Riskaudit Comments on the IRR Report

„Safety Relevant Issues and Measures Khmelnitsky 2 and Rovno 4 NPPs“

(IRR Vienna, June 1997)

EXECUTIVE SUMMARY

1. Introduction/Framework

As part of its due diligence, the European Bank for Reconstruction and Development (EBRD) has to verify whether the "Completion and Safety Upgrade of Khmelnitsky 2 and Rovno 4 NPPs Project" (K2R4 Project) meets the EBRD policy requirements on nuclear safety.

The due diligence of the safety aspects of the project is being supported by a Riskaudit-led Consortium[1] of Western Technical Safety Organisations (TSO) under a TACIS project. The TSO Consortium performed an independent safety assessment of the project and produced in January 1998 the Riskaudit report No. 120 "Final Safety Assessment Report for Loan Approval Procedures". The information provided by the NPP in the modernisation programmes and the additional upgrading proposals developed in the other national programmes were considered by Riskaudit as input data. The evaluation was based on comprehensive generic knowledge on VVER 1000/320 safety deficiencies which has been enriched by specific input information on K2R4 provided by Ukrainian experts during technical evaluation meetings. Riskaudit did not perform any specific calculation in the framework of this project. The safety evaluation performed by Riskaudit is based on the application to these Units of internationally recognised safety principle and of safety practices used in Western countries.

As part of its own review process, the Austrian Bundesminister für Umwelt, Jugend und Familie requested the Austrian Institute of Risk Research (IRR) of the Academic Senate of the University of Vienna to perform its own technical assessment of this project. The main task was to identify the most relevant safety issues and review and evaluate whether they are properly addressed within the frame of the K2R4 project. Results of this assessment are given in the IRR-Report No. 14a "Safety Relevant Issues and Measures Khmelnitsky 2 and Rovno 4 NPPs“, Vienna, June 1997.

The Riskaudit report No. 120 concludes that, to the extent that all Riskaudit recommendations will be taken into account and that all proposed and recommended measures will be properly implemented:

- The construction, management and operation of the plants will be in line with the fundamental principles set out in International Atomic Energy Agency (IAEA) documents. These include, in particular the IAEA Safety Series No 75 - INSAG-3, and the Nuclear Safety Standards (NUSS) Codes of Practice.

- Each level of the defence in depth concept will be significantly increased.

- The upgraded plants will be able to achieve a safety level in line with Western safety objectives and practices, for both design and operational safety.

[1] The Consortium of Technical Safety Organisations (TSO) comprises Riskaudit GRS/IPSN International; AEA Technology (UK); ANPA (Italy); GRS (Germany); and IPSN (France).

- The proposed measures complemented by those recommended by Riskaudit are considered to be complete and adequate to cope with internationally recognised safety deficiencies for this type of plant.

- The schedule for modernisation (in particular the choice between measures that must be implemented before start-up and those that can be implemented during the first few years of operation) is acceptable from a safety point of view.

- After implementation of corrective measures for weak points already identified, completion of proposed plans for inspection and after correction of corresponding possible weak points, the quality status of the plant will be in line with the quality achieved in Western plants.

The EBRD commissioned Riskaudit in April 1998 to advise the Bank whether all issues raised and comments made in the IRR report have been taken into account in the final safety assessment for the loan approval procedure. Riskaudit was asked to check whether the conclusions of the Riskaudit Consortium are still valid in view of the IRR report.

2. Evaluation Process

The statements presented in the IRR Report have been checked with reference to the safety evaluation conducted by Riskaudit of the specific modernisation programme revision 2 proposed by the Ukrainian central utility for completion and safety improvement of the Rovno 4 and Khmelnisky 2 Nuclear Power Plant, takin,g into consideration the generic and operational programmes valid for all VVER 1000 and under development in Ukraine.

This safety evaluation included:

- the verification of the completeness of the modernisation programme and of the generic and operational programme to give adequate consideration to all existing recommendation made for the VVER 1000

- the verification of the acceptability of the proposed measures with reference to the Western European safety practices.

- the verification that postponing the implementation of some of the measures to after start up could be accepted from a safety point of view.

All technical statements and/or safety concerns, presented in the IRR report have been reviewed by Riskaudit with the objective of checking whether the basis for the statement were consistent with the reactor design, status and improvement programme and in such case whether the conclusion drawn was relevant to good safety practices accepted by Western European regulators.

3. Overview

Several of the statement made in the IRR report (areas logistic, safety culture) include other than purely technical aspects such as economical, political, societal as well as concerning safety culture.

Indeed in these areas progress are needed, however the completion and modernisation of K2R4 has to be seen as a key factor in installing the dynamic of improvement that will benefit also to all operating Nuclear NPPs.

Regarding nearly all technical areas (core, component integrity, systems, instrumentation and control electric power, containment, internal and external hazards, accident analysing ...), IRR statements evidenced insufficient informations regarding the objectives and content of the programmes or are not justified with regards to Western safety practices.

Some areas of concern such fuel and waste management where not included in the scope of Riskaudit evaluation. However it is known that programmes in these areas are under development in Ukraine with the support of international organisations especially in relation with the decommissioning of Chernobyl and that adequate technical solutions exists for all these problems.

4. Conclusion

The IRR report does not present any new relevant technical safety issues or safety upgrading measures which had not yet been considered in the K2R4 project. All technical areas discussed by IRR were already known and have been treated by the Riskaudit Consortium of Technical Safety Organisations.

The last version of the modernisation programme for K2

R4 (as well as the detailed evaluation report produced by Riskaudit) were obviously not yet available to IRR at the time when they prepared their report. The IRR statements suffer from this lack of essential information. As a consequence, some of the comments and conclusions presented by IRR on technical areas are incomplete or not up-to-date.

Evaluations of economic, logistic, political, and social aspects in Ukraine cannot be commented in detail by Riskaudit. However, Riskaudit expects that the situation concerning those issues will improve and that completion of these two plants at a Western safety level will be one of the elements of the expected improvement.

The general IRR conclusion asserting that the planned completion and modernisation of Khmelnitsky Unit 2 and Rovno Unit 4 will not fulfil the nuclear

safety requirements of the EBRD policy is not valid because it is based on information not proven, not justified or incomplete.

In the view of Riskaudit, the conclusions of its report No.120 to the European Commission and other co-lenders on the safety aspects of the K2 R4 project remains valid.

RISKAUDIT REPORT N°136

Riskaudit Comments on the IRR Report „Safety Relevant Issues and Measures Khmelnitsky 2 and Rovno 4 NPPs“

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Attachment: Tabular Summary of IRR Important Safety-Related Issues

List of acronyms

Atomaudit	Ukrainian Expert Organisation
CEC	Commission of the European Community
CPS	Control and Protection system
DOE	Department of Energy (USA)
EBRD	European Bank for Reconstruction and Development
ECCS	Emergency Core Cooling System
EQ	Equipment Qualification
EU	European Union
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Control
INSAG	International Nuclear Safety Advisory Group
IRR	Austrian Institute of Risk Research
K2	Khmelnitsky NPP, Unit 2
LBB	Leak Before Break
LOCA	Loss of Coolant Accident
MP	Modernisation Programme
NTD	Non DestructiveTesting
NDE	Non Destructive Examination
NPP	Nuclear Power Plant
NRA	Nuclear Regulatory Authority of Ukraine
NUSS	Nuclear Safety Standards (IAEA)
PSA	Probabilistic Safety Assessment
PTS	Pressurized Thermal Shock
R4	Rovno NPP, Unit 4
RPV	Reactor Pressure Vessel
SG	Steam Generator
OPB	General Soviet Regulations for Nuclear Power Plant Safety
TMI	Three Mile Island NPP (USA)
VVER-1000	Soviet Origin Pressurized Water Reactor
Xe	Xenon

Introduction/Framework

As part of its due diligence, the European Bank for Reconstruction and Development (EBRD) has to verify whether the "Completion and Safety Upgrade of Khmelnitsky 2 and Rovno 4 NPPs Project" (K2R4 Project) meets the EBRD policy requirements on nuclear safety.

The due diligence of the safety aspects of the project is being supported by a Riskaudit-led Consortium[2] of Western Technical Safety Organisations (TSO) under a TACIS project. The TSO Consortium performed an independent safety assessment of the project and produced in January 1998 the Riskaudit report No. 120 "Final Safety Assessment Report for Loan Approval Procedures". The information provided by the NPP in the modernisation programmes and the additional upgrading proposals developed in the other national programmes were considered by Riskaudit as input data. The evaluation was based on comprehensive generic knowledge on VVER 1000/320 safety deficiencies which has been enriched by specific input information on K2R4 provided by Ukrainian experts during technical evaluation meetings. Riskaudit did not perform any specific calculation in the framework of this project. The safety evaluation performed by Riskaudit is based on the application to these Units of internationally recognised safety principle and of safety practices used in Western countries.

As part of its own review process, the Austrian Bundesminister für Umwelt, Jugend und Familie requested the Austrian Institute of Risk Research (IRR) of the Academic Senate of the University of Vienna to perform its own technical assessment of this project. The main task was to identify the most relevant safety issues and review and evaluate whether they are properly addressed within the frame of the K2R4 project. Results of this assessment are given in the IRR-Report No. 14a "Safety Relevant Issues and Measures Khmelnitsky 2 and Rovno 4 NPPs“, Vienna, June 1997.

The Riskaudit report No. 120 concludes that, to the extent that all Riskaudit recommendations will be taken into account and that all proposed and recommended measures will be properly implemented:

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- Each level of the defence in depth concept will be significantly increased.

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- The upgraded plants will be able to achieve a safety level in line with Western safety objectives and practices, for both design and operational safety.

- The proposed measures complemented by those recommended by Riskaudit are considered to be complete and adequate to cope with internationally recognised safety deficiencies for this type of plant.

- The schedule for modernisation (in particular the choice between measures that must be implemented before start-up and those that can be implemented during the first few years of operation) is acceptable from a safety point of view.

- After implementation of corrective measures for weak points already identified, completion of proposed plans for inspection and after correction of corresponding possible weak points, the quality status of the plant will be in line with the quality achieved in Western plants.

The EBRD commissioned Riskaudit in April 1998 to advise the Bank whether all issues raised and comments made in the IRR report have been taken into account in the final safety assessment for the loan approval procedure. Riskaudit was asked to check whether the conclusions of the Riskaudit Consortium are still valid in view of the IRR report.

The work performed by Riskaudit is technically oriented. Results achieved during the course of the TACIS-funded safety assessment of the K2R4 project have been used as main source of information. Riskaudit comments on the IRR report are presented hereafter.

Each area of concern identified by IRR is commented upon by Riskaudit, using:

- IRR statements and/or safety concerns (No. of pages and headlines in accordance with IRR report); and

- Riskaudit's comments including technical conclusion

Additionally to this evaluation of each area of concern, general Riskaudit comments are provided as well as an overall conclusion.

A tabular summary of IRR important safety-related issues with the corresponding Riskaudit view is attached to the report.

General Riskaudit comments

Safety issues mentioned in the IRR report have mainly two origins:

- evaluation reports produced by IAEA, DOE, Riskaudit,
- Austrian analysis results on VVER 1000 safety.

Considering the sources of information of IRR, all comments on safety issues presented in the IRR report have been carefully examined by Riskaudit in order to check if additional aspects have to be included in the Riskaudit analyses for further demand.

Obviously, IRR suffers of a lack of information. It appears that some key elements were not known by IRR:

- existence of Modernisation Programme revision 2 (MP)
- existence of generic programmes valid for all Ukrainian VVERs 1000
- existence of operational programmes.

This lack of information casts a shadow over the IRR report.The evaluation methodology used by IRR as well as their technical safety goals are not visible. It is not obvious that such goals exist, this explains certainly the inconsistencies found in the report (for example between components integrity part and I&C chapter).

Evaluation of technical IRR statements

Area: Logistics

(i) IRR statements - General (page 24)

(1) A number of issues concern the infrastructural and logistic preconditions of NPPs. Besides technical, these issues include economic, political and societal aspects and, if at all, usually cannot be resolved by a set of relatively simple measures. They have a considerable influence on the nuclear safety and may be ranked even up to the highest category IV as "not acceptable".

Riskaudit comment:

2. Classification of safety issues by IAEA is based on technical criteria which are not applicable for such societal conditions. Utilisation of IAEA ranking is not pertinent.

   The importance of the infrastructural and logistic issues in Ukraine is recognised, even if it can not be the task of a technical safety organisation like Riskaudit to evaluate in detail the economic situation, the nuclear infrastructure, and similar non technical issues. Nevertheless, it has to be pointed out that the situation concerning the infrastructural and the logistic situation has been improved since the Chernobyl accident. In particularly in the last years progress were achieved, partly by support of Western countries (e.g. communication systems). Situation will continue to be improved in the frame of the modernisation programme and of other national and international programmes.

   To certain extent the IRR evaluations pertaining to infrastructural and logistic issues seem to be predominantly predictions for which no justification is given.

Therefore it is not justified that logistic issues be ranked in the highest IAEA category IV.

(i) IRR statements - Safety Culture (page 27-29)

(2) Note that safety culture programs do not in themselves represent safety culture. Such programs are merely the initiation of a process which has to be taken over by knowledgeable, well-educated and prepared, and highly motivated persons. The lack of such persons in Ukraine is in part the result of their poor income due to the critical economic situation in the country.

(3) The success of safety culture programs is hindered by the difficulties of involved persons to change their traditional attitude to nuclear safety.

Riskaudit comment:

1. Safety culture is that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance (IAEA INSAG4). That means that safety culture concerns the requirement to match all safety issues with appropriate perceptions and action. Nevertheless, the modernisation programme and the associated branch and operational programmes aim at, on one hand, bridging the gap between the former safety requirements valid at the design period and the current international practices, and on the other hand, improving the operational safety in operating procedures, management, plant operation, training, emergency planning in order to enforce the « safety culture ».

   In any case, safety culture is a general attitude which of course has to be improved but which can not be transferred only with safety culture programmes but rather through practical exercises. In that direction the implementation of the K2/R4 modernisation programme together with the shut down of Chernobyl will permit to significantly improve Ukrainian safety culture.

2. Real efforts are done at the level of governmental organisation as well as at the level of NPPs in order to improve the whole nuclear energy production organisation. The NPPs operators have taken significant steps to clarify management expectations for safety and safety culture. Strengthening of safety culture in operation is a permanent action.

3.2 Area: General

(i) IRR statements - Preservation and Mothballing (page 32-34)

(1) One of the most important general safety-relevant problems for K2/R4 is that at least during 1990-1993 conservation and mothballing were marginal, or not accomplished at all, because of the moratorium. The economic crisis ...

During the moratorium, responsibility for handling problems of the unfinished units was transferred to the managers of the nuclear plants.

(2) Any comparisons concerning mothballing with Temelin NPP units are inappropriate because construction work at Temelin has been continuous....

(3) Concerning the state. .Quality of existing erected parts of the installation has not yet been examined.
Furthermore the qualification of existing components called to operate under accidental conditions will be addressed ....Riskaudit has announced a specific report on this key issue.

(4) From this point of view the estimated costs and completion time for the K2/R4 project are questionable because the basis for the estimation is incomplete. These estimations must be judged as too small. A thorough evaluation of the status of the equipment has to be performed in order to provide a sound basis for cost and time estimations. This sound basis is still missing.

(5) Unknown and unpredictable difficulties can be expected in the process of checking the degradation level of installed equipment. The possibilities to check certain equipment, cables, constructions, and check for the presence of hidden defects, etc. will be reduced. Because of the reported restricted funds in the Ukrainian nuclear industry, uncertainties will occur in the results from the field tests of equipment. It is also questionable whether all parts of damaged or degraded equipment will be replaced. Thus, higher rates of equipment failure during the start-up phase and initial operation have to be expected, which could have a very negative effect on plant reliability and safety.

<u>Riskaudit comment:</u>

1. Information given by IRR can not be supported. Inspection results demonstrate the acceptability of conservation status even if some repairs or limited replacements are necessary (identified and planned). Transfer of the responsibility for handling problems of the unfinished units to the managers of the nuclear plants during the moratorium time was certainly the best solution.

2. It is important to take note of the inspection results demonstrating the acceptability of the existing quality status.

3. Qualitative inspections have been performed on Rovno 4 and Khmelnitsky 2 units, considering the following aspects: mechanical, metallurgical, civil works, electrical, I&C and turbine.
   In the Riskaudit report N° 120 it was announced a specific report on quality but not on qualification. This specific report on quality gives a positive statement on methodology and results of the quality inspection.

4. A sound basis for cost and time estimations exists. The cost and time estimations are based on the evaluation of the status of the equipment (quality inspection).

5. The inspections performed have to be considered as insights into the plant status to evaluate the quality status of equipment and materials. It has been recommended by Riskaudit that prior to commissioning, a complete and systematic inspection programme be developed and implemented together with the commissioning programme. Conservation status of mechanical equipment is considered in general acceptable even if some repairs or limited replacements are necessary and planned. The same opinion is valid for electrical components on both sites. NPPs are taking necessary repair/replacement action.

(i) IRR statements - Qualification of Equipment (page 34-35)

(2) Riskaudit has also identified this issue and recommends a "Branch Programme for Accidental Qualification of Existing Equipment". According to their preliminary judgement, this issue potentially requires extraordinarily time-consuming and/or expensive measures and should be implemented after start-up of K2/R4 (Riskaudit, 1996).

(3) Equipment qualification appears to be a critical path on the way to complete the K2/R4 NPPs. Unknown difficulties can be expected due to the unsatisfactory mothballing and conservation situation. This might also lead to higher costs within this area.

(4) In qualifying equipment, the categories safety-related and non-safety-related have to be thoroughly identified. Qualification of safety-related equipment must be performed in any case before start-up of the reactor. Thus, IRR cannot follow in general the Riskaudit recommendation on implementing a "Branch Programme for Accidental Qualification of Existing Equipment" after start-up of K2 and R4. IRR can only agree with this recommendation in the case of non-safety-related equipment.

(5) It is mandatory that impaired safety equipment be replaced rigorously. This process must be strictly observed by an independent licensing authority.

Riskaudit comment:

1. Riskaudit is not correctly cited. Riskaudit has recommended that „Accidental Qualification of Existing Equipment" issue be solved. In any case the origin of the programme, MP or branch programme, is not the key point.
   The Riskaudit judgement is also not correctly cited. In fact Riskaudit was not responsible of any evaluation regarding cost of the measures and possible difficulties for schedule implementation. This is clearly stated in the Riskaudit report.

2. The items „quality of existing equipment" and „qualification" are not linked.
   Conservation status is good, weak points are identified and planned to be corrected. Even if not under Riskaudit responsibility, it can be said that corresponding costs are known.

3. For the purpose of Accidental Equipment Qualification (EQ) program implementation, two groups of equipment are identified: new equipment and existing equipment. New equipment is equipment that will be ordered in the course of the plant completion. Existing equipment is equipment that has been installed or purchased. New equipment will be subject before start-up to EQ programme. Application of the EQ requirements to existing equipment is discussed hereafter.
   Following establishment of the EQ master list (established using a specific analysis of equipment needed to reach a safe state after an event) and the equipment service conditions, the design organisation will determine which components have already documentation (test, analysis, or combination thereof) to support EQ status. From this effort, three groups of components will be developed:

   Group 1: Equipment for which documentation to support EQ status is available.
   Group 2: Equipment for which documentation on testing and/or analysis is available, but components do not meet service conditions.
   Group 3: Equipment for which documentation to support EQ status is not available.

   A plan to allocate equipment within each group is as follows:

   Group 1 Qualified equipment
   Group 2 Additional information will be requested from manufacturer.
   Depending on the outcome, the equipment will be moved to Group 1 or 3.
   Group 3 Testing or replacement

   Group 3 components would be subject to qualification or replacement process before start-up. If not possible a similar approach as the one used generally in West (based on safety justification to be provided demonstrating for example existence of functional redundancy or low risk contribution or implementation of compensatory measure) will be recommended.

4. Impaired components would be subject to a qualification or replacement process. This process will be strictly observed by NRA.

3.3 Area: Core

(i) IRR statements - General (page 36)

(1) Russian technology for manufacturing fuel pellets and assemblies still does not involve movable burnable absorbers, neutron absorbers incorporated in the fuel pellets, updated absorbing materials for control rods, etc.

Riskaudit comment:

1. The fuel use is planned to be optimised by low leakage loading, use of burnable absorbers in the fuel and non-uniform axial distribution of this absorber. Also the nuclear design codes to describe accurately the burn-up effects will be verified on the basis of experimental data from trial operation at Zaporoshie-3. Finally, new control rod design is planned to be installed on the basis of new materials (Dysprosium Titanate, Hafnium) to achieve extended service life-time and higher efficiency.

   As an overall conclusion on fuel assemblies design, Riskaudit considers that the measures proposed in the modernisation programme will permit to significantly optimise the fuel loads.

(ii) IRR statements-Control Rod Insertion Reliability / Fuel Assembly Deformation (page 36)

(1) It is astounding that "Control Rod Insertion Reliability/Fuel Assembly Deformation", which is a generic safety issue of the WWER-1000/V-320 control rod mechanism, has apparently not yet been resolved. The root causes for the failure in several Eastern plants still remain to be identified.

(2) Among other difficulties, the unresolved problems with power control can be taken as a strong indicator for a lack of specific expertise in the involved countries; this situation appears to be aggravated by the disintegration of the Eastern system.

Riskaudit comment:

1. Malfunctions have occurred in the operation of VVER-1000 Control and Protection System (CPS). Control rods drop time exceeded their design value (4 s). In some cases, rods were hanging in the lower part of the reactor core. This issue has been carefully analysed by designer, operators and research institutes. Results have been presented and discussed with international organisations. The cause of malfunction has been identified as additional friction forces (between CPS absorbing rods and guiding channels) caused by distortion of guiding channels. For solving the problem different options were proposed. For Rovno 4 and Khmelnitsky 2, the issue will be solved before start-up by the proposed modernisation measures.

2. As previously explained, the issue related to control rods insertion reliability will not remain unresolved (has been already corrected on operating plants) and the situation can not be taken as indicator for a lack of specific expertise in the countries involved.
   Regarding control rods reliability issue, Riskaudit considers that the set of measures which will be implemented on Rovno 4 and Khmelnitsky 2 will permit to solve the safety issue.

(iii) IRR statements - Power Density Control System (page 37-38)

(1) According to Riskaudit the potentially very expensive and/or time-consuming measure will be implemented after start-up.

(2) The fact that such a measure is not the practice for Soviet-designed units operating in base load mode may decrease the priority for timely implementation. This issue is partly addressed in the Ukrainian Modernisation Programme.

Riskaudit comment:

1. The Riskaudit judgement is not correctly cited. In fact Riskaudit was not responsible of any evaluation regarding cost of the measures and possible difficulties for schedule implementation. This is clearly stated in the Riskaudit report.

2. An automatic control of Xenon oscillations and power distribution is being developed. The implementation is planned for after start-up because an automatic control must be carefully examined.
   Regarding Xenon and power control, the proposed measures will permit to solve the safety issue.

(iv) IRR statements - Xenon oscillations (page 38)

(1) This issue is partly addressed in the Ukrainian Modernisation Programme.

Riskaudit comment:

1. This item is fully addressed in the modernisation programme (see also § iii).

3.4 Area: Component Integrity

(i) IRR statements -General (page 39)

(1) Reactor pressure vessel embrittlement is a generic problem of VVERs.

(2) Pressure vessel integrity is also required in the event of a large LOCA of the primary loops. In this case the pressure vessel represents the coolant container for residual heat removal from the still heated reactor core. Thus, maintaining the integrity of the pressure vessel is mandatory in order to contain radioactive material and to maintain coolability of the reactor core.

Riskaudit comment:

1. Sensivity of the RPV weld metal to neutron embrittlement depends on contents of embrittlement promoting impurities (such as Phosphorus, Copper and Nickel), but also on neutron flux. To present knowledge the content of Nickel is somewhat higher than required in the Ukrainian specification. On the other side, it is

proposed to reduce the neutron flux at the weld facing the core. This will permit to improve the situation by reduction of brittle fracture potential.

2. Pressure vessel integrity of VVER-1000 is not challenged under normal operation. However, the integrity has also to be ensured in the event of pressurised thermal shock (PTS). The large LOCA event mentioned by IRR is not a leading transient concerning vessel integrity (because the pressure of the primary circuit is quickly reduced). In any case, some improvement measures have also been proposed to reduce the risk of thermal shock.
   By implementation of the measures proposed in the modernisation programme, risk due to reactor vessel embrittlement will be significantly reduced.

IRR statements - RPV Embrittlement and its Monitoring (page 39-40)

(1) This problem is generic for all VVERs. Only limited solutions appear possible. Generally there is insufficient space for inspection of the RPV walls from the outer side on the level of the critical (high irradiated) weld.

Riskaudit comment:

1. By specific measures in the modernisation programme the cold shocks effects and irradiation on the RPV will be significantly reduced (see (i)).
   Type and number of surveillance specimen will be brought into compliance with the Ukrainian code. A new design of containers will be localised in the gap between the core and the vessel wall where the cold primary water is flowing. This new location will represent the irradiation conditions in the vessel wall with respect to energy distribution of the neutron field and irradiation temperature at a justified leading factor.
   Repositioning of irradiation surveillance specimen will permit together with other measures to better predict RPV embrittlement. It is Riskaudit's conclusion that the safety issue will be solved.

(iii) IRR statements - Non-Destructive Testing (page 40-41)

(1) ...several compromises will have to be found in reliably determining a comprehensive catalogue of material properties and conditions. The success in this area will be strongly influenced by the amount of available funding (note: the problem mentioned by IRR relates to restricted accessability and need to develop specific tools).

(2) Additional problems concern the persistent lack of qualification requirements for methods, personnel and equipment.

Riskaudit comment:

1. On operating plants, similar systems have been implemented successfully. This shows that technical difficulties can be solved.

2. The concern of IRR on LBB and NDT due to the persistent lack of qualification requirements for methods, personnel and equipment is not substantiated by IRR. Riskaudit can not share this opinion due to the fact that operating experience feedback do not confirm the IRR statement.
   By implementation of the foreseen programme, Non Destructive Examination will be performed in a satisfactory way.

(iv) IRR statements - Steam Generator Collector Integrity (page 41-44)

(1) Regular NDE inspections on possible collector cracking should be performed with manipulators.

(2) Manufacturing problems and "environmentally assisted cracking" of the steam generator, however, will still remain a problem. For both units the condenser tube material is type Cu-Ni-Fe 5-1. No replacement is proposed in the Modernization Programme, which will not allow improvement of the secondary chemical mode.

(3) Unless the information given by Atomaudit on developed hardware measures to eliminate the shortcomings is confirmed the improper design of steam generators manufactured for R4 and K2 will probably not allow their operation until the end of the plant design life time.

Riskaudit comment:

1. In order to reduce the potential of steam generator collector integrity, numerous measures will be implemented including extended in service inspection using the best techniques.

2. For a given problem, different solutions may exist. The proposed solutions given in the modernisation programme (including automatic monitoring and control system for chemical conditions of secondary bulk water) is also suitable to reduce corrosion attack.

3. The safety concern is not to know if the existing equipment will permit or not to operate up to end of plant life time. If needed those components could be exchanged. More important for safety are the surveillance of components status even if some measures (such as cleaning procedure of secondary side, low temperature stress release treatment, additionally hydraulic rolling of tubes in collector holes and modification of secondary circuit water chemistry) have been implemented to different extent in particular steam generators. Measures are proposed in the programme in order firstly to reduce the probability of primary to secondary leakage events and secondly to properly manage such events.

(v) IRR statements - Steam and Feedwater Piping Integrity (page 44-45)

(1) According to Riskaudit preliminary judgement, this issue potentially requires extraordinarily time-consuming and/or expensive measures.

(2) Failure of the highly energised and not separated steam lines on the 28.8m level between reactor building and machine hall represents a generic problem of the WWER-1000/V-320 reactors. An extreme high vulnerability exists in this area for safety-relevant pipes, e.g. of the feedwater lines to the steam generators. This problem apparently cannot be fully solved by secondary measures like rigid embedding and separating walls. Primary measures are mandatory, e.g. rerouting and separating steam lines in combination with solid protection against pipe whip in case of failure. These primary measures are very cost intensive because they require a complete redesign of an area with limited space for improved installations. This may explain why such primary measures have not yet been taken in NPPs with WWER-1000/V-320 reactors. This issue is addressed in the Ukrainian Modernisation Programme. A satisfactory technical solution, however, is still pending.

Riskaudit comment:

1. The Riskaudit judgement is not correctly cited. In fact Riskaudit was not responsible of any evaluation regarding cost of the measures and possible difficulties for schedule implementation. This is clearly stated in the Riskaudit report.

2. In the MP, the problem is planned to be firstly analysed, and in case of necessity (not yet demonstrated), a solution is planned to be implemented. Before implementation, nature of the solution (re-routing or other) will be proposed for independent evaluation. There is no reason to consider that no technical solution exists.

3.5 Area: Systems

(i) IRR statements- ECCS Sump Screen Blocking (page 46)

(1) One of the best and most cost-effective solutions appears to be the use of an insulation which is effectively protected against impinging jets resulting from possible leaks. Fiber-less insulation should be recommended to help overcome the problem. Also, a reliable fixing technology for the insulation has to be selected ; it must be able to withstand any adverse environmental condition in the endangered area inside the containment.

(2) According to a preliminary judgement by Riskaudit, this issue potentially requires extraordinarily time-consuming and/or expensive measures and should be implemented before start-up of K2 and R4.

Riskaudit comment:

1. The measures proposed in the Modernisation Programme are more complete than listed by IRR. It is also planned in this programme to replace the thermal insulation (before start-up) by fiber-less material as recommended by IRR.
   The utilisation of this new solution will permit to solve the ECCS sump screen

blocking issue ; in case of LOCA, coolability of ECCS heat exchangers will not be impaired due to blocking by fibers from insulation.

2. The Riskaudit judgement is not correctly cited. In fact Riskaudit was not responsible of any evaluation regarding cost of the measures and possible difficulties for schedule implementation. This is clearly stated in the Riskaudit report.

(ii) IRR results-SG safety and relief valves (page 47)

(1) Replacement of safety and relief valves is mandatory for the primary and secondary side in order to manage the possible fluid phases from steam to water under all emergency and accident conditions.

(2) Based on Western experience, verifying the capability of such valves in test facilities is problematic because real boundary conditions can't be recreated.
Noneless, efforts must be made to attain realistic and consistent boundary conditions for testing. Furthermore, reliable analytical verification (...) must be requested and performed.

Riskaudit comment:

1. The replacement of valves is not mandatory. In fact, what is required is for the NPPs to demonstrate the reliable operation of those components in all situations they are called to operate (including when necessary steam to water phases). Such demonstration is proposed in the modernisation programme. (In case of failure in the demonstration, the components will be replaced by qualified ones).

2. Western feedback has demonstrated that verifying the capability of such valves in test facilities is not problematic using for the test boundary conditions representatives of the reality. Such test are planned to be performed. (They are considered as more representatives than analytical verification).

As a general conclusion Riskaudit states that safety and relief valves for primary and secondary side will be demonstrated to be able to perform their function in all conditions under which they are called into operation.

3.6 Area: Instrumentation & Control

(i) IRR statement - Reactor Vessel Head Leak Monitoring System (page 49)
(1) This safety issue is generic for all VVER-1000/V-320 reactors. An adequate solution seems possible.

Riskaudit comment:

The leaktightness of the head penetrations is achieved using two concentric seals and leak detection is based upon the collection of water from the space between the seals on all the flanges. The leaktightness should be ensured by preventive

measures (quality of sealing, especially at the assembly). This measures will have to be implemented before start-up.

3.7 Area: Electrical Power

(i) IRR statements - Emergency Battery Discharge Time (page 50)

(1) Reliable solutions for this issue can be found.

Riskaudit comment:

1. No comment.

(ii) IRR statements - Residual lifetime of cables (page 51-52)

(1) According to a preliminary judgement by Riskaudit, this issue potentially requires extraordinarily time-consuming and/or expensive measures and should be implemented after start-up of K2 and R4.

(2) This issue is not addressed in the Ukrainian Modernisation Programme.

Riskaudit comment:

1. The Riskaudit judgement is not correctly cited. In fact Riskaudit was not responsible of any evaluation regarding cost of the measures and possible difficulties for schedule implementation. This is clearly stated in the Riskaudit report.

2. A measure is included in the MP in order to solve this issue.

3.8 Area: Containment

(i) IRR statements -General (page 52)

(1) If the situation described above is an accurate interpretation of the DOE report (DOE, 1987), it would appear that any severe accident which results in penetration of the bottom of the containment would result in a potentially large release of radioactivity into the environment.

Riskaudit comment:

1. The information given in the DOE report is not accurate (e.g. description of Stendal NPP containment instead of K2/R4).
   The K2/R4 containment design approach is consistent with Western practices. (Due to its very low probability Core melting is not taken as Design Basis Accident).

(i) IRR statements -Containment Bypass (page 52-53)

(2) A satisfactory solution is limited due to the specific steam generator design used and its potential to fail.

Riskaudit comment:

1. The possibilities of bypass scenarios will be systematically analysed before start-up. Modifications will be introduced if necessary. Analysis will include the calculation of the LOCA transients due to leaks from the primary to the secondary side of steam generators. Measures are planned further to reduce the frequencies of leaks from the primary to the secondary side and to cope with this accidents.

A special emphasis has been given to this important issue**.**

(iii) IRR statements -Containment Structure (page 54)

(3) Riskaudit did not address the problem of tension losses.
It has to be stressed that any deficiencies of the containment have thoroughly to be investigated and assessed.

Riskaudit comment:

1. The concern of tension losses of the pre-stressing has been addressed by Riskaudit. A specific measure (development of diagnosis of forces in pre-stressing cables and improvement of the existing containment state monitoring) is included in the modernisation programme. Additionally specific recommendation by Riskaudit has been given in order to deal with cables corrosion issue.

3.9 Area: Internal Hazards

(i) IRR statements -Fire prevention (page 55)

(1) The possibilities of fires and their effects on safety require a much more detailed treatment than performed by the IAEA experts. A minimum requirement would be a PSA.

Riskaudit comment:

1. Complementary to the modernisation measures listed by IRR, an overall fire hazard analysis is planned to be performed in order to check the adequacy of the proposed measures and to complement the programme if necessary. This approach is fully consistent with Western approach and is internationally recognised. Additionally, PSA is also planned to be performed.

(ii) IRR results: Pipeline breaks impact inside the Reactor building (page 56)

(1) According to a preliminary judgement by Riskaudit, this issue potentially requires extraordinarily time-consuming and/or expensive measures and should be implemented before start-up of K2 and R4.

(2) Special attention has to be given to the impact of pipe breaks inside the reactor building. The results have to be followed by appropriate measures.

Riskaudit comment:

1. The Riskaudit judgement is not correctly cited. In fact Riskaudit was not responsible of any evaluation regarding cost of the measures and possible difficulties for schedule implementation. This is clearly stated in the Riskaudit report.

2. The study planned to be performed includes also the analysis of this hazard inside the reactor building. Necessary modifications are also planned to be implemented.
   The proposed approach is consistent with Western approach.

(iii) IRR results: High energy pipes ruptures (page 56)

(1) According to a preliminary judgement by Riskaudit, this issue potentially requires extraordinarily time-consuming and/or expensive measures and should be implemented before start-up of K2 and R4.

(2) This issue is only partly and insufficiently addressed. Additional analytical efforts are necessary (....). The possibility of implementing such measures must be investigated.

Riskaudit comment:

1. The Riskaudit judgement is not correctly cited. In fact Riskaudit was not responsible of any evaluation regarding cost of the measures and possible difficulties for schedule implementation. This is clearly stated in the Riskaudit report.

2. The modernisation programme include the realisation of an exhaustive analytical analysis of high energy pipes ruptures hazards. Depending on the results, necessary hardware measures will be implemented.
   The proposed approach is consistent with Western approach.

3.10 Area: External Hazards

(i) IRR statements- Extreme weather conditions: low temperature (page 57)

(1) According to a preliminary judgement by Riskaudit, this issue potentially requires extraordinarily time-consuming and/or expensive measures and should be implemented before start-up of K2 and R4.

(2) The issue is partly addressed in the modernisation programme.

Riskaudit comment:

1. The Riskaudit judgement is not correctly cited. In fact Riskaudit was not responsible of any evaluation regarding cost of the measures and possible difficulties for schedule implementation. This is clearly stated in the Riskaudit report

2. The issue (analysis, definition and implementation of necessary measures) is planned to be completely addressed by the measure proposed in the modernisation programme. The proposed approach is consistent with Western approach.

(ii) IRR results: Man Induced External Hazards and Seismicity (page 57)

(1) This issue must be included into a site-specific modernisation programme.

Riskaudit comment:

1. The (site specific) modernisation programmes include measures dealing with these aspects. Analysis and necessary modifications are planned to be performed.
   The proposed approach is consistent with Western approach.

3.11 Area: Accident Analysis

(i) IRR statements -PSA (page 58-59):

(1) Under Western practice, nuclear plants are not permitted to operate until a comprehensive Probabilistic Safety Analysis (PSA) has been prepared, reviewed and approved.

(2) Until now, PSA results for VVER-1000 units have been obtained only for Balakovo-4, Kozloduy 5&6 and for Temelin 1. The PSA Level 1 study for Balakovo 4 includes a limited number of internal initiating events and the results are too optimistic.

(3) For Kozloduy 5&6,..... Human behaviour is not evaluated either and only full power conditions are covered.

(4) The expected PSA results for the Ukrainian NPPs discussed above (i.e. refer to points 2 and 3) will no doubt be much worse. In the Ukraine, three PSA projects are in various stages of development.

(5) No plans exist for conducting plant-specific PSAs for Khmelnitsky 2 and Rovno 4. ...

(6) The proposed modernisation programme is not based on probabilistic results and criteria, but merely on practical experience and deterministic assumptions. Nevertheless, it is also stated that probabilistic criteria will be used for decision making.
Without performing a plant-specific PSA the, contribution of a measure to overall NPP safety cannot be evaluated. However, PSAs can provide figures to indicate the relative safety improvement.

Riskaudit comment:

1. In most of Western countries it is not a regulatory requirement to produce a comprehensive Probabilistic Safety Analysis (PSA) for licensing.

2. PSAs have been elaborated for more NPPs than mentioned by IRR (e.g. Novovoronezh 5, Balakovo 5&6). In any case, a full PSA is planned to be performed for Rovno 4 and Khmelnitsky 2. In order to avoid lacks or optimism in the study, it is expected that this PSA will be reviewed by an independent organisation supporting the local authority for its licensing action.

3. For Kozloduy 5&6 PSA, human actions were modelised. See also comment given in 2.

4. The Ukrainians have gained some experience in the performance of PSA and have got support (hardware, software and training) from some Western companies. See also comment given in 2.

5. In the framework of the modernisation programme PSAs are planned for both units.

6. Western Safety evaluation approach is generally deterministic.

(ii) IRR statements -Rapid Reactivity Increase (page 59-60)

(1) The rapid reactivity and power increase in VVER-1000s during operation could be caused mainly by control rod ejection. ...

(2) However, in some cases (effective control rod fully inserted in the core) the rapid control rod ejection could result in fuel melting, damage to the fuel rod cladding, and damage to the primary circuit boundary. After such an accident, the possibilities to cool the core could be significantly affected. Sudden rupture of a control rod drive mechanism housing will also perforate the reactor upper unit, leading to loss of coolant accident.

(3) According to the Modernisation Programme, no plans exist to use fuel of new design, burnable neutron absorbers, or new patterns for the initial fuel loading of K2/R4.

(4) A complete set of rod ejection analyses must be accomplished for the start-up phase of operation of K2 and R4, taking into consideration the potential severity of this type of accident.

Riskaudit comment:

1. It is also true for Western PWRs that a rapid reactivity and power increase during operation could be caused by control rod ejection. Also, additional causes are possible. All of them are considered in the modernisation programme.

2. No evidence is given that the rapid control rod ejection could result in fuel melting. The performance of complete set of control rod ejection analyses is planned in the modernisation programme in order to demonstrate the contrary. In case of failure in the demonstration (not expected) modification would have to be implemented.

3. The use of new fuel design including burnable absorber integrated in fuel is proposed in the modernisation programme. The development of fuel containing burnable absorber and its use in low leakage loading is proposed as means to optimise use of fuel.

4. A complete set of accident analyses including rod ejection analyses will be accomplished for the start-up phase of operation of K2 and R4.

3.12 Area: Spent Fuel and radioactive waste management

(i) IRR statements- Spent Fuel Storage (page 61-62)

(1) A critical situation with the spent fuel storage capacity can be expected by the year 2000.

Riskaudit comment:

1. Within the frame of its safety assessment of the K2/R4 project, the Riskaudit consortium has not been requested to evaluate the safety aspects of spent fuel management programme. Such an evaluation is planned to be performed on the basis of relevant plans, which are currently being prepared by Energoatom.

(i) IRR statements- Radioactive Waste Management (page 62)

(2) There is a lack of a proper infrastructure for radioactive waste treatment and management in Ukraine.

Riskaudit comment:

1. Within the frame of its performed safety assessment of the K2/R4 project, the Rikaudit consortium has not been requested to evaluate the safety aspects of radioactive waste management. Such an evaluation is planned to be performed on the basis of relevant plans, which are currently being prepared by Energoatom.

3.13 Area: Post TMI requirements

(i) IRR results - Post TMI requirements (page 63)

(1) The important items (...) are addressed in the modernisation programme (...). It is highly recommended that this as yet unaddressed TMI requirements be included in the modernisation programme.

Riskaudit comment:

1. The post TMI lessons have been indirectly taken into consideration by the Ukrainian experts, during preparation of the modernisation programme, when they considered as sources for modifications :
   - valid regulation (which integrated post TMI lessons),
   - internationaly recognized deficiencies (found by Western experts having integrated among others post TMI lessons).

The situation as described by IRR is not complete or not correct : some items qualified as « not explicitly mentioned » (in the MP) are included either in the original project (e.g. reactor coolant system vents) or in the modernisation programme (e.g. procedure reviews).

3.14 Area: Vintage Design of K2 / R4 - Rules, Norms and Standards

(i) IRR statements- General (page 67-69)

(1) The basic safety principles of VVER-1000s are similar to those of the Western PWRs of the early 1970s. However, their original design does not appear to be organic and is too complicated; it resembles a conglomerate of a number of systems outfitted with rather old and poor-quality equipment requiring considerable protection and control automation. There are several reasons for the relatively low safety level and poor performance indicators of the plants. ...

Riskaudit comment:

1. The IRR statement is not justified and not scientifically substantiated. The construction of K2/R4 commenced in the eighties according to the original design for Soviet VVER 1000/V-320. The design basis was the Soviet "General Safety Principles of Nuclear Power Plants during Design, Construction and Operation" (OPB-73) which provides a multi-stage system of safety precautions and also the „Regulation for NPP Nuclear Safety“ (PBYa-04-74). R4 and K2 are of the model 320 following the so called «small series». The experience feedback from the design and construction of these units was introduced in VVER-1000/V-320..
   In the period of K2/R4 design and construction the OPB-73 was replaced by the OPB-82. New features of OPB 82 resulted from the operational experience feedback and from the international safety development. Among others OPB 82 includes a more accurately formulated single failure criteria and a refined classification of safety systems. These features were considered in the design of the VVER 1000 «standard» serie model 320 and have influenced the K2 and R4 projects. As a result the basic safety principles are similar with those existing for Western PWRs.

2. After the Chernobyl accident the most recent standards in force in Ukraine were developed, namely OPB 88 and its associated standards. Among the new features in OPB 88 is the consideration of Beyond Design Basis Accidents. The comparison of the Nuclear Power Plant Safety Concept contained in OPB 88 and the associated technical standards with the INSAG 3 and NUSS (IAEA) requirements establishes that the Ukrainian safety concept, as reflected in OPB 88, is comparable to INSAG 3 and NUSS (comparison is given in IAEA report (W WER-RD-69).
   The aim of the Modernisation Programme was to identify and to fill in the gap between the original design of K2/R4 and current national rules and international requirements. When upgraded, K2/R4 will fulfil most of OPB 88 requirements (only new design for NPPs of the next generation can meet all requirements) and the resulting safety level will correspond to the one achieved on existing Western NPPs.

3.15 Area: Safety Problems in Other WWER-1000/V-320 Upgrading Projects

(i) IRR statements- General (page71-74)

(1) Both options (Zaporozhie 6 NPP and Temelin NPP) are confronted with significant technical problems. Neither of the two approaches are satisfactory from the safety point of view, not to mention the economic aspect.

Riskaudit comment:

1. Temelin project cannot be compared to Rovno 4 and Khmelnitzky 2 project (different philosophy for upgrading). For this reason, the „significant technical problems“ said by IRR as encountered on Temelin can not be expected on Rovno 4/Khmelnitsky 2. Regarding Zaporoshie, IRR mentions some „significant technical problems“. Those significant difficulties are unknown to Riskaudit. In any case, the Rovno 4 and Khmelnitsky 2 objective is to improve the safety situation compared to operating VVER-1000 (including Zaporoshie 6).

4 Conclusion

The IRR report does not present any new relevant technical safety issues or safety upgrading measures which had not yet been considered in the K2R4 project. All technical areas discussed by IRR were already known and have been treated by the Riskaudit Consortium of Technical Safety Organisations.

The last version of the modernisation programme for K2/R4 (as well as the detailed evaluation report produced by Riskaudit) were obviously not yet available to IRR at the time when they prepared their report. The IRR statements suffer from this lack of essential information. As a consequence, some of the comments and conclusions presented by IRR on technical areas are incomplete or not up-to-date.

Evaluations of economic, logistic, political, and social aspects in Ukraine cannot be commented in detail by Riskaudit. However, Riskaudit expects that the situation concerning those issues will improve and that completion of these two plants at a Western safety level will be one of the elements of the expected improvement.

The general IRR conclusion asserting that the planned completion and modernisation of Khmelnitsky Unit 2 and Rovno Unit 4 will not fulfil the nuclear safety requirements of the EBRD policy is not valid because it is based on information not proven, not justified or incomplete.

In the view of Riskaudit, the conclusions of its report No.120 to the European Commission and other co-lenders on the safety aspects of the K2R4 project remains valid.

Tabular Summary of IRR Important Safety-Related Issues

for K2/R4 - Comparison IRR/Riskaudit

(The issues in the following table were selected by IRR due to their consideration on high relevance for safety and/or for financial and time efforts.)

	IRR view		Riskaudit view	
Important Safety-Related Issues	**Addressed in Ukrainian Modernisation Programme**	**Comments**	**Addressed in Modernisation Programme (Implementation : b or a)**[**]	**Comments**
Area Logistics				
Economic Situation in the Ukrainian Energy Sector (IRR)	not	The economic situation in Ukraine is characterised by a deep crisis. No domestic funds are available for modernisation projects in the energy system.	not	Not technical issue - Has been already improved and will continue to be improved. [*]
Nuclear Infrastructure (IRR)	not	After the disintegration of the USSR, an unsatisfactory situation exists in Ukraine.	not	Not technical issue - The modernisation project is planned to be conducted in close co-operation with nuclear countries. Ukraine is not isolated and not as weak as mentioned. No issue. [*]
Safety Culture (IRR)	not	The safety culture is generally insufficiently developed in Ukraine, especially on responsible levels of	not, but in operational NPPs	Safety culture cannot be improved by a „single“ measure. Has been (and continues to be) improved.

[*] Riskaudit has no specific technical competence on these items ; [**] a: implementation after start-up; b: implementation before start-up

	IRR view		Riskaudit view	
Important Safety-Related Issues	**Addressed in Ukrainian Modernisation Programme**	**Comments**	**Addressed in Modernisation Programme** (Implementation : b or a)**	**Comments**
		management.	programmes	
Spare Parts (IRR)	not	The lack of spare parts is a problem which exists for the whole Ukrainian nuclear industry.	not	Not technical issue. The utility re-organisation (pre-condition for financing) will permit to solve this issue financially. No more issue. *
Fresh Fuel (IRR)	not	The lack of fresh fuel is a problem which exists for the whole Ukrainian nuclear industry.	not	Not technical issue. There is absolutely no such problem in Ukraine. All NPPs are regularly re-loaded. Not safety issue. *
Area General				
Preservation and Mothballing (IRR)	not	This issue is not yet sufficiently investigated. Strong indications exist for minimal or missing conservation/mothballing of equipment and components, which might result in large cost overruns.	not, but „inspection activities“ and conse-quences	Demonstration of existing quality has been provided. Needed corrections are identified and are in the way to be solved.
Qualification of Equipment (IAEA, Riskaudit)	partly	This task is still pending. Implementation has not yet been satisfactorily demonstrated.	yes + Riskaudit recommend-ation (b, partly a)	Modernisation measures are planned. Safety issue will be solved.

Important Safety-Related Issues	IRR view		Riskaudit view	
	Addressed in Ukrainian Modernisation Programme	Comments	Addressed in Modernisation Programme (Implementation : b or a)**	Comments
Area Core				
Control Rod Insertion Reliability/Fuel Assembly Deformation (IAEA)	yes	This is a generic problem for VVER-1000/V-320s. It remains unresolved.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.
Power Density Control System (Riskaudit)	partly	This is a TMI requirement which must be fulfilled.	Yes (a)	Modernisation measures are planned. Safety issue will be solved.
Xe-Oscillations (Riskaudit)	partly	This is a generic issue, which is not yet resolved.	Yes (a)	Modernisation measures are planned. Safety issue will be solved.
Area Component Integrity				
RPV Embrittlement and its Monitoring (IAEA)	yes	This problem is generic for all VVERs. Only limited solutions appear possible. Generally there is insufficient space for inspection of the RPV walls from the outer side on the level of the critical (high irradiated) weld.	Yes (b)	Modernisation measures are planned including re-location of surveillance specimen containers, low leakage, fluence measurement...Problem is not linked with inspection from outside. Safety issue will be solved.
Non-Destructive Testing (IAEA)	yes	See above.	Yes (a, partly b)	Modernisation measures are planned. Safety issue will be solved.
Steam Generator Collector Integrity (IAEA)	yes	This situation is insufficiently taken into account in the original VVER-1000/V-320 design. A design solution is still	Yes (b)	Modernisation measures are planned (prevention and mitigation). Safety issue

Important Safety-Related Issues	IRR view		Riskaudit view	
	Addressed in Ukrainian Modernisation Programme	Comments	Addressed in Modernisation Programme (Implementation : b or a)**	Comments
		pending.		will be solved.
Steam and Feedwater Piping Integrity (IAEA, Riskaudit)	yes	The integrity is impaired for all VVER-1000/V-320 reactors. Basic acceptable solutions are needed. Related measures might become cost intensive.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.
Area Systems				
ECCS Sump Screen Blockage (IAEA, Riskaudit)	yes	A solution for this problem is generally possible.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.
Steam Generator Safety and Relief Valves (IAEA, Riskaudit)	yes	This safety issue is generic. A satisfactory solution is generally possible.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.
Area Instrumentation & Control				
Reactor Vessel Head Leak Monitoring System (IAEA)	yes	This safety issue is generic for all VVER-1000/V-320 reactors. An adequate solution seems possible.	Yes (b)	Modernisation measures are planned: Prevention + monitoring of primary leak. The safety issue will be solved.
Area Electrical Power				
Emergency Battery Discharge Time (IAEA)	yes	Reliable solutions for this issue can be found.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.

Important Safety-Related Issues	IRR view		Riskaudit view	
	Addressed in Ukrainian Modernisation Programme	Comments	Addressed in Modernisation Programme (Implementation : b or a)**	Comments
Residual Life Time of Cables (Riskaudit)	not	This issue is not yet assessed. Corresponding measures might become cost intensive .	yes (a)	Modernisation measures are planned. Safety issue will be solved.
Area Containment				
Containment Bypass (IAEA)	yes	A satisfactory solution is limited due to the specific steam generator design used and its potential to fail.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.
Containment Structure (IRR)	not	Any deficiencies of the containment have thoroughly to be assessed and corrected.	yes + specific Riskaudit recommend-ation (a, partly b)	Modernisation measures are planned. Safety issue will be solved.
Area Internal Hazards				
Fire Prevention (IAEA)	yes	The fire hazards potential and its prevention have not yet been sufficiently addressed in the modernisation programme. A PSA is necessary to take effective measures.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.

	IRR view		Riskaudit view	
Important Safety-Related Issues	**Addressed in Ukrainian Modernisation Programme**	**Comments**	**Addressed in Modernisation Programme** (Implementation : b or a)**	**Comments**
Pipeline Breaks Impact Inside the Reactor Building (Riskaudit)	yes	Sufficient and reliable measures are still open.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.
High Energy Pipes Ruptures (Riskaudit)	partly	This is a safety issue applicable to all VVER-1000/V-320 reactors. Basic solutions to safely separate high energy pipes are still needed. Appropriate measures are potentially cost intensive.	Yes (b)	Modernisation measures are planned. Safety issue will be solved.
Area External Hazards				
Extreme Weather Conditions: Low Temperature (Riskaudit)	partly	Assessing this issue will require performing a review of the design basis.	Yes (b, partly a)	Modernisation measures are planned. Safety issue will be solved.
Man-induced external hazards and seismicity (IRR)	partly	This issue must be assessed in site-specific investigations, which have not yet been performed.	Yes (b, partly a)	Modernisation measures are planned. Safety issue will be solved.
Area Accident Analysis				
Plant-specific PSA (IRR)	partly	The proposed modernisation programme for K2/R4 is not based on plant-specific PSA results. Thus the possibility exists that measures are taken with unknown level of impact on plant safety.	Yes (b and a)	Modernisation measures are planned. Safety issue will be solved.

Important Safety-Related Issues	IRR view		Riskaudit view	
	Addressed in Ukrainian Modernisation Programme	Comments	Addressed in Modernisation Programme (Implementation : b or a)**	Comments
Rapid Reactivity Increase (IRR)	not	A complete set of rod ejection analyses has to be accomplished for the start-up phase of operation of K2 and R4, taking into consideration the potential severity of this type of accident.	Yes (b, partly a)	Modernisation measures are planned. Safety issue will be solved.
Area Spent Fuel and Radioactive Waste				
Spent Fuel Storage (IRR)	not	A critical situation with the spent fuel storage capacity can be expected by the year 2000.	not	No technical difficulties to deal with the issue.
Radioactive Waste Management (IRR)	not	There is a lack of a proper infrastructure for radioactive waste treatment and management in Ukraine	not	No technical difficulties to deal with the issue.