TC Project ROM/4/017
IAEA-RU-4950
ORIGINAL: ENGLISH
Distribution Restricted

INTERNATIONAL ATOMIC ENERGY AGENCY

REPORT OF THE

IPERS

(INTERNATIONAL PEER REVIEW SERVICE)

PRE-REVIEW MISSION

FOR THE

CERNAVODA

NUCLEAR POWER PLANT

PROBABILISTIC SAFETY EVALUATION (CPSE - PHASE B)

IN

ROMANIA

31 October to 3 November 1994

DIVISION OF NUCLEAR SAFETY

NUCLEAR SAFETY REVIEW MISSION

UNDER TC PROJECT (ROM/4/017)
DIVISION OF TECHNICAL CO-OPERATION PROGRAMMES

PREAMBLE

This report presents the results of the IAEA international peer review services (IPERS) pre-review mission which reviewed the status of the present version of the Cernavoda probabilistic safety evaluation (CPSE), a Level 1 internal events Probabilistic Safety Assessment (PSA) for the Cernavoda, Unit 1, nuclear power plant.

Distribution of the IPERS report is left to the discretion of the Romanian Government; this includes the removal of any initial restrictions. The IAEA makes the report available only with the permission declared by the Romanian Government.

Any use or reference to the views expressed in this report that may be made by the competent Romanian organizations is solely their responsibility.

Important Notice

This report does not contain any commitment from any of the persons and organizations involved in generating the report. The statements, suggestions and recommendations contained in the report have to be regarded as informal proposals to be considered for implementation by the participating organizations.

INTERNATIONAL PEER REVIEW SERVICE

FOR THE CERNAVODA PROBABILISTIC SAFETY EVALUATION

Final Report of the Pre-Review (31 October to 3 November 1994)

TABLE OF CONTENTS

1. BACKGROUND

The Cernavoda NPP project started in 1977 with an agreement between the Romanian and Canadian governments to cooperate in the field of atomic energy. A joint AECL (Atomic Energy of Canada Limited) Romanian study resulted in the decision to envisage the CANDU 6 reactor type as the basic NPP unit. Agreements for the first unit were reached in April 1979 and for the second unit in 1981. The agreements covered the licenses for the CANDU 6 design, the NSSS design, supply of equipment from Canada and technical assistance in detailed local engineering, quality assurance and construction. In parallel to these agreements, contracts were negotiated for the BOP (Balance of plant) and turbine generator with Ansaldo (Italy) and GE (US) in 1981. At the same time a number of other license and cooperation agreements were signed with Canadian, Italian, US and Romanian manufacturers to permit Romania to manufacture much of the equipment. This includes manufacturing of fuel and production of heavy water (both operational at present).

During the eighties construction work was going on mainly for Units 1 and 2, but also for the remaining Units 3, 4 and 5. In October 1990 an IAEA Pre-OSART mission was conducted at the Cernavoda site. The key recommendations were:

- Give more responsibility and financial control to the plant owner,
- Reduce interference from various government ministries and promote quality,
- Implement adequate management and work procedures,
- Seek and enhance assistance from the manufacturers for construction management.

As a result of these recommendations an AECL-Ansaldo consortium was formed in 1990 and implemented in 1991, which is responsible on behalf of RENEL (Regia Nationala de Electricitate) for finalizing, commissioning and operating Unit 1 for the first 18 months. RENEL remains to be the overall responsible owner of the plant, while at the same time being subcontractor for many construction, commissioning and licensing tasks for the consortium. Together with the installation of the consortium the governments of Canada and Italy provided financing of the project. Connection to the grid of Unit 1 is now scheduled for spring 1995. No decision regarding Unit 2 (and the remaining units which are at a lesser degree of completion) has been taken up to now.

Regarding PSA and reliability activities, in 1986 a first IAEA mission was conducted in Romania by the author to initialize a PSA and reliability programme for the Cernavoda NPP project. In 1988 a limited scope PSA (CPSE-Phase A, Cernavoda Probabilistic Safety Evaluation) was started and completed in 1992. An IAEA IPERS PSA review took place in the year 1990 resulting in a number of recommendations. Afterwards a few single expert missions were conducted in the years 1990 and 1991 to provide support for the implementation of the IPERS recommendations. In the following CPSE-Phase B during 1993 and 1994 a complete PSA for internal initiating events was conducted. The PSA team has prepared a summary report for this study, see Ref. [1].

The mission which is described in this report was jointly requested by the utility RENEL and the safety authority (CNCAN, Comisia Nationala Pentru Controlul Activitatilor Nucleare). The purpose of the mission conducted during the period of 31 October to 3 November 1994 was to discuss the status of the PSA and reliability work, future steps in the area of PSA and also issues connected with the cooperation of the RENEL PSA and reliability groups at Bucharest, Pitesti and Cernavoda. The following institutions were visited:

- Safety authority (CNCAN, Comisia Nationala Pentru Controlul Activitatilor Nucleare), Bucharest
- RENEL headquarters (RENEL-GEN, Grupul de Energetica)
- ISPE (Institutul de Studii si Proiectari Energetice, RENEL), in Bucharest-Magurele, CITON (Centrul de Inginerie Tehnologica Obiective Nucleare) designer group,
- ICN (Institutul de Cercetari Nucleare), Institute for Nuclear Research (RENEL), in Pitesti
- Safety and reliability group at Cernavoda

The main counterparts during the mission were Ms. Liliana Comanescu (RENEL-GEN Bucharest, PSA and reliability coordinator) and Mr. Dan Serbanescu (CNCAN Bucharest). Appendix A gives the Agenda for the mission, Appendix B the participants for the different stages of the visit.

2. INTERACTION OF THE PSA WITH THE CERNAVODA NPP

As a major recommendation it is usually strongly suggested that the plant organization and plant staff are taking part and are integrated in the PSA work. Therefore a number of related recommendations in this connection have been made in the previous IPERS review. This involvement should normally cover almost all the PSA areas and especially PSA applications. Particular areas where the quality of an internal events Level 1 PSA depends in a significant way on the interaction of the plant and the PSA work are the following:

- Modeling plant features as designed and installed, related information from the plant,
- Setting up of a complete and comprehensive list of initiators,
- Plant response to initiating events, analysis of accident sequences,
- Human error assessment and modelling,
- Plant system requirements,
- Dependence analysis and modeling,
- Assessment of component reliability data and parameters.

Interaction with the plant staff is also necessary for the discussion of findings and of related proposals for improvements at the plant. For a living PSA usually a small group of plant staff is permanently involved (full time) at the plant.

During the visit it became evident that there are difficulties for the PSA project in the area of the interaction of the PSA with the plant which are discussed in the

following paragraphs. On the other hand, the PSA even in its preliminary stage has resulted in a number of specific proposals for design improvements, some of them have been accepted by the plant consortium. In addition to this, the PSA work has significantly enhanced the understanding of the safety related plant features on the side of the PSA team and the PSA team has acquired most of the know-how to perform an internal events Level 1 PSA. The author believes, that these items represent a significant achievement.

The Cernavoda NPP, Unit 1, which is at present in the commissioning phase and is scheduled to begin operation next year, basically represents a design of the seventies. It appears that due to the special conditions during the construction of the plant no major design upgrades have been made during the last 15 years. It is standard practice to have a "design freeze" during the final construction period, because major design changes at this stage could make completion and safe startup of the plant almost impossible. Even without major design changes the final construction, commissioning and startup phase of a nuclear power plant usually represents a period with considerable stress on all participating parties. At Cernavoda additional problems have to be faced by the plant consortium, see Ref. [2]. Due to these circumstances it might be explainable that the plant consortium has decided to restrict the support of the PSA work to a minimum and that it has also decided to use the SDM (Safety design matrices) and reliability analyses for the purpose of licensing in place of a PSA. It has to be mentioned, that in Canada the SDM and reliability analyses approach is now considered as being obsolete for new plants and that a Level 1 PSA is required.

After considering all these facts, the author would like to make the following basic suggestions:

(1) The position of the plant consortium should be accepted at present and interaction between the plant staff and the PSA made in a pragmatic way on a case by case basis.

(2) The base case internal events level 1 PSA (CPSE Phase B) should be completed with high priority to complement the safety analyses presently conducted on behalf of the plant consortium. The PSA is required to identify weak points in the design of the plant and to prioritize safety related modifications. On the other hand the PSA team should support and participate in the SDM and reliability analyses done at present for licensing of the plant.

(3) The procedure for and the implementation of the reliability data collection and evaluation program agreed upon with the plant consortium should be completed and enforced with high priority.

(4) The PSA should be continued by first extending it to internal fires and floods, and to external events and on a longer time frame as a living PSA.

Details following from these basic suggestions are given in Section 5, containing the recommendations.

One other difficulty encountered by the teams which greatly hampers communication between the teams are the limitations in telephone and fax connections between the geographically separated groups. Therefore one of the most urgent requirements would be dedicated fax machines for the teams. It should however be investigated before acquiring such equipment whether the available telephone connections would allow an effective use of this equipment. If this is not the case efforts should be done to improve the situation.

3. STATUS OF THE CERNAVODA PROBABILISTIC SAFETY EVALUATION (CPSE) AND FUTURE STEPS

In the year 1986 the first IAEA mission was conducted in Romania by the author to initialize a PSA and reliability programme for the Cernavoda NPP project. Under a cooperation contract with the IAEA (within the framework of a coordinated research programme) during the period of 1990 to 1991 a limited scope PSA was performed (CPSE Phase A). The study comprised 9 event trees and fault trees for 17 systems. This limited PSA was the subject of an IAEA IPERS review mission in October 1990 resulting in a number of detailed recommendations concentrating on the following areas:

(1) Initiating event analysis,

(2) Accident sequence analysis,

(3) System analysis,

(4) Component data,

(5) Treatment of dependencies and human interactions,

(6) Documentation and result presentations, and

(7) Quality assurance.

Afterwards a few single expert missions were conducted to provide support for the implementation of the IPERS recommendations. PSA team members undertook fellowship training in the areas of plant response, plant system analysis and PSA methodology and techniques. PSA procedures and a quality assurance manual were elaborated and issued to cover all PSA Level 1 activities.

In the following CPSE phase (CPSE Phase B) during 1993 and 1994 a complete PSA for internal initiating events was conducted. According to the PSA team the main objectives for the CPSE Phase B study are:

(A) The Level 1 PSA has been requested by the safety authority as a complement to the limited SDM and reliability analyses approach used for licensing.

(B) To identify weak points in the Cernavoda Unit 1 plant design. Based on the results of the present version of the CPSE, 55 design issues were identified. These design issues comprise the ECCS, the service water system, the chilled water system, the feedwater system, the condensate system, the instrument air system and back-up cooling for the Class III diesel generators and instrument air compressors.

(C) To be used by RENEL as a independent way to support and evaluate the SDM and reliability analyses to be issued for licensing the Cernavoda Unit 1 NPP. The final version of the SDM and reliability analyses is actually completed now and the experience and database from the CPSE is used for the purpose.

(D) To be used for evaluation of test intervals and of maintenance and monitoring activities. An important part of this objective is the reliability data collection and evaluation program at the plant. **This application is referred to in the report as application D (T/M evaluation).**

On the longer term a complete PSA study Level 1, 2 & 3 is intended to be performed. It is also planned that the study is to be extended for internal fires and floods and external events and initiating events associated with the refueling machines and waste management facilities and the D_2O tower.

The present report focusses on the recommendations of previous IPERS missions in Romania and assesses the implementation of these recommendations in the CPSE Phase B study performed in the years 1992 to 1994. Appendix C contains a list of the recommendations of previous IPERS reviews and the status of implementation.

The author believes that all major recommendations have been implemented in the study with the important exception of common cause failure analysis and consideration of secondary effects (pipe whip, jets, steam and water flooding). Also discussed during the mission was the documentation available for a full size IPERS review. The author believes that this documentation is sufficient for this purpose. It has to be mentioned that the technical means available to produce the extensive documentation for a PSA is considered by the author to be completely inadequate at present.

4. SUMMARIES OF THE DISCUSSIONS WITH THE DIFFERENT GROUPS

The co-ordination of the PSA activity is done by RENEL-GEN, Safety Department. The study is performed by two teams, the team in Bucharest-Magurele (CITON) and the team in Pitesti (ICN). In the following paragraphs the discussions with the two teams and also with the team at the site are shortly summarized.

4.1 CITON (RENEL, Centrul de Inginerie Tehnologica Obiective Nucleare), Bucharest-Magurele

The team in Bucharest-Magurele consists of 8 members. Their main task consists of the assessment of accident sequences, plant response and event tree development but also they are performing the integration of the fault trees developed in Pitesti into the overall PSA model.

The group is presently equipped with one 286 PC and 3 386/33 PCs and 4 matrix printers. The author believes that this equipment is by far inadequate and outdated especially with regard to printing and reporting facilities and with regard to the integration and evaluation process for the overall PSA model. Given the geographic situation (Cernavoda plant site, PSA group in Pitesti) the communication possibilities with the other groups are poor.

The group would need as a minimum in addition to the present equipment the following items:

1 Copying machine with automatic feeder, zoom and A3 capacity
1 Fax machine of moderate capacity (provided that there is a reasonable telephone line available)
1 Flatbed scanner including PC software

2 Modern PCs
2 Laser printers (one high capacity)

4.2 ICN (RENEL, Institutul de Cercetari Nucleare), Pitesti

The group at ICN Pitesti consists of 12 members. The main task of this group within the CPSE consists in systems analysis and fault tree development. For event tree and fault tree construction and evaluation they have developed an own code package which appears to work well and has some specific capacities. However, for finalizing the CPSE a validated evaluation code package should be used.

The group suffers under similar communication difficulties as described for the team in Bucharest-Magurele. The group is equipped at present with the following equipment which is judged by the author to be slightly less inadequate than the one at Bucharest-Magurele:

1 RISC 600 computer
2 486 PC
1 PS/2-50 PC
1 386 PC
2 Low capacity laser printers
2 Matrix printers

The group would need as a minimum in addition to the present equipment the following items:

1 Copying machine with automatic feeder, zoom and A3 capacity
1 Fax machine of moderate capacity (provided that there is a reasonable telephone line available)
1 Flatbed scanner with PC software

1 Modern PCs (preferably 2)
1 High capacity laser printer

4.3 Safety and reliability group at Cernavoda

The safety and reliability group at Cernavoda consists of 7 members. The group is presently very little involved in the PSA. The group will be responsible for the reliability data collection and evaluation program.

5. RECOMMENDATIONS

5.1 Base case PSA

The base case internal events level 1 PSA (CPSE Phase B) should be completed with high priority to complement the safety analyses presently conducted on behalf of the plant consortium. The PSA is required to identify weak points in the design of the plant and to prioritize safety related modifications. There are two major items to be considered:

(A) The PSA needs to be reviewed by external experts. For this purpose a standard IPERS review mission is proposed for spring 1995. Preferably the review should be conducted at the Cernavoda site. As a tentative date end of April 1995 has been agreed on informally.

The areas which should be covered with preference are the following:

- Accident sequence analysis, plant response,
- Event tree construction,
- HI (Human interaction) and HRA (Human reliability analysis),
- Success criteria.

(B) Performing the missing CCF (Common cause failure) analysis and secondary effects consideration. The limitations of the presently available evaluation codes would make a comprehensive CCF analysis very difficult. Therefore it should be considered to acquire a state-of-the-art code package (see Paragraph 5.5). For the proposed IAEA IPERS review it would be preferable if the CCF analysis would be available.

For a later date when the completed PSA is available the author suggests to organize a workshop for the review and use of the PSA by the regulatory authority.

5.2 Reliability data collection and evaluation program

The procedure for and the implementation of the reliability data collection and evaluation program agreed upon with the plant consortium should be completed and enforced with high priority. The author suggests that an expert with extended experience in that field reviews and helps to finalize the procedure and the program.

5.3 Extension of the PSA for internal fires and floods and external events

As recommended by the previous IPERS mission the PSA should be extended to internal fires and floods and external events with some priority. This activity could be supported by specialized workshops and courses.

5.4 Application D (T/M evaluation)

Considering the tasks described above, application D (T/M evaluation) and related applications at the plant have to be considered on a longer time frame. It has to be noticed that usually the base case PSA needs to be updated in several aspects, the most important being:

- The present base case PSA even after completion will be a PSA for a plant in the construction stage and not the operating stage. This impacts mostly on the HI and HRA by looking into detailed conditions and procedures for HIs presently not available.

- Usually the reliability models have to be refined for a living PSA, e.g. the reliability models for components accounting for detailed T/M procedures and practices.

It is suggested to establish a practical programme to update the PSA for this purpose and to establish a reasonable range of practical applications. The connection to the reliability data collection and evaluation program at the plant needs to be considered.

5.5 Equipment and software

As described above, a basic difficulty encountered by the teams which greatly hampers communication between the teams are the limitations in telephone and fax connections between the geographically separated groups. Therefore one of the most urgent requirements would be dedicated fax machines for the groups at Bucharest-Magurele and Pitesti. Before acquiring such equipment it should, however, be investigated whether the available telephone connections would allow an effective use of the fax machines. If this is not the case, efforts should be done to improve the situation. Also the printing and reporting equipment is far from being adequate. The

equipment which would be needed to reach a modest level of printing and reporting capability is described in Paragraphs 4.1 and 4.2.

The software presently used by the team consists of the software package developed at ICN for fault tree development and evaluation and IRRAS 4.0 for the overall integration and quantification. For finalizing the base case PSA the team would need a state-of-the-art PSA software which could be IRRAS 5.X if available. At the site CAFTA is used. The preferred software package used in the region (Hungary, Slovakia, the Czech Republic) is Risk Spectrum (Relcon AB, Sweden) which should be also considered. According to the originator company no major compatibility problems with other software should arise when Risk Spectrum would be acquired. In any case, the question of the software used for the further work should be considered on a priority basis, because converting the PSA model at a later stage would require a considerable extra effort.

5.6 Other supporting activities

Other supporting activities, like fellowships, workshops, meeting participations and expert missions would be needed in the areas described in the previous paragraphs, such as:

- HI and HRA,
- Accident sequence analysis, plant response,
- Success criteria,
- CCF analysis,
- Secondary effects consideration,
- Internal fires and floods and external events,
- Reliability data collection and evaluation,
- PSA applications (e.g. T/M evaluation),
- Use of the software package envisaged for the continuation of the work.

6. REFERENCES

[1] Romanian Power Authority; Cernavoda Probabilistic Safety Evaluation. RENEL, Bucharest, November 1994.

[2] Campureanu, T.; Petrunik, K.J.; Valentini, P.; Romanian Nuclear Power "Cernavoda" Project. Paper presented at the IAEA International Conference on "The Nuclear Power Options", IAEA, Vienna, 5 - 8 September 1994

Appendix A: AGENDA OF THE MISSION

Monday, 31 October 1994

08.30 - 09.00	Transfer from hotel to RENEL headquarters, Bucharest
09.00 - 10.00	Welcome at RENEL, discussion of the overall project
10.00 - 10.30	Transfer to RENEL-CITON, Magurele
10.30 - 12.30	Technical discussion with the CITON PSA and reliability group
12.30 - 14.00	Lunch break
14.00 - 17.00	Technical discussion with the CITON PSA and reliability group
17.00 - 17.50	Transfer to hotel, Bucharest

Tuesday, 1 November 1994

07.00 - 10.30	Transfer from hotel to Cernavoda NPP
10.30 - 12.30	Welcome at Cernavoda NPP, technical discussion with the RENEL PSA and reliability team at the site
12.30 - 14.00	Lunch break
14.00 - 16.30	Technical discussion with the RENEL PSA and reliability team at the site, discussion with the consortium safety engineer at the site
16.30 - 20.00	Transfer to hotel, Bucharest

Wednesday, 2 November 1994

08.00 - 10.00	Transfer from hotel to ICN Pitesti
10.00 - 12.30	Welcome at ICN Pitesti, technical discussion with the ICN PSA and reliability group
12.30 - 14.00	Lunch break
14.00 - 16.30	Technical discussion with the ICN PSA and reliability group
16.30 - 18.30	Transfer to hotel, Bucharest
Evening	Dinner invitation (RENEL)

Thursday, 3 November 1994

08.45 - 09.00	Transfer from hotel to CNCAN, Bucharest
09.00 - 12.00	Technical discussion at CNCAN
12.00 - 12.30	Wrap-up, transfer to airport

Appendix B: LIST OF PARTICIPANTS

Monday, 31 October 1994

RENEL Headquarters, Bucharest

Ms. Liliana Comanescu (RENEL Bucharest, PSA and Reliability Coordinator)
Mr. Teodor Chirica (Nuclear Projects Director, RENEL Bucharest)

RENEL-CITON, Bucharest-Magurele

Mr. Dan Serbanescu (CNCAN)
Ms. Liliana Comanescu (RENEL Bucharest, PSA and Reliability Coordinator)

Mr. Gheorghe Florescu (ICN, Pitesti)
Mr. Silviu Gradinaru (CITON)
Mr. Stefan Mehedinteanu (CITON)
Mr. Petre Popa (CITON, head of the CITON PSA Group)
Mr. Constantin Robitu (CITON)
Mr. Dumitru Teodorescu (CITON)

Tuesday, 1 November 1994, Cernavoda NPP

Mr. Dan Serbanescu (CNCAN)
Ms. Liliana Comanescu (RENEL Bucharest, PSA and Reliability Coordinator)

Mr. Peter Conquest (AECL-Ansaldo Consortium)
Mr. Sorin Ghelbereu (PMT, Reliability Supervisor)

Ms. Emilia Dode (PMT)
Ms. Dorina Ionascu (PMT)
Ms. Mariana Mircea (PMT)
Ms. Iuliana Mirescu (PMT)
Mr. Iulian Arion (PMT)
Mr. Gabriel Strasser (PMT)
Mr. Eduard Tudor (PMT)

Wednesday, 2 November 1994, ICN Pitesti

Ms. Liliana Comanescu (RENEL Bucharest, PSA and Reliability Coordinator)

Mr. Constantin Gheorghiu (ICN, Scientific Deputy Director)
Mr. Ilie Turcu (ICN, head of the ICN PSA Group)

Ms. Minodora Apostol (ICN)
Ms. Roxana Deaconu (ICN)
Ms. Mirela Forascu (ICN)
Ms. Daniela Georgescu (ICN)
Ms. Alina Nainer (ICN)
Ms. Gabriela Radu (ICN)
Mr. Gheorghe Florescu (ICN)
Mr. Gabriel Georgescu (ICN)
Mr. Gheorghe Negut (ICN)
Mr. Bogdan Prunaiche (ICN)

Thursday, 3 November 1994, CNCAN, Bucharest

Mr. Lucian Biro (CNCAN, Director, Nuclear Regulatory Division)
Mr. Dan Serbanescu (CNCAN)
Mr. Dumitru Dina (RENEL Bucharest, head of the Safety Group)
Ms. Liliana Comanescu (RENEL Bucharest, PSA and Reliability Coordinator)

Mr. Ilie Turcu (ICN, head of the ICN PSA Group)
Mr. Petre Popa (CITON, head of the CITON PSA Group)

Appendix C: RECOMMENDATIONS OF PREVIOUS IPERS REVIEWS, STATUS OF IMPLEMENTATION

ISSUE NO.	PSA AREA	RECOMMENDATION	SOURCE	STATUS CPSE-B, COMMENTS
1	PSA organization	Reach a formal agreement with the designer concerning their active participation in the project	IPERS p.18	Done, see main text on PSA - NPP interaction
2	PSA organization	Establish common procedures for modeling, which must be used	IPERS p.18	Done
3	QA	Documentation as specified in the existing CPSE procedure, should be signed by the analyst, checker and project officer to show that all agree that the procedure has been followed and that it is complete and accurate	IPERS p.59	Done
4	QA	Instructions for the development of the FTs and ETs and the documentation to be produced	IPERS p.14	Done
5	QA	It is recommended that the procedures should be extended to cover checking of event and fault tree development and analysis, both internally and with design team, and to cover documentation control	IPERS p.15	Done
6	QA	Document validation and verification of computer software	IPERS p.33	Done
7	QA	The software development should be subject to QA procedures covering specification, design and testing	IPERS p.15	Done

ISSUE NO.	PSA AREA	RECOMMENDATION	SOURCE	STATUS CPSE-B, COMMENTS
8	Initiating event (IE) analysis	Extend IE list, completeness of IE list to be checked (including common cause initiators)	IPERS p.5, p.9, p.12	List of internal IEs completed, common cause initiators considered
9	External IEs	External IEs should be considered	IPERS p.21	External IEs are outside of the scope of CPSE Phase B, screening analysis made by another RENEL group
10	Success criteria	Realistic success criteria should be used		Success criteria reviewed on the basis of available sources and analysis
11	Success criteria	Sensitivity studies will evaluate the impact of potentially more realistic success criteria	IPERS p.10	Not done yet
12	Success criteria	Specify cases where deterministic calculations have to be performed to resolve issues related to success criteria. If possible resolve the issues, based on other PSAs for similar plants, information supplied by AECL, extrapolations, etc. Carry out detailed calculations only in cases with potentially significant impact.	IPERS p.18	Partially covered. Detailed deterministic calculations have not been performed yet.
13	IE grouping	IE grouping to be reviewed, grouping into PDS (Plant Damage States). Transient analysis should be made available to group IEs	IPERS p.9	Done
14	Event tree construction	Use unique event tree heading event names	IPERS p.10	Done
15	Accident sequence analysis	Extend references to design documentation and supporting analysis	IPERS p.10	Done

ISSUE NO.	PSA AREA	RECOMMENDATION	SOURCE	STATUS CPSE-B, COMMENTS
16	Accident sequence analysis	Information on performance parameters and setpoints to supplement the component requirement descriptions should be expanded	IPERS p.10	Done
17	Plant features	Plant features (ECCS, MPI CVs, Raw Service Water System) to be checked and modelled	Follow-up review	Done
18	System analysis	Establish formal procedures for systems analysis QA	IPERS p.33	Done
19	System analysis	Develop and include fault trees for supports and supplies	IPERS p. 11	Done, with the exception of detailed room cooling and ventilation (due to low reliability of chilled water system)
20	System analysis	Complete fault tree models for systems connected to IEs	IPERS p.5	Done for overpressure protection system and PHT pumps
21	System analysis	Use meaningful event labels (system, component, failure modes)	IPERS p.36	Done
22	System analysis	Check for labeling errors	IPERS p.36	Done
23	System analysis	Fault tree documentation considered as controlled document	IPERS p.59	Done
24	Plant features	The relevant design information needs to be checked for all issues identified in the CPSE	IPERS p.9	Done as far as possible
25	Plant features	It is recommended that should be increased contact between the CPSE team and design team to make sure that the CPSE work accurately reflects the current status of the plant	IPERS p.15	See main text on PSA - NPP interaction

ISSUE NO.	PSA AREA	RECOMMENDATION	SOURCE	STATUS CPSE-B, COMMENTS
26	Plant features	Assure that there is a constant flow of information from the designer to the members of the CPSE team. The information should include latest systems documentation. Also, information concerning the status of deterministic safety analysis should be provided.	IPERS p.18	See main text on PSA - NPP interaction
27	Plant features	Establish regular contacts between the persons responsible for specific systems in the designer organi-zation and the member of CPSE team dealing with each systems, respectively.	IPERS p.18	See main text on PSA - NPP interaction
28	HRA (Human Reliability Assessment)	Errors of commission	Follow-up review	Done, issue needs to be checked by a HRA specialist
29	HI (Human Interaction) modeling	Errors of commission at component level should be deleted	IPERS p.13	Done, issue needs to be checked by a HRA specialist
30	HI (Human Interaction) modeling	Errors of commission involving decisional errors should be evaluated at the system level for sensitivity studies, however these should be not included in the final results	IPERS p.13	Not done, issue needs to be checked by a HRA specialist
31	HI modeling	A systematic analysis be performed to identify all potential human errors of commission which can cause initiating events (e.g. initiation of RSW)	IPERS p.45	Issue needs to be checked by a HRA specialist
32	CCF (common cause failure) analysis	Incorporate CCF analysis, use beta model (screening value 0.1)	IPERS p.11, p.12, p.38	Not done, planned

ISSUE NO.	PSA AREA	RECOMMENDATION	SOURCE	STATUS CPSE-B, COMMENTS
33	CCF (common cause failure) analysis	Common cause contributors which are dominant can be evaluated to determine operational and design methods of reducing the contributors	IPERS p.12, p.38	Not done, planned
34	Dependencies modeling	Calibration errors of redundant trains or components	IPERS p.12	Not done, it is claimed that independent teams do task for different trains. It is recommended to consider such effects.
35	Secondary effects	Secondary effects (pipe whip, jets, steam and water flooding) should be considered	IPERS p.12	Not yet done
36	CD (Core damage) definition	CD definition needs to be refined	IPERS p.9	Done
37	Core damage definition and grouping	Event sequences with successful moderator cooling, which presumably lead to some intermediate level of core damage need to be evaluated and grouped in a separate category	IPERS p.9	Done
38	IE frequency estimates	Check generic data for applicability to Cernavoda	IPERS p.9	Done
39	IE frequency assessment	IE frequency assessment based on system fault trees to be checked	IPERS p.9	Done
40	Component reliability parameters	Use parameters which lean towards the conservative side	IPERS p.11	Done
41	Component reliability parameters	Component reliability parameters should be as specific as possible and reflect conditions	IPERS p.12	Done, comprehensive list of all parameters to be produced for final report
42	Component boundary	Check component boundaries, consistency with reliability parameters	IPERS p.37	Done

ISSUE NO.	PSA AREA	RECOMMENDATION	SOURCE	STATUS CPSE-B, COMMENTS
43	Component boundary	Supports and supplies should be modeled separately, not included in component	IPERS p.37	Done
44	Component reliability parameters	Use recommended failure rates	IPERS p.37	Done
45	T/M (Test and maintenance) modeling	Include proper test and maintenance considera-tions in all systems	IPERS p.11	Done
46	T/M modeling	Use the recommended component test intervals, maintenance and mission times	IPERS p.37, p.38	Done, check un-scheduled maintenance contribution and technical specification limitations
47	T/M modeling	Use specific T/M parameters	IPERS p.38	Done
48	Quantification	Prevent loss of sequences/cutsets	IPERS p.13	Done, needs to be checked
49	Quantification	Adequate formulas to be used	IPERS p.13	Done
50	Sensitivity analysis	Perform sensitivity studies to evaluate effects of different data values and different assumptions	IPERS p.33	Sensitivity analysis not systematically performed for CPSE Phase B. Some few cases for SDS1, SDS2 and ECCS test intervals have been performed
51	Documentation	Documentation and re-ferences to be extended		Done
52	Documentation of results	Meaningful event labels and description in results presentation	IPERS p.36	Done
53	Documentation	Improve system analysis documentation to facilitate further evaluation and reviews	IPERS p.11	Done
54	Documentation	Extend system and fault tree description	IPERS p.31	Done
55	Documentation of results	Clearly state design insights and design issues	IPERS p.11	Done, more comments and assessment of findings is needed

ISSUE NO.	PSA AREA	RECOMMENDATION	SOURCE	STATUS CPSE-B, COMMENTS
56	Documentation of sequence and system analysis	All documents to be dated	IPERS p.59, p.60	Done
57	Documentation control	Event tree documentation should be considered a controlled document. Any changes should be subject to the same procedures.	IPERS p.60	Done
58	Documentation	Documentation should follow IAEA PSA Level 1 procedure	IPERS p.14	Done
59	Documentation	Road maps and cross-references to other pertinent sections should be provided	IPERS p.14	Done
60	Documentation	The results should be organized to show the dominant sequences contributing to the CDF, the dominant system and human contributors to each sequence and the dominant component and human error contributors to each system	IPERS p.14	Done
61	Documentation	Limitations and assumptions associated with each analysis should be clearly described	IPERS p.14	Done
62	Documentation	The notation and units in the IAEA PSA Level 1 procedures should be used (e.g. 2.7e-3/year as the format of reporting a sequence frequency)	IPERS p.14	Done
63	Documentation	Contributions from support systems should be highlighted	IPERS p.14	Not yet done
64	Documentation	Graphs or bar charts of the contributions should be presented for more effective communication of the CPSE findings and insights	IPERS p.14	Not yet done

ISSUE NO.	PSA AREA	RECOMMENDATION	SOURCE	STATUS CPSE-B, COMMENTS
65	Application of PSA insights	Plant construction is going on without re-cognition of the CPSE insights	IPERS p.17	See main text on PSA - NPP interaction
66	Application of PSA insights	Communication of CPSE insights to the authority should be intensified	IPERS p.17	Established
67	Application of PSA insights	Familiarization with CPSE insights is of critical importance to the authority, the designer and the utility. assumptions and insights gained from the CPSE should be discussed and presented on regular basis to the designer, the utility and the regulator	IPERS p.17	See main text on PSA - NPP interaction
68	Application of PSA insights	Agree on the process leading to incorporation on the insights into the design work and development of pro-cedures. Direct contacts between the CPSE team and the designers (AECL and Ansaldo) are desirable	IPERS p.18	See main text on PSA - NPP interaction
69	PSA applications	To support such applications as operator training, development of technical specifications and of emergency procedures, relevant procedures must be developed. This is the responsibility of the designer and the utility	IPERS p.18	Some studies performed
70	Use of PSA results	Discuss with the regulatory body the role of PSA in the regulatory process	IPERS p.18	Done