by competent teams in particular in Hungary and the Slovak Republic.

10. The transient and accident behaviour of the VVER-1000 reactor has also been investigated quite extensively. For instance, a feasibility study on licensability of an improved VVER-1000 design was done in Finland in 1992. It included a full scope analysis of postulated design basis events. The analysis was updated by a Finnish team in 1995 to support an application to build a similar plant in China.

11. Other VVER-1000 analysis have been done by Western experts for instance in Germany for a plant which was never completed, and for the Temelin plant under construction in the Czech Republic.

12. In conclusion, the accident analysis of both VVER-440 and VVER-1000 designs is considered sufficient to provide an adequate understanding of the generic safety characteristics of the plants.

VVER 440/230

13. In the EU candidate countries, there are six nuclear power plant units of this type: four in Bulgaria and two in Slovakia.

14. The design of the VVER 440/230 was based on the assumption that a double-ended guillotine break of the main circulation line or the pressuriser surge line in the reactor cooling system is not possible. Instead, the accident assumed as the design basis for the safety systems was a break of a pipe directly connected to the main circulation lines. Following on from this basic assumption, all pipe joints to the main circulation lines were equipped with throttling devices. This would limit the maximum leak rate from any broken primary circuit pipe to the equivalent of a guillotine break of 32 mm diameter. This was the basis for designing VVER 440/230 safety systems, and consequently the capacity of the emergency core cooling systems is very small. It also meant that the design did not feature a substantial, Western-style, containment around the reactor cooling system to limit potential radioactive releases in a loss of coolant accident. The as-built confinement system of VVER 440/230s has little overpressure capability and its leaktightness characteristics are poor.

15. Although a large break in a reactor coolant circuit has never occurred at any nuclear power plant, a large break LOCA is generally postulated as a design basis for safety systems in Western designed nuclear power plants.

16. In addition to the inadequate safety systems, the VVER 440/230 plants had two other major safety concerns:

- Internal hazards such as fires or floods, and external hazards such as seismic events or plane crash, were not adequately considered in the original design. Thus the redundant parts of the safety systems were not adequately separated from each other, and are vulnerable to common cause failures. Some important safety systems were installed close to high-energy systems or in high fire risk area (e.g. the turbine hall). Consequently, an event in one part of the plant could result in complete loss of vital safety functions;
- The auxiliary systems, such as electrical power supply or cooling systems which support the safety functions, were designed with inadequate redundancy. Consequently, a single failure in a critical component of an auxiliary system could result in a loss of the support function and also a loss of the main safety function.

17. Some additional safety concerns are common to all VVER plants being operated in the EU applicant countries:

- The original quality of electrical equipment and Instrumentation & Control equipment was inadequate, and the equipment was not qualified to function in accident conditions;
- The reactor pressure vessel wall is exposed to higher irradiation by fast neutrons than most Western designed reactor pressure vessels, and therefore the embrittlement of the vessel material proceeds more quickly;

- The design of the main barrier between primary and secondary coolant inside the steam generators (primary collector) is less robust than the tube sheet in Western PWRs, and the possibility of large primary to secondary circuit leak therefore needs to be taken into account in the design of the safety systems.

18. The safety concerns with VVER 440/230 plants are discussed in detail in an IAEA report (Ref. 1). All the plants have addressed these concerns to various degrees by backfitting and design changes.

19. When assessing the overall safety of the VVER 440/230 plants, it should be noted that these plants, like all VVER 440s, have some inherent safety characteristics which are superior to most modern Western plants. The principal safety characteristic of all VVER 440 plants is the large volume of primary coolant. These reactors have more than twice as much coolant per megawatt as any Western designed NPP. This allows major transients to occur without damage to the reactor core, e.g. interruption of all AC power supply to plant equipment for at least six hours, or a complete loss of heat sink for a similar time. This large coolant volume also mitigates any anticipated transients so that the coolant pressure stays well below the opening set point of the safety valves. This safety feature provides an effective protection against the possible escalation of many transients to more severe events.

20. Other significant inherent safety features are:

- Small and robust reactor core: any oscillations in spatial power distribution quickly die away, and do not require active control as in larger reactor cores;
- Low peak fuel temperatures with good retention of fission gases within the ceramic fuel pellets;
- Low heat flux from the fuel to the coolant giving a very large margin to critical heat flux in normal operation and during abnormal transients, and slow temperature increase in loss of coolant accidents;
- Robust design of main components and piping, including the main circulation lines of the reactor cooling system, which are made of austenitic stainless steel;
- The ability to isolate any failed loop of the reactor cooling system, and after isolation to bring the plant to safe shutdown using normal operating procedures;
- Compared to Western PWRs, risks during shutdown associated with a reduced coolant inventory are limited in a VVER 440 because there is no need to decrease the water level in the primary circuit during a refuelling or maintenance outage.

21. The following conclusions can be made regarding the safety of VVER 440/230 plants:

- The original plant design has inadequate systems to cope with potential accidents, and its safety is not acceptable to Western European standards;
- However, all VVER 230s currently operated in applicant states have been significantly modified to varying degrees as compared to the original design. To become acceptable to Western standards, they need to reach a comparable level of protection as achieved for fully upgraded VVER 213 reactors, and they require extensive improvements to the Emergency Core Cooling System, to the Residual Heat Removal System and to the containment functions, and the technical feasibility of such upgrading programmes remains to be demonstrated and assessed. Therefore, the current or anticipated safety after implementation of all modifications should be considered on an individual basis;
- The generic safety issues identified by the IAEA have been addressed to varying degrees at all the plants;
- It is possible to remove most of the safety concerns by refurbishment, but it requires a major investment. However it does not appear feasible to backfit the plants with a reactor containment that could achieve the leaktightness required of Western PWRs. This means that protection against accidents leading to activity release in the containment cannot be guaranteed in a way required in Western European plants and that the current leak rates would probably not mitigate the consequences of large LOCAs and severe accidents consistently with current Western practices;

- Due to the inherent safety features of the VVER-440 design, the transients and accidents caused by equipment failures are less severe, and their rate of progress is relatively slow compared with Western PWRs, giving operators more time to take corrective actions. However, it is difficult to quantify the safety gain associated with this.

VVER 440/213

22. In the EU candidate countries, there are 11 nuclear power plant units of this type: four in Hungary, four in the Czech Republic, and three in Slovakia. One more unit is expected to start up in Slovakia in 1999.

23. The accidents used as a design basis for the VVER 440/213 safety systems are similar to those postulated in Western plants, including a double-ended guillotine break of the main circulation line in the reactor coolant system. The safety systems are quite similar to those in Western PWRs. Mostly, they consist of three redundant parts, and any of those parts could provide the intended safety function. This goes beyond many Western designed plants which have only two redundant parts in their safety systems.

24. VVER 440/213 reactors have bubbler condenser type pressure suppression containments. This is a unique Soviet design and there remain doubts about its performance during design basis accidents. Although this has been studied analytically and with model tests, there is a common desire to confirm the results with additional large-scale tests.

25. Another concern is the containment leaktightness, as the leak rates measured in integral tests have been generally significantly higher than allowed for Western containments. On the other hand, the comparison with Western containments is not straightforward because of the pressure suppression system. So far, the behaviour of the bubble condenser containment under severe accident conditions has not been addressed.

26. Compared with major safety concerns of the older VVER 440/230 plants, design improvements include:

- Internal and external hazards have been addressed to various degrees on a plant specific basis, and there are major design differences between the plants. There are still concerns in this area, but to a lesser extent than for the VVER 440/230s;
- Protection against single failures in the auxiliary and safety systems has generally been provided by design, although improvements in detail have been required as a backfitting measure.

27. The safety concerns with VVER 440/213 plants are discussed in detail in an IAEA report (see Ref. 2 and 4). Most of these concerns have been addressed on a plant specific basis.

28. All the inherent safety characteristics discussed in connection with VVER 440/230 plants are equally valid for the VVER 440/213 type. Extensive model testing and safety analysis has been done in several countries, including recent analyses with state of the art computer codes. These analyses have confirmed the safe behaviour of the reactor core and its cooling system in all abnormal transients. Furthermore, it has been confirmed that these plants can be brought to safe shutdown following accidents which are generally assumed as design basis events for modern nuclear power plants.

29. The following conclusions can be made regarding the safety of VVER 440/213 plants:

- The original plant design had safety deficiencies which would not be acceptable by Western European standards. At all the plants, most of the safety deficiencies have been addressed by backfitting and plant modifications;
- An unresolved general issue is the performance of the reactor containment during design basis accidents. The necessary experimental tests are being planned as a PHARE project;
- Should the efficiency of the containment functions be clearly demonstrated, it should be feasible to upgrade the safety of the VVER 440/213 plants to a level comparable with many of the plants currently operating in Western Europe. This upgrading should adequately address all the safety issues identified by the IAEA.

VVER 1000/320

30. In the EU candidate countries there are two nuclear power plant units of this type in operation, both of them in Bulgaria. In the Czech Republic, two further units are being built that were originally of a similar design but have been extensively modified during construction.

31. The VVER 1000 plants were designed to similar safety requirements as Western plants, and have equivalent safety systems. However, it is doubtful whether the overall safety level of the VVER 1000 plants is as high as the safety of the VVER 440/213s. The reason is that the higher power VVER 1000 plants have lost the inherent safety features of the smaller VVER 440 plants.

32. The main safety concern regarding the VVER 1000 plants lies with the quality and reliability of individual equipment, especially with the instrumentation and control equipment. Also the embrittlement of the reactor pressure vessel needs continuous attention and action will need to be taken if it approaches a hazardous level.

33. The main barrier between primary and secondary coolant inside the steam generators is a greater safety concern than in the VVER 440 plants, and it has been necessary to replace a number of steam generators when failures have been observed in this barrier. It remains to be demonstrated by further successful operating experience that design improvements have solved these problems.

34. The plant layout has weaknesses that make the redundant system parts vulnerable to hazardous systems interactions and common cause failures caused by fires, internal floods or external hazards.

35. The safety concerns about the VVER 1000 plants are discussed in detail in an IAEA report (Ref. 3; also Ref. 5).

36. The following conclusions can be made regarding the safety of VVER 1000 plants:

- The original plant design had deficiencies which would not be acceptable by Western European standards. At all plants, many of these deficiencies have been addressed by backfitting and plant modifications;
- It is feasible to upgrade the safety of the VVER 1000 plants to a level comparable with many of the plants being operated in Western Europe. This upgrading should adequately address all the safety issues identified by the IAEA.

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