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NPP Cernavoda 3/4
Bilateral Consultation

Evaluation

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ÖSTERREICHISCHES ÖKOLOGIE INSTITUT

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NPP CERNAVODA 3/4
BILATERAL CONSULTATION

Evaluation

Antonia Wenisch
Richard Kromp

Ordered by the
Federal Ministry for Agriculture, Forestry,
Environment and Water Management,
Project Management Department V/6 "Nuclear Coordination"

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ÖSTERREICHISCHES ÖKOLOGIE INSTITUT

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Authors

Ing. Antonia Wenisch, Österreichisches Ökologie-Institut
Mag. Richard Kromp, Österreichisches Ökologie-Institut

Austrian Institute of Ecology
Seidengasse 13
1070 Vienna, Austria

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1 INTRODUCTION

Within the announcement of the EIA/ESPOO procedure for the construction of NPP Cernavoda Unit 3 and 4 Romania has invited Austria in 2007 to participate. The Austrian Institute of Ecology was assigned by the Federal Environmental Agency to elaborate an Expert Statement to the EIA report.

The main focus of this Expert Statement was on the safety of the Cernavoda NPP, because of its influence to potential accidents which could cause significant radioactive emissions in the planned Cernavoda NPP Units 3 and 4. From an Austrian point of view an emission is significant if a long-range transport to Austria could lead to an impact in Austria that requires protection measures for parts of the population there. Following the submission of the Experts Statement by the Austrian Federal Ministry for Agriculture, Forestry, Environment and Water management to the Romanian Ministry of Environment and Sustainability Austria was invited to a bilateral consultation. In preparation of this consultation the Austrian Institute of Ecology elaborated several questions which should be discussed with the experts of the applicant for the construction license.

The bilateral consultation included a visit at the Cernavoda NPP as well as a meeting at the Ministry of Environment and Sustainability.

We received a lot of information, most of our questions have been answered. Because the discussion time during the meeting at the Ministry was limited, we are pleased that we could take with us all the presentations of the NPP's Experts. Thus we could go again through the well elaborated answers Nuclearelectrica and AECL experts had prepared. The evaluation of the new information is presented in the following chapters.

The evaluation of the new Information mainly refers to the following documents:

Environmental Impact Assessment Report for NPP Cernavoda Unit 3 and 4 (ICIM 2007)

1. Technical Report for NPP Cernavoda Unit 3 and 4 (CITON 2006)
2. Welcome to Cernavoda (presentation M. Serban 18.03.2008) (SERBAN 2008)
3. Nuclearelectrica: Environmental radiation protection programs (presentation 18.03.2008) (RADIATION 2008)
4. Emergency Planning and Preparedness, Cernavoda NPP Health Physics Department, Cernavoda NPP Health Physics Department (presentation V. Simionescu 18.03.2008) (SIMIONESCU 2008)
5. Nuclearelectrica: NPP Cernavoda, Units 3 and 4 Bilateral Consultations According to the EIA-Directive/ESPOO Convention, Answers to the Austrian questions. (presentation 19.3.2008) (ANSWERS 2008)
6. maps and figures,information on modifications and a presentation, attached to a letter of the Romanian Ministry of Environment and Sustainability, received at 10.04.2008

This evaluation of the bilateral consultation compares the information provided by the EIA documents, with the information the Austrian delegation received during the visit of the NPP Cernavoda and the meeting at the Ministry of Environment in Bucharest. The structure of this report follows the Expert Statement (EX-STAT 2007) and the question catalogue (QUESTIONS 2007) prepared for the bilateral meeting and submitted to the Romanian Ministry of Environment.

In general, the evaluation of the information given to the issues to be discussed is divided into following topics for each question:

I. treatment of the issue in the EIA documents

II. bilateral consultation (visit at the plant included)

III: conclusion and recommendation

2 SUMMARY

This evaluation of the bilateral consultation compares the information provided by the EIA documents, with the information the Austrian delegation received within the Bilateral Consultation according to the EIA-Directive/ESPOO Convention, concerning NPP Cernavoda Units 3 and 4, in Bucharest on March 18th/19th, 2008. The consultation consisted of a visit at the plant site and the meeting at the Ministry of Environment and Sustainability in Bucharest.

The issues discussed mainly concerned:

- the risk of significant radioactive emissions caused by malfunctions in the planned Cernavoda NPP Units 3 and 4.
- the actual status of the construction of the existing buildings.
- design improvements for NPP C 3/4

In preparation of the consultation the Austrian Institute of Ecology elaborated several questions to be discussed with the experts of the applicant for the construction license. The discussion was characterised by great transparency. We received a lot of information, most of our questions have been answered. Because the discussion time during the meeting at the Ministry was limited, we are pleased that we could take with us all the presentations of the NPP's experts. Later on we received additional information material about planned changes and some maps. in the fiollowing we present some recommendations, concerning the main topics discussed during the consultation

1. Status of the buildings

Before resumption of construction work NPP C 3/4 , the Romanian experts stated that an extensive investigation of the concrete structure will be carried out. In particular, we recommend to prove the reinforced concrete parts on top of the containment, where the original steel rods stick out of the concrete since the 1980ies (outdoor!). At these structure boundaries water could have invaded into the concrete structures, which could have caused damage by frost during winter time. Before the resumption of construction work containment and reactor building's structure should be in pristine condition. We recommend to request information about the results of the investigation of consequential repair work at the reactor building's reinforced concrete structure.

2. Reactor core

Several improvements are proposed for Cernavoda units 3/4. We appreciate the recent information about planned safety improvements.

According to the operator the simultaneous random failure of more than one fuel channel is of low probability and therefore not considered as a design basis event. Further propagation by impact of pipe whip has been examined. It is not said in which document this analysis is explained, but it should be verified by the safety assessment. To observe the integrity of fuel rods and tubes during operation is an important part of aging managment.

The new moderator make up and cooling system which could be used for removing the decay heat from the reactor core, if the low pressure ECCS is not available. This process system will be equipped with both a water source and a cooling pump separated from the process water sources and pumps (Emergency water supply /004). Another important improvement concerns the end shield cooling of the calandria.

The realization of such improvements will be a contribution for the prevention of severe core damage. Information about their completion and verification of their function in the safety assessment is recommended.

3. Containment

Containment behavior in case of BDBA has not been discussed within the consultation. But we were informed that a PSA level 2 will be carried out. Information about the results would be of high interest for Austria (large release frequencies and related release fractions for different nuclide groups).

The issue of hydrogen build-up is ignored in the EIA documents, but igniters are installed in the RB – the igniter's power supply is from EPS. It is said that the igniters alone are supposed to be enough.However, the installation of passive recombiners is discussed. We recommend the installation of passive hydrigen recombers, because the are independent of supply systems.

4. Seismic

Since earthquake is the main risk for common mode failures probably concerning the whole plant, it is of major interest to Austria to continue the discussion on the impact of common mode failure events considered as BDBA.

A crucial issue is the potential impact by an earthquake to the common water intake and pump house. Common mode failures are possible also at the discharge systems. Their probability is said to be lower than 10E-6, exact values have not been provided. Many technical improvements are planned, but not brought to a finish in design. Romanian experts explained that there are or will be two alternative water supply tanks per unit, each 1,500 m^3 volume, for emergency supply in case the common water intake is blocked. There is also an additional, completely separated water intake. The additional intake does not use common structures as pipelines, also the pumps are separated. At the maps only tanks for fire water are visible. The verification of the implementation additional emergency water tanks for each unit is of high importance to minimize the impact of external events to the common water supply system.

While of course it is not obligatory to take into account the recommendations of the IAEA draft safety guide on evaluation of seismic hazards for existing NPPs published in 2007, it is advisable to do so, in order to ensure that the latest scientific findings are considered within the plant design.

5. Safety assessment

According to additional information material from AECL (AECL CANDU6, 2007) the development of CANDU 6 improvements from Wolsong 1 to Wolsong 2/3/4 and to Qinshan 1/2 includes a impressive list of systems.In order to get a comprehensive overview on the safety status of the new Cernavoda units, we recommend to request which of these impovements ared implemented in NPPC 2 and which will be realized in CNPPC 3/4.

The improvements in design stage, such as Shield Cooling System, Moderator Makeup System, additional water tanks, new design of the seal plates and isolation valves and improved ergonomics of the control room, haven't been been brought to a finish in design at the time of the visit. The new information material contains more details. However, we recommend to observe their realisation and to demand the verification of their function in the safety assessment.

A worst case concerning the release of radioactive substances to air has not been discussed by the Romanian experts. The Preliminary Safety Analysis Report (PSAR) will be submitted as part of the application for the construction license. It is not available at the present time. An open question is whether early containment failure can be prevented in all event sequences and are there event sequences (regardless of their probability of occurrence) which could cause emissions > 2% of the Cs-I inventory of the core.

We recommend to demand the PSAR document, when finished and the results of the PSA level 2, in order to further evaluation of potential emissions which could be relevant for transboundary impact. PSA results of NPP C3/4 compared to unit 1 and 2 could be used for the verification of the efficiency of the safety improvements.

3 EVALUATION OF INFORMATION

3.1 Status of the buildings of NPPC 3/4

We request more detailed information of the construction status and arrangements inside the reactor building (containment) and service building.

I. treatment of the issue in the EIA documents

The EIA report (ICIM 2007) does not provide sufficient information about the conditions of the buildings after the long construction break, and whether or how the buildings have been mothballed during this period. At the time of grid connection of the units 3 and 4, the design of the civil structures will be more than 20 years old.

II. bilateral consultation

Unit 3 Reactor Building: Structural concrete of the Containment Structure base slab, perimeter wall, lower ring beam, lower dome and upper ring beam, 90% of the Internal Structure structural concrete works have been completed; Unit 3 Service Building: All structural concrete of the superstructure and its foundation concrete works have been completed. All structural steel has been completed up to Elevation 109.0 m. Unit 4 Reactor Building: Structural concrete of the Containment Structure; base slab, perimeter wall and lower ring beam has been completed. Internal structure concrete works partially completed; Unit 4 Service Building: All foundation concrete has been completed. There is no technical equipment for operation of the units inside the buildings yet (ANSWERS 2008).

During operation, the “Spent Fuel Discharge Room” (R001) is not always part of the containment. It is separated from the containment with a stainless steel valve, and opens, when the fuel loading machine has docked to discharge spent fuel. At this time a second valve in the middle of the transfer canal closes, and the inner part of the canal plus discharge room is part of the containment. after discharging the valve to the containment closes and the canal valve’s status changes to open. At this status the discharge room and transfer canal are part of the service building.

There was a Preservation Programm started for existing parts, right after the work at the buildings was interrupted. There will be an investigation and repair program (non destructive testing of concrete structure). This is planned to be finished during the time of preparation of construction.

III. conclusion and recommendation

The above mentioned investigation program should in particular focus on the investigation of the reinforced concrete parts on top of the containment, where the original steel rods stick out of the concrete since the 1980ies (outdoor!). At these structure boundaries water could have invaded into the concrete structures, which could have caused damage by frost during winter time. Before the resumption of construction work containment and reactor building's structure should be in pristine condition.

We recommend to request information about the results of the investigation of consequential repair work at the reactor building's reinforced concrete structure.

Are any improvements planned, compared to unit 1 or 2?

I. treatment of the issue in the EIA documents

The EIA documents (ICIM 2007) and (CITON 2006) do not provide sufficient information about improvements planned to implement within the completion of units 3 and 4.

II. bilateral consultation

Reference Plant for Unit 3&4 will be the as-commissioned NPPC 2 plant. Examples of planned design changes concern the Shield Cooling System; Moderator Recovery and Makeup System; strengthening the design of the seal plates and the containment extensions (including isolation valves); improved ergonomics of the control room (ANSWERS 2008).

The Moderator Makeup System uses both a water source and a cooling pump separated from the other water sources and pumps (these informations were given orally during the meeting). Neither a detailed design nor any maps of the moderator makeup system and most of the other improvements (see chapter 1.c. of this evaluation) have been completed at the time of the visit. Informative maps and drawings of significant changes of the arrangement of SSC's due to improvements (intake and discharge points, channels, moderator makeup system, additional tanks, common parts and others) not being presented in the EIA documents (ICIM 2007) and (CITON 2006) have been requested.

In April 2008 we received additional information describing design modifications planned for Cernavoda 3 and 4:

- Control Room: The Control Room has been updated for Qinshan. AECL recommends the same upgrade for Cernavoda 3
- Strengthening the design of the seal plates and containment extensions for MSLB + Failure of Dousing
- Provision of Recovery System for Moderator and PHT (addition of Moderator Makeup System/MMS) to ensure the effectiveness of the moderator as a heat sink. The MMS was considered for Cernavoda 2, but the concept was insufficiently developed for implementation.
- Shield Cooling System Improvements (24-inch rupture disc on inspection port, as included in Point Lepreau planned refurbishment) (MDM, 2008):

III. conclusion and recommendation

The planned improvements, such as Shield Cooling System, Moderator Makeup System, additional water tanks, new design of the seal plates and isolation valves and improved ergonomics of the control room, haven't been been brought to a finish in design at the time of the visit. The new information material contains more details. We appreciate the information about these safety improvements. Information about their completion and verification of their function in the safety assessment is of high interest for Austria.

Are there safety improvements which cannot be carried out because of the actual construction status? (e.g. wall thickness)

I. treatment of the issue in the EIA documents

The next generation of CANDU reactors is planned to have a containment building with steel lined 1.8 m thick walls, designed to withstand external events such as earthquakes, tornado, floods, aircraft crashes and malevolent acts (PETRUNIK 2007). The EIA documents exclude most external impacts from discussion because of their low probability of occurrence.

It is not clear whether improvements could be required for enhanced seismic resistance, or for protection against aircraft strike, terrorism and sabotage. The EIA documents (ICIM 2007) and (CITON 2006) do not provide sufficient information about this issue.

II. bilateral consultation

The thickness of the containment structure cannot be altered. While some safety improvements are limited due to existing structures, there are other safety improvements that can still be implemented with the current layout of the Units 3&4 (see Q1b). Possible are improvements like: to arrange a steel liner inside of the transfer- tunnel of the defuelling machine. This Improvements follow the results of PSA at U1: e.g. an additional emergency water intake, with separate pumphouse and pipes.

According to additional information material from AECL (AECL CANDU6, 2007) several improvements have been implemented at Wolsong 2/3/4 and Qinshan 1/2.

Development from Wolsong 1 (1983) to Wolsong 2/3/4:

- New trips on SDS1/2 added
- Addition of Main Steam Isolating Valves (MSIV)
- ECC availability improvements – Additional ECC HX
- Annulus gas recirculation
- Extensive environmental qualification
- Steam line break protection by rerouting lines
- Addition of a Post LOCA Instrument Air

Development from Wolsong 2/3/4 (1997/98/99) to Qinshan 1/2 (2002/03):

- Stainless steel liner added to:
  - Spent fuel transfer bay (implemented, see (ANSWERS, 2008))
  - Spent fuel bay
  - Spent resin tanks
  - All R/B active drainage sumps
  - All S/B basement drainage sumps
- Fire protection enhancements:
  - Improved redundancy
  - Detectors and fire sprinkler nozzles within the charcoal filter

- Main steam lines redesign:
  - Relocation of the main steam lines and feedwater lines
  - Reinforcement of the S/B roof above the MCR area
- MCR more ergonomic and plant display design (already implemented, see (MDM, 2008))
- Enlarged SCA

III. conclusion and recommendation

Apart from the containment wall, there were no improvements named, which could not be implemented because of the construction status. But the documents named several modifications which have been or will be implemented in NPP C 3/4 design.

From the recent documents cited above it is not possible to decide which of the improvements at other CANDU6 reactors are already or will be implemented in Cernavoda 3 and 4 design. We recommend to observe their realisation and to demand the verification of their function in the safety assessment.

Maps and section drawings of the buildings would be instructive to evaluate interferences and common mode failures (e.g. due to breakdown of common auxiliary systems).

I. treatment of the issue in the EIA documents

The Cernavoda CANDU 6 reactors are stand alone units, but some technological services at Cernavoda NPP are common for all units. Interferences between the units which will lead to common mode failure are excluded by Nuclearelectrica. But it is agreed that the shared water intake and discharge system is vulnerable to common mode failure (for the shared discharge canal an alternate route is available).. Since detailed maps and exploded drawings of the buildings have not been provided by the EIA report (ICIM 2007), an evaluation of potential impacts of external events, influence of one plant on another and effects of common mode failures at the site is not possible in a professional way.

II. bilateral consultation

There are no interferences between the 4 units, which could lead to any common mode failure. Common mode failure only can take place at the intake and discharge systems, which are shared. A review shows that the probability of common mode failure due to the shared intake has a very low probability. The shared discharge has even lower probability, as an alternate route is available at all times. Common mode failure probability is lower than 10E-6.

Following informations were given during the consultation (orally): The Moderator Makeup System uses both a water source and a cooling pump separated from the other water sources and pumps. There are 2 alternative water supply tanks per unit, each 1,500 m^3 volume, in case the common water intake is blocked. There is an additional, completely separated water intake. The additional intake does not use common structures as pipelines, also the pumps are separated. The additional intake is located near the main intake, but deeper in the ground. It was said that “as long there is groundwater and as long as the Danube flows”, this additional water supply provides water. For a better understanding maps with the location of the additional tanks, the additional underground intake and the additional pumps have been requested by the Austrian Experts.

Among the figures and maps we received in April one figure 6: (GEN.LAYOUT, 2008) shows the location of two domestic tanks with a volume of 1000 m³ each, as well as the location of the domestic water supply.

III. conclusion and recommendation

Common mode failures are possible at the intake and discharge systems. Their probability is lower than 10E-6, exact values have not been provided. Many technical improvements are planned, but not brought to a finish in design. Maps and drawings of locations (with declaration of the depth) of these separated non-common underground water intakes, channels and pumps etc. (belonging to the Moderator Makeup System, the alternative water supply tanks etc.) are of large interest in order to evaluate the probability of common mode failures. From the recently received additional figures only the general layout (fig,6) shows the Cernavoda site. The figures showing the R/B and parts of the plant are CANDU 6 general information. Therefore some questions concerning common mode failures are still open:

1. Within the visitation of Cernavoda NPP on 18th of March, 2008 and the consultation in Bucharest on 19th of March, 2008, the Romanian experts provided the information, that there Common mode failures are possible at the intake and discharge systems. Their probability is lower than 10E-6, exact values have not been provided. Many technical improvements are planned, but not brought to a finish in design.
2. The map shows the location of Emergency Water Supply (Description Code 004), but It does not provide information about
   - which water source is used, groundwater or water from the water channel?
   - the depth of the intake duct – under groundlevel and the separated location of pump and electric power supply?

In order to assess the common failure risk due to complete pump house destruction, these informations is important.

Another open question is the location of the SCA (secondary control area) which was said to be somewhere protected at the bottom of the R/B, but is not shown in the figures.

The exact values of common mode failure probabilities due to the shared intake as well as the shared discharge have not been clarified and still remain of large interest, since Austria is not only interested in DBA's, but also in BDBA's which could significantly affect Austria's territory. The verification of the implementation additional emergency water tanks for each unit is of high importance to minimize the impact of external events to the common water supply system.

Moreover, we want to discuss the capability of the buildings to withstand external impacts as plane crash, earthquake, missiles (e.g. caused by interferences of one unit to the next one).

I. treatment of the issue in the EIA documents

Reactor building and service building are seismically qualified corresponding to the design basis earthquake. However, external threats such as natural disasters, air plane crash and other human impacts like terrorism and sabotage are not considered in the design, because their frequency of occurrence is assumed to be very small (< 10E-6). The capability of the buildings to withstand external impacts are not discussed in the EIA documents (ICIM 2007) and (CITON 2006).

II. bilateral consultation

Plane crash: The probability of an aircraft crash is about 10-7; therefore aircraft crash is not a design basis event for CANDU 6 plants. CANDU design has inherent characteristics that protect from this type of event. Two-group separation will allow the safe shutdown of the reactor. Shutdown mechanisms are physically located in two areas separated and protected by thick reinforced concrete walls and slabs. Two separate areas to initiate shutdown, Main Control Room (MCR) and Secondary Control Area (SCA). See for more detail in (ANSWERS 2008). Cernavoda 2 has been assessed by AECL for the ability to withstand such events. The study has shown that structural robustness provides for protection against light aircraft crashes. For a range of commercial airliner types, the containment structure would maintain its integrity.

Earthquake: CANDU 6 at Cernavoda has been conservatively qualified for a design basis earthquake with a peak horizontal ground acceleration of 0.2 g using the Canadian Standards Association N289.3 Standard Ground Response spectra. CANDU 6 design is conservative. This leads to the fact that CANDU 6 plants can survive much higher earthquake levels (i.e. > 0.3 g). SNN has recently performed a Probabilistic Seismic Hazard Assessment (PSHA) which was used in a seismic PSA for unit 1 of Cernavoda. The results of the PSHA and PSA were reviewed and endorsed by the IAEA. The results of the Cernavoda 1 PSA indicated that there are some design upgrades and replacements need to be implemented to increase the seismic robustness of the plant. The experience from this assessment and unit 2 construction will be evaluated for implementation in the Unit 3 & 4 units.

Missile penetration: Analysis has been performed for missiles of significant size, weight and speed impacting directly on the building. None were found to penetrate through the containment wall. The design of Cernavoda NPP U2 took into consideration a series of external event analyses (shipment of dangerous products, aircraft crash etc.) that could affect the plant; these issues are presented in Chapter 2 of FSAR. There is a probability of 10^{-6} events/year that the missiles coming from the turbine-generator may damage the MCR; in this case, the SCA remains available, so the plant can be shut down in safe conditions. There is a maximum probability of 10^{-8} that the missiles hit the equipment in the R/B, a value lower than 10^{-7} events/year, so that the event is considered not credible.

III. conclusion and recommendation

The (ANSWERS 2008) state that resistance is sufficient against light aircraft crash, but without specified data on weight and velocity. An open question is still which commercial airliners could jeopardize the containment structure's integrity, and how the development of commercial flights in this region is assessed for the future.

There is also the open question of military flights in this region and their potential to endanger the containment structure.

Regarding earthquake, CANDU 6 plants are said to be conservative in seismic design and therefore are able to survive much higher earthquake levels (i.e. > 0.3 g peak horizontal ground acceleration) than the DBE with 0.2 g (which is the Canadian Standard). Furthermore, the results of a recently performed PSHA were used within the Cernavoda 1 PSA, which resulted among others in the need of some design upgrades and replacements in order to increase the seismic robustness of the plant. (for evaluation see section 4.Questions concerning seismic hazard)

Regarding missile penetration, there is a probability of 10^{-6} events/year that missiles coming from the turbine-generator may damage the MCR. In this case, the SCA remains available. Missiles hitting the equipment in the R/B is not considered as a DBA due to the probability of 10^{-8} events/year.

We recommend to demand to be informed about results of the preliminary safety assessment concerning external impacts to NPP Cernavoda 3/4.

3.2 Questions concerning the reactor core

The pressure tubes are the pressure bearing barriers of the core. Degradation of these pressure tubes, end fittings and feeder pipes is a generic problem of CANDU units, also observed in NPPC-1. Are any improvements planned concerning the material and design for the pressure and calandria tubes (as in Wolsong & Quinshan)?

I. treatment of the issue in the EIA documents

There have been problems with delayed hydride cracking as a result of deuterium-zirconium alloy reactions in several CANDU reactors. These problems with CANDU pressure tubes persist (EX-STAT 2007). Hydride cracking and fretting were observed in the last years at the Cernavoda-1 plant in Romania, which only started operation in 1996 (RADU 2003). Improved pressure tube material was used in Wolsong 2, 3, and 4 and for the Quinshan units to reduce impurities, minimize hydrogen content and further improve fracture toughness (AECL 2005).

The EIA documents (CITON 2006) and (ICIM 2007) do not provide sufficient information about improvements planned concerning the material and design for the pressure and calandria tubes.

II. bilateral consultation

In the past, at some CANDU plants the feeders have thinned more than expected. So the material used and the methodology for installation has been changed for all future. Material of the tubes was not subject to change. Cernavoda 1 and 2 already have the improved pressure tube and feeder design. The improvements which were implemented are:

- new type of garter springs
- high Chromium concentration on feeders material to mitigate the Flow Accelerated Corrosion phenomena;
- improvements of feeders manufacturing process by heat treatment of feeders to release the residual stress.

Regarding the pressure tube and calandria tube materials, the Cernavoda 1 and 2 have the same material as Quinshan and Wolsung. Fuel channel assemblies and feeders are periodically inspected as part of the mandatory "Periodic Inspection Program" and the results are communicated to the Romanian Regulator (CNCAN). The first CANDU reactors have experienced primary system pipe rupture due to "hydride brittle cracks". Due to change of material and control of the layer of the tubes this problem no longer exists.(delayed hydrid cracking can be monitored by diameter expansion – indicated by garter spring's position, for measuring the hydrid content, scraping inside the tube is required)

III. conclusion and recommendation

D_2O loss monitoring during operation and periodic inspection of the pressure tubes were explained as an important system to prevent breaks and failures in the PHTS;

At each outage an appropriate selection of 10 to 20 channels are inspected – Data collection is required for aging management and is also subject of scientific knowledge exchange in the CANDU Owners Group. All improvements identified in time from operating experience and R&D Program will be implemented to the Cernavoda units 3 and 4.

The EIA report states that the calandria vessel is able to cope with a simultaneous break of pressure and calandria tube. Are the relief ducts required if more than one tube is affected?

I. treatment of the issue in the EIA documents

According to the EIA documents (ICIM 2007) and (CITON 2006) it is unclear why relief ducts at the calandria vessel are required, if the calandria vessel is able to withstand the pressure caused by a simultaneous break of a pressure tube and calandria tube.

II. bilateral consultation

The simultaneous break of one calandria tube and its inlying pressure tube is considered in the design basis for the CANDU 6. Following hypothetical in-core break events, the calandria vessel will be subjected to additional loadings because of pressurization in the calandria vessel due to incompressibility of the liquid phase. In the short term, the calandria shell pressure reaches a very high peak value (within about 20 ms). These short duration pressure spikes have found not to impart sufficient energy to the large and massive reactor structure to result in significant pressure boundary displacements.

The associated stresses are consequentially low and are bounded by the stresses resulting from the steady state pressures. In the longer term, the pressure rise in the moderator is limited by opening of calandria relief pipe rupture discs (within 5 seconds). This results in a subsequent reduction of the calandria pressure. The long-term moderator pressure does not threaten calandria integrity.

The simultaneous random failure of more than one pressure tube/calandria tube is of sufficiently low probability that it is not considered as a design basis event.

In order to assess the integrity of the adjacent fuel channels the various possible failure modes of the fuel channels were examined and showed that the adjacent channel integrity was maintained considering the impact by the pipe whip, fuel ejection, and jet impingement. That is propagating channel failure will not occur.

III. conclusion and recommendation

The simultaneous random failure of more than one fuel channel is of sufficiently low probability and therefore not considered as a design basis event. To observe the integrity of fuel rods and tubes during operation is an important part of aging managment. Further propagation by impact of pipe whip etc. has been examined. It is not said in which document this analysis is explained, but it should be verified by the safety assessment. The results are of high interest in order to assess the frequency and impact of a large release to the environment and therefore not only for Romania but also for potential transboundary emissions.

To observe the integrity of fuel during opartion is an important part of aging managment

The qualification of the moderator cooling system as an emergency system for residual heat removal should be clarified. Which other operational systems shall be qualified for emergency procedures?

I. treatment of the issue in the EIA documents

In the EIA report (ICIM 2007) it is argued that, in case of an accident, the moderator could cool the decay heat of the core, provided that the reactor shutdown system had stopped the fission process. The capability of the moderator circuit and the cooling water in the calandria vault to remove the residual heat if the primary heat transfer system fails is not explained sufficiently.

II. bilateral consultation

Breaks in the primary heat transport system (HTS) piping are considered in the design basis for the CANDU 6. For these events, the ECCS is designed and credited to automatically respond to the break.

The moderator system is a safety related process system which is used to cool the reactor core if a large break in PHT occurs and Emergency Core Cooling System (ECCS) is not available. The moderator system is credited to cool the fuel and maintain channel integrity. These events results in the pressure tubes heating up and diametrically expanding to contact its corresponding calandria tube. Heat from the fuel is transferred to the moderator fluid, which is cooled by the moderator cooling system. The coincident loss of the moderator cooling system for the above event is considered to be BDBA. However, if such an event were to occur, the moderator fluid would then heat up and eventually start to boil off. There is a sufficiently large inventory of moderator fluid in the calandria vessel that cooling would continue to be available for a period of hours. During this time, the operator has the capability to provide cooling water to the calandria vessel using the new moderator makeup system, proposed for Cernavoda, Units 3 and 4, thereby ensuring that the calandria vessel remains full.

III. conclusion and recommendation

The new moderator makeup system proposed for Cernavoda units 3/4 the moderator can be used for removing the decay heat from the reactor core, if the low pressure ECCS is not available.

It was stated during discussion that the moderator makeup system uses both a water source and a cooling pump separated from the other water sources and pumps.

The realization of this additional cooling system would enhance the cooling capacity in case of unavailability of the ECCS itself. This could be a contribution to prevent severe core damage. Verification of the realisation would be of interest for Austria.

3.3 Questions concerning the containment

Which standards are taken as design basis for the containment?

I. treatment of the issue in the EIA documents

From the EIA report it is not clear according to which standards the containment and its systems are designed. The information given is only that Unit 1 will be the reference for unit 3 and 4. Unit 2 was designed to standards which are probably outdated now. Therefore a discussion about which Canadian and which IAEA standards will be met by the new Cernavoda NPP units is required.

II. bilateral consultation

A list of standards (requirements and procedures) has been provided the Austrian Experts. For further information see (ANSWERS 2008).

III. conclusion and recommendation

The list indicates that actual standards have been considered.

The complexity of containment systems could increase the containment failure risk under severe accident conditions. Therefore, containment behavior during beyond design basis accidents should be part of the discussion at the consultation.

I. treatment of the issue in the EIA documents

The EIA report makes clear that containment isolation relies on a complex of (active) safety systems. Their function is explained in some details. However, some information is missing, e.g. it is not clear from the EIA report how many parts of the dousing system are necessary to prevent a containment failure.

In general, important issues of containment reliability, such as the complexity of the containment systems and it's behavior under severe accident conditions, are not discussed. Containment behavior in case of BDBA is not dealt with in EIA report (ICIM 2007).

II. bilateral consultation

The design features related to containment systems to cope with accidents are the "containment isolation", the "dousing system", the "local air cooler" and the "hydrogen control". Upon detection of high-pressure conditions, the dousing system is automatically actuated for pressure suppression.

The total dousing water inventory is ~1,500 M. (ANSWERS 2008). Depressurization by dowsing can be ensured by 4 out of 6 nozzles.

The long-term containment heat sink is provided by the local air coolers (LACs).

There are implicit containment heat sinks that may play an important role in the mitigation of severe accident conditions: Moderator heat sink and Shield cooling. Recovery of moderator cooling can arrest the severe accident early on (failure of moderator cooling is a pre-requisite for severe accident conditions). In the long-term, the shield cooling system can reduce the heat input into the Reactor Building. (ANSWERS 2008)

In contrast to an explanation during the NPP visitation it was stated by the Romanian experts at the meeting, that "venting of containment air through the ventilation is only for post accident conditions -not for pressure relief".

The issue of hydrogen build-up is ignored in the EIA documents, but igniters are installed in the RB -the igniter's power supply is from EPS. Installation of passive recombiners is discussed – but igniters alone are supposed to be enough. (for further information see (ANSWERS 2008))

Severe Accident Management Guidance (SAMG) contains strategies to mitigate the severe accident conditions. In addition, low probability severe accidents that lead to severe core damage are analyzed in the context of the level-2-PSA.

III. conclusion and recommendation

Containment behavior in case of BDBA has not been discussed within the consultation. But we were informed that a PSA level 2 will be carried out. Information about the results is of high interest for Austria.

In case of a severe accident interaction of steam and zircalloy in the reactor core could result in hydrogen buildup in the containment. This could lead to explosions and damage of the containment. Which measures are planned in order to avoid such situations (e.g. hydrogen recombi-nation)?

I. treatment of the issue in the EIA documents

The large zirconium inventory of the CANDU core reacts exothermically with steam at the temperature which could be reached in a severe accident, this reaction yields hydrogen. Hydrogen gas is a threat for the containment stability, because it reacts explosively with containment air (EX-STAT 2007). Hydrogen recombination is not mentioned in the EIA documents (ICIM 2007) and (CITON 2006).

II. bilateral consultation

To mitigate issues due to the short-term releases of Hydrogen, Hydrogen igniters are installed in the R/B. In addition, SNN will evaluate the installation of Passive Auto-Catalytic Recombiners (PARS), which have been used on other projects.

III. conclusion and recommendation

Hydrogen igniters and maybe Passive Auto-Catalytic Recombiners are going to be installed in order to meet the needs due to the hydrogen buildup issue. The evaluation of the installation of Passive Auto-Catalytic Recombiners (PARS) should be communicated to Austria, because it is a relevant measure to reduce the hazard of radioactive emissions due to containment failure.

Is an improvement of tritium retention planned for NPPC 3/4?

I. treatment of the issue in the EIA documents

During normal plant operation tritium is transferred to the secondary circuit by diffusion (ICIM 2007). Furthermore, the EIA report points out, that under abnormal conditions there might be unmonitored releases of vapor, which could be contaminated with deuterium, tritium, radioactive aerosol particles and gases. (EX-STAT 2007). The EIA report (ICIM 2007) does not provide information about improvements of tritium retention planned for NPPC 3/4.

II. bilateral consultation

The heavy water systems in the CANDU design have been extensively engineered to ensure leak tightness, high integrity and high reliability. Public dose remains well below an operating target of 50 μSv/a, For further reduction of tritium emission at Units 1, 2 and later on to Units 3&4 Nuclearelectrica is considering the installation of a tritium removal facility on Cernavoda NPP site. Subsequently, the feasibility study for tritium removal facility for Units 1&2 has been approved. Currently, design and licensing activities are in progress. According to the project schedule approved together with the feasibility study, the due date for finalization of this facility is 2012.

III. conclusion and recommendation

Because of the notoriously high tritium emissions of CANDU plants into the environment we appreciate that Nuclearelectrica is going to install a tritium removal facility for NPPC unit 1/2 and later for unit 3/4.

3.4 Questions concerning seismic hazard

The scientific basis for the evaluation of site seismology and seismic design has essentially evolved during the last years.

I. treatment of the issue in the EIA documents

Romania is one of the most active earthquake regions in Europe besides Italy. Earthquake risk is a much-discussed problem of the Romanian NPP. This concerns seismic qualification which is of importance for the safety systems and safety related systems as well as the buildings, the reactor core design, fuelling machine and the storage pool for spent fuel. According to the EIA report (ICIM 2007), the relevant systems and buildings are designed to withstand the design basis earthquake (DBE). As it was stated in the Austrian Expert Statement new developments of science should be considered in the seismic evaluation of the plant:

As stated in the recent IAEA draft safety guide DS383 published in 2007, the scientific basis for the evaluation of site seismology and seismic design has essentially evolved during the last years. For example, it is stated, that although peak ground acceleration is a parameter widely used to scale the seismic input, it is also a known technical finding that the ability of seismic ground motions to cause damage to SSC’s that behave in a ductile manner is not well correlated with the peak ground acceleration level. Numerous field observations and research and development programmes have demonstrated, that a high capacity seismic design relies on ductile behaviour in accommodating large strains rather than on the balancing of large calculated forces (IAEA DRAFT 2007). An other relatively new seismic issue is “ageing”. During seismic evaluation, ageing degradation due to ageing effects that reduce the seismic capacity of SSC’s should be considered (IAEA DRAFT 2007). Further more the draft recommends, that, as a general principal of any seismic safety evaluation to be performed for an existing nuclear installation, the evaluation should be made considering the current state of the installation at the time when the assessment is performed (IAEA DRAFT 2007). The buildings of units 3 and 4 have to be seen as an existing installation, since the majority of the concrete construction work has been completed during the 80ies. The EIA report (ICIM 2007) does not give sufficient information about considered guidelines.

II. bilateral consultation

It will be examined by the Romanian side, in how far the recommendations of the draft safety guide (IAEA DRAFT 2007) have already been considered. Since the new safety guide of 2007 is in a draft status, it is of course not obligating to consider the recommendations. On one side, Nuclearelectrica promised to take the recommendations into account, because it would be a matter of a win-win-situation, and due to the fact, that they are co-authors of this draft, they are quite sure that some recommendations have already been considered (orally). On the other side, the Romanian Regulatory Authority objected, that they will not consider unpublished recommendations, as long as they can be subject of changes.

III. conclusion and recommendation

While of course it is not obligatory to take into account the recommendations of the draft published in 2007, it is advisable to do so, in order to ensure that the latest scientific findings are considered within the EIA.

More detailed information on the studies cited in the EIA documentation concerning the methods and scientific basis of the analysis are required, because these studies were not available to us. A discussion of results of the level-1-PSA of seismic events for NPPC 1 and the lessons learned from that PSA should be presented.

I. treatment of the issue in the EIA documents

The EIA report describes the NPP site as having unique properties being a stable island in an earthquake region. The Cernavoda NPP site can be influenced by 7 seismic sources and the zone around the Cernavoda Nuclear Power Plant is affected by faults, but these faults are old and sealed and they didn't move at least since Paleogene. Moreover studies made by the Faculty of Geology of the University of Bukarest showed, that within Cernavoda area it can be specified that morphologic features are due to erosion, not to active tectonic processes. Taking into account the whole geological context and the tectonic evolution of the zone around the Cernavoda Nuclear Power Plant, on a radius of over 50 km, it results that this one is tectonically stable, without recent reactivations and without obvious elements of tectonic activity (ICIM 2007).

On the other side, the IAEA safety guide No. NS-G-3.3, published in 2002, provides recommendations on how to determine the ground motion hazards for a plant at a particular site and the potential for surface faulting. Within this, 4 regions have to be analysed: regional scale (150 km of radius), near regional scale (25 km of radius), site vicinity (5 km of radius) and site area scale (1 km of radius). Very important are so called palaeoseismological investigations. The studies cited in the EIA report concerning the methods and scientific basis of the analysis have not been available to us. More detailed information on these studies are required in order to discuss the issue. It is not clear, in how far the recommendations of the safety guide NS-G-3.3 published in 2002 (IAEA 2002b) have been taken into account.

Furthermore, there are no results of the SL-1 PSA of seismic events for the NPPC1 presented within the EIA report (ICIM 2007).

II. bilateral consultation

For Cernavoda NPP, the most recent scientific data for evaluation of site seismology and seismic design were used to perform in 2005 the studies "Probabilistic Seismic Hazard Assessment (Paul C. Rizzo & Associates) for Cernavoda NPP" and "Level 1 Probabilistic Safety Assessment. Seismic Events Analysis for CNE Cernavoda Unit 1" (for further information see EIA report). These scientific studies were evaluated with positive conclusions by both CNCAN and IAEA. The general methodological basis of this analysis meets the requirements of EPRI 1002989 – Seismic Probabilistic Risk Assessment Guidelines. The plant vulnerability to seismic core damage event is analyzed using the internal-events PSA as the basis. It should be noted that ground acceleration ranges for the third seismic initiator (0.3 to 0.4 g) dominates the risk (more than 50%). The next dominating seismic initiator is the second one (0.2 to 0.3 g ground acceleration ranges), contributing with about 25% to seismic risk. This is an expected result since the CNE PROD design basis earthquake is 0.2 g. Based on the results from seismic PSA, areas of plant improvement were identified and actions were already taken to reduce the dominant contributors. Such actions include the elimination of interactions between various electrical/I&C cabinets and the improvement of block walls near the Class I and Class II batteries.

The Austrian experts criticism regarding the possibly too small region (50 km radius) considered within the seismic investigations presented in the EIA documents (in opposite to the recommendations of the IAEA safety guide (IAEA 2002b), to investigate a region with 150 km radius) was objected by the Romanian delegation. Regarding the information of the Romanian Delegation (verbally), a region with a diameter of 350 km was considered within the seismic investigations and evaluations. Therefore the information provided in the EIA report (ICIM 2007) was simply misleading. According to the experts of Nuclearelectrica the EIA documents are outdated in this respect.

III. conclusion and recommendation

The information provided on both the seismic studies cited in the EIA report and the level-1 PSA show that improvement such as elimination of interactions between various electrical/I&C cabinets and the improvement of block walls near the Class I and Class II batteries could reduce the impact of seismic events to the plant. All information about such areas of plant improvement and the resulting reduction of the dominant contributors data should be provided to Austria in order to evaluate the seismic hazard for the core integrity.

Safety margins in the seismic design are of high importance because earthquake is the main risk for common mode failures probably concerning the whole plant (4 NPP units, SF and operational radioactive waste storage). Information about safety reserves in seismic design should be provided.

I. treatment of the issue in the EIA documents

Safety margins of the seismic design are still an important open question. The geological studies quoted in the EIA report (ICIM 2007) are from 2004, made by the University of Bucharest. There is also stated that the seismic analysis has been approved by an IAEA experts mission. Since only results of these studies are quoted, the argumentation that the seismic qualification levels are sufficient is not sufficiently explained.

Moreover, it has to be considered that all four reactor buildings at the Cernavoda site are co-located in a small area and rely on several common systems located in common buildings. In the same area, all the spent fuel is collected in the fuel bays and there is also the interim storage. Thus, an earthquake for which the plant is not designed could lead to a large disaster.

Information on the seismic design safety margins is not included in the EIA report (ICIM 2007).

II. bilateral consultation

As already discussed above in this evaluation, CANDU 6 at Cernavoda has been conservatively qualified for a design basis earthquake with a peak horizontal ground acceleration of 0.2 g using the Canadian Standards Association N289.3 Standard Ground Response spectra. CANDU 6 design is conservative. This leads to the fact that CANDU 6 plants can survive much higher earthquake levels (i.e. > 0.3 g). SNN has recently performed a Probabilistic Seismic Hazard Assessment (PSHA) which was used in a seismic PSA for unit 1 of Cernavoda. The results of the PSHA and PSA were reviewed and endorsed by the IAEA. The results of the Cernavoda 1 PSA indicated that there are some design upgrades and replacements need to be implemented to increase the seismic robustness of the plant. The experience from this assessment and unit 2 construction will be evaluated for implementation in the Unit 3 & 4 units.

The common mode failure issue due to external events has not explicitly been discussed.

III. conclusion and recommendation

According to the provided information, CANDU plants are able to survive much higher earthquake levels (i.e. > 0.3 g peak horizontal ground acceleration) than the Canadian Standard DBE with 0.2 g. Furthermore, the Cernavoda 1 PSA resulted in the need of some design upgrades and replacements in order to increase the seismic robustness of the plant. Detailed information about all upgrades and replacements within the measures to increase the seismic robustness of the plant should be provided for evaluation of the seismic hazard issue.

As discussed in chapter 1.d. of this evaluation, it is stated by the Romanian Experts, that common mode failures, which only can take place at the intake and discharge systems, are characterized by a very low probability (information word by mouth: lower than 10^{-6}). The shared discharge has even lower probability, as an alternate route is available at all times. The exact values could not be provided. Since earthquake is the main risk for common mode failures probably concerning the whole plant, it is of major interest to Austria to continue the discussion on this issue, even if the common mode failure events are considered as BDBA.

Why is a 1000 year return period considered for the design basis earthquake, not a 10.000 year return period as in France and Germany?

I. treatment of the issue in the EIA documents

The design basis earthquake is assumed to have an intensity of 8 on the MSK–64 scale and a peak ground acceleration of 0.2 g. The return period according to the EIA report (ICIM 2007) is 1 in 1,000 years. This 10^{-3} recurrence rate chosen as design basis is comparatively brief. Nuclear regulatory authorities in Germany and France stipulate that a recurrence rate of 10^{-4} is assumed as design basis. Thus, the Romanian design does not comply with good international practice. This would require to assume for the design basis of the safe shutdown earthquake (DBE) a recurrence rate of at least 10^{-4}, the same as is used concerning floods.

II. bilateral consultation

The 1/1000-year return period is the basis for C1 & C2, with C2 being the reference design for C3 & 4. This is consistent with Canadian and international practices in place from the 1970's and 80's. The adoption of a 1/10,000 return period is consistent with direction that international practice is following. For Cernavoda NPP, DBE (0.2 g) with return period of 1000 years is defined in site license, issued by Romanian regulatory authority (CNCAN). The Probabilistic Seismic Hazard Assessment (PSHA), done in 2004 for Cernavoda site, estimated that DBE (at 0.2 g) has a probability of occurrence of 10^{-3}, as required by the license. According to PSHA, if DBE is required to have a return period of 10,000 years, the peak ground acceleration will be of around 0.35 g. However, the seismic PSA showed enough design conservatism for all seismically qualified SSC modeled, because they were found with HCLPF capacity (fragility parameter) of 0.45 g to 0.5 g, which is the screening limit according to international standards. The Romanian Experts argue, that since the fragility parameter of the modeled SSC shows a value of 0.45 g to 0.5 g, the seismic PSA has enough design conservatism, due to the fact that a DBE with 10^{-4} recurrence rate having a peak ground acceleration "around 0.35 g".

III. conclusion and recommendation

According to the provided information, the peak ground acceleration of a 10^{-4} recurrence rate DBE is slightly lower than the HCLPF capacity (fragility parameter) of the modeled SSC. Even with a 10^{-4} recurrence rate it seems to be "within the limit", but one should bear in mind, that in fact it is "on the limit". According to the probabilistic consideration 95% of the seismic events will not cause severe damage to the plant. The small remaining risk could cause a beyond design base accident and should be analysed in the plant's PSA.

3.5 Questions concerning safety assessment

Among the design basis accidents (DBA) listed in the EIA some are assessed to cause individual effective doses exceeding 50 mSv (which is the allowed limit for a DBA e.g. in Germany). Therefore, it is unclear why the EIA report concludes that "DBAs and BDBAs have non-significant radiological impacts to the public located outside the exclusion boundary (1 km from the reactor)".

I. treatment of the issue in the EIA documents

In the EIA report some "non-design-base accidents" are presented, which are covered by the Preliminary Safety Report of Cernavoda Unit 2. It is stated, that it is clear that both DBAs and BDBAs for Cernavoda NPP have non-significant radiological consequences for the public located outside the exclusion boundary (1 km from the reactor) (ICIM 2007). Some of the presented DBA scenarios result in very high exposures of people in the exclusion zone, If such high doses are allowed to result from design base accidents, this practice does not comply with good practice in other European countries, where an exposure limit of 50 mSv is allowed for a DBA, instead of 250 mSv as it is in Romania. Without delivering source terms, time tables and energy involved in the accident sequence, understanding of the results concerning exposure presented in the EIA report (ICIM 2007) is not possible.

II. bilateral consultation

According to Romanian legislation, the effective dose in case of DBA, at the borders of the exclusion zone, shall be less than 250 mSv. This requirement was based on US NRC 100.11 CFR. The licensing basis of the latest licensed CANDU 6 also included the requirements of the Canadian Nuclear Safety Commission (CNSC) draft regulatory document, C-6 Rev.0. This document provide the guidance to identify the events that have to be analyzed in the Safety Report that supports the plant license. It also sets dose limits for categories of events, according to their frequency of occurrence, However, for some single failure events (i.e. failure of a process system), more restrictive event classification is imposed, regardless of the event frequency. The accidents listed in the EIA with effective doses exceeding 50 mSv were assessed based on very conservative assumptions, which include the assumption of failure of containment isolation. For other designs and in other jurisdictions, such an accident sequence is considered as beyond design basis, as it has an estimated frequency of less than 1E-5. Analysis indicates that for events with frequency higher than 1E-5/year the public effective dose is smaller than 10 mSv. In fact, this is true for almost all the events with frequency higher than 1E-6 The design basis for CANDU 6 includes events with frequencies lower than 1E-5 which is normally considered as the threshold for design basis events. This approach has led to include in the design basis of the CANDU 6, events with low frequency, including events during which safety systems are assumed to be impaired. Therefore, for CANDU there are events analysed as part the design basis, which for other designs, such as PWRs, are considered beyond design basis.

III. conclusion and recommendation

We understand that the definition of the design basis is different in different countries, but we want to emphasize that the German design also has to consider a single failure of emergency systems in case of an initiating event as e.g. a loss of coolant accident. Containment failure has to be discussed separately, because in the CANDU reactor the containment is different from that of a PWR.

Besides that In the last years the discussion of design requirements has evolved. The consideration of event sequences with a lower probability, which could cause core damage leads to the development of design features and procedures to minimize the consequences of such event chains.

Severe accidents with a probability of occurrence < 1 E-6/a are not considered in the EIA. Information should be provided which accident scenarios are not covered by the EIA report (and the technical documentation).

I. treatment of the issue in the EIA documents

Accidents with a probability of occurrence less than 10^{-6}/year are not dealt with in the EIA report (ICIM 2007) at all. This is argued with the strong concept of CANDU preventing a rapid development of the accident. Nonetheless severe accidents cannot be excluded. Overheating of the zircalloy cladding during a LOCA is possible and in case of a large LOCA even damage of the cladding cannot be excluded (DORIA 2001).

II. bilateral consultation

A detailed accident analysis is a requirement of the license application for design and construction of the NPP and will be documented in the preliminary safety report.

Typically, the severe accident scenarios that are analyzed for the level-2-PSA include:

- Small LOCA coincidental with loss of emergency core cooling and loss of moderator heat sink.
- Stagnation feeder break LOCA coincidental with loss of emergency core cooling and moderator drain.
- Station Blackout (loss of all heat sinks due to loss of electrical power to Group 1 and Group 2 equipment).
- Steam generator tube rupture (SGTR) coincidental with loss of emergency core cooling and moderator heat sink (containment bypass).
- Loss of shutdown cooling during shutdown state when HTS is full, cold and depressurized coincidental with loss of emergency core cooling and moderator heat sink

III. conclusion and recommendation

The Preliminary Safety Analysis Report (PSAR) will be submitted as part of the application for the construction license. It is not available at the present time. The PSAR document or the main results should be provided to Austrian experts when available, in order to further evaluation.

Results from the preliminary safety assessment report should be presented at the consultation and an explanation to which extent improvements implemented in other CANDU-6 plants will be realized in NPPC 3/4, too.

I. treatment of the issue in the EIA documents

In order to discuss the potential impact of severe accidents to other countries, in the Austrian Comment to the Scoping Stage (WENISCH, 2007b) it was already requested to include more information on this topic in the EIA report (ICIM 2007). Related to that, the presentation of the accidents analysis in the EIA should give an overview on the Probabilistic Safety Assessment results for Cernavoda unit 3 and 4 (accident scenarios, core damage frequency, large release frequency, source terms instead of dose limits). This information is missing in the EIA report (ICIM 2007), although new design requirements apply emission limits as a probabilistic safety target, instead of dose limits.

II. bilateral consultation

Detailed accident analysis is a requirement of the license application for design and construction of nuclear power station. This work will be documented in the Preliminary Safety Analysis Report (PSAR) submitted as part of the application for the construction license. This document for Units 3&4 is not available at the present time. The reference plant design for Cernavoda Units 3&4 is Cernavoda Unit 2 as commissioned, plus the design changes already discussed and approved by CNCAN. These changes include improvements implemented in other CANDU 6 plants as well. See the answer for Question 1 b). At the end of 2009 the preliminary safety assessment has to be completed in order to get the construction license.

The Austrian experts requested absolute source terms for DBA and BDBA instead of DEL's in order to enable a better comparison possibility with other nuclear power plants. Only a general idea of the source terms for DBA could be provided: DBA means loosing < 2% of the Cs-I inventory, loosing 1% of the inventory is called Containment Failure. Release rates for other nuclide groups have not been provided.

III. conclusion and recommendation

A worst case concerning the release of radioactive substances to air has not been discussed by the Romanian experts. The Preliminary Safety Analysis Report (PSAR) will be submitted as part of the application for the construction license. It is not available at the present time. An open question is whether early containment failure can be prevented in all event sequences and are there event sequences (regardless of their probability of occurrence) which could cause emissions > 2% of the Cs-I inventory of the core.

The PSAR document or at least the results of the PSA L2 should be provided to Austria, when available, in order to further evaluation of potential emissions which could be relevant for transboundary impact.

When will specific severe accident management guides (SAMGs) for NPP Cernavoda be developed and implemented?

I. treatment of the issue in the EIA documents

According to the EIA report (ICIM 2007), severe accident management is not yet implemented at NPPC Unit 1 and 2. Generic Severe Accident Management Guidelines (SAMG's) have been developed by the CANDU owners group (COG). According to the EIA report these SAMG's shall be used as input data in for level-2-PSA. Specific SAMG's for NPP Cernavoda shall be developed, too. Level-2-PSA is scheduled for 2009 and will include severe accidents. (ICIM 2007). It is not clear when these specific SAMG's are going to be developed and implemented.

II. bilateral consultation

In Canada, regulatory requirements for Severe Accident Management (SAM) program is documented in Canadian Nuclear Safety Commission (CNSC) Regulatory Guide G-306, "Severe Accident Management Programs for Nuclear Reactors", 2006 May. Under the auspicious of the CANDU Owner's Group (COG), the nuclear industry in Canada have developed generic and initial station-specific Severe Accident Management Guidance (SAMG) for all CANDU plants in Canada (completed in 2007). The general SAMG approach developed by the Westinghouse Owner's Group (WOG) was followed, suitably modified to take into account the unique CANDU design features. The Cernavoda NPPs have already purchased the proprietary generic COG SAMG. The conversion of the generic COG SAMG into the initial station-specific SAMG is in progress for Unit 1. The implementation of SAMG for Units 3&4 will be a condition for receiving the operation license from CNCAN.

III. conclusion and recommendation

The implementation of SAMG for Units 3&4 will be a condition for receiving the operation license from CNCAN. Information on SAMGs implementation is of major interest for Austria, too.

Is the full scope PSA (including external events) for Unit 1 finished? Is it possible to discuss the results at the consultation? In particular information on core damage scenarios should be provided (source terms included).

I. treatment of the issue in the EIA documents

PSA results are not subject of the EIA documents (CITON 2006 and ICIM 2007).

For NPPC Unit 1 a level-1-PSA (therefore not including external events) has been carried out. The results are presented in the National Report to CNS (ROMANIA CNS REPORT 2004).

II. bilateral consultation

The level-1-PSA results for Unit 1 are presented in IR-01551-PSA-110 "Level 1 PSA – Seismic, Fire and Flood Events Analyses – Summary Report". The dominant core damage sequences are discussed in this report. Information on source terms specific to Cernavoda NPPs are not yet available, but they will be available after level-2-PSA completion. Nevertheless, the results of level-1-PSA does not indicate major differences on the accident scenarios as compared with Generic CANDU PSA reference Analysis done by AECL which shows that significant time is available for operator during station blackout and Large LOCA accidents to arrest the accident progression. The total mass of Cs and I released to the environment in the form of CsI and CsOH is less than 2% of the initial Cs and I inventory for both scenarios. Regarding SNN decision to develop full scope PSA for Cernavoda NPP, it should be mentioned that, the main reason to develop very detailed and high quality plant specific PSAs was to support the risk informed decision making during day by day plant operation (at unit 1 the risk monitor is already in use by planning, safety and operation departments) in order to maintain a low risk profile. The generic PSA application regarding the design verification has been already accomplished by AECL during plant design by using the Safety Design Matrices and Generic PSA. The specific level-1-PSA developed by SNN for Cernavoda NPP Unit 1 confirmed the design adequacy and identified some minor design changes which do not significantly decrease the CDF.

III. conclusion and recommendation

The full scope PSA (level-2-PSA) for unit 1 is not finished yet. The dominant core damage sequences are discussed in level-1-PSA. Information on source terms specific to Cernavoda NPPs are not yet available, but they will be available after level-2-PSA completion.

Is there a PSA for NPPC-2 planned?

I. treatment of the issue in the EIA documents

PSA results are not subject of the EIA documents at all (CITON 2006 and ICIM 2007).

II. bilateral consultation

Level-1-PSA for Unit 2 is in progress and it is planned to be reviewed by an IAEA IPSART mission. Level-2-PSA is planned to commence after level-1-PSA for Unit 2 is completed.

III. conclusion and recommendation

PSA results and lessons learned from this assessments for design of NPP C 3/4 are considered as important information for Austria.

The four defined emergency zones at NPP Cernavoda (1km, 2km, 10km, 50 km) are not in accordance with current international standards (e.g. of (IAEA 2007)). The intervention measures are not explained sufficiently. More detailed information should be provided at the consultation.

I. treatment of the issue in the EIA documents

According to the EIA documents In the surroundings of the NPP, four zones are defined for protective measures: a 1 km unpopulated exclusion zone, a 2 km low-population zone, and for BDBAs a 10 km short-term and a 50 km long-term emergency planning zone. The four defined emergency zones (1 km, 2 km, 10 km, 50 km) are not in accordance with current international standards: The IAEA recommends the definition of a precautionary action zone (PAZ) of 3-5 km (with a recommendation on 5 km) and an urgent protective action planning zone (UPZ) with a radius of 5-30 km (IAEA 2007).

There is only one exit route out of town crossing a bridge, because the other direction of this main road leads to the NPP (WENISCH 2003).

II. bilateral consultation

The “Environmental Impact Assessment Report for Cernavoda NPP Units 3 and 4” was made based on CNE-PROD, RD-01364-RP8, revision 1, On-site Radiological Emergency Plan, 1994. In the mean time the On-Site Emergency Control Center was built and all the component of the Emergency Planning and Preparedness Program according to multiunit NPP requirements have been adjusted. The projects were developed according to IAEA safety standards and guides. In this new revision of the emergency plan, in order to ensure an efficient off-site emergency response, three Emergency Planning Zones were established according with IAEA safety standards, for more detail see (ANSWERS 2008).

The protective actions are established comparing the calculated projected doses with GIL. These protective actions will be recommended to Public Authorities immediate when the incidents assessment and classification process is done, for more detail see (ANSWERS 2008).

Regarding the exit routes we have to underline that there are two main exit/evacuation routes, which are not passing near the plant: one is crossing the bridge to Fetesti town; second is to Seimeni-Dunarea-Harsova/Constanta. A third route is under construction (highway Cernavoda- Constanta).

III. conclusion and recommendation

After visiting the Emergency Centre it was clear that the EIA description of the emergency planning is outdated. The emergency zones have been changed in accordance with IAEA safety standards, the previous information provided by the EIA report has been misleading. The intervention measures have been explained sufficiently. Nevertheless, it should be clarified, if the latest (at the time of adapting the zones) possible IAEA safety standards have been used.

An open question is still the monitoring (dose rate measurement) and environmental investigations of radioactive contamination. It seems that several organisations are responsible for carrying out such analyses, without cooperation among them. Which institution has an overview about all findings concerning radioactivity in Romania, if there is a joint report, we would appreciate to get this.

How will neighbouring and affected parties to the Espoo convention be informed in case of an accident in NPP Cernavoda?

I. treatment of the issue in the EIA documents

The EIA report (ICIM 2007) does not discuss how the public is going to be informed about an accident. Information about protective measures are missing. The IAEA recommends information of the public if a nuclear accident happens (IAEA 2002), also (EURATOM 89/618) requires information of members of the public in case of a radiological emergency.

Furthermore, the EIA report does not give information about if and how Romania is planning to provide information for the public of neighbouring and affected parties, according to existing EU-standards, in case of emergency situations.

II. bilateral consultation

Romania is part of the IAEA Convention for Early Notification in Case of a Nuclear Accident and part of the IAEA Convention for Assistance in Case of Nuclear Accident or Radiological Emergency. CNCAN is the national Competent Authority and National Warning Point for Romania as defined according to the ENATOM 2007 arrangements issued by the IAEA. A 24 hour service is operated by CNCAN as described in the ENATOM manual. The input for reporting the events in the framework of the Early Notification Convention is given by Cernavoda NPP according to the emergency plans and arrangements. Romania has signed bilateral treaties with Bulgaria, Hungary, Greece, Slovakia, Russian Federation and Ukraine regarding the early notification in case of nuclear accidents. CNCAN is the responsible Romanian authority in charge of implementing these treaties. Using the same forms and arrangements as per the IAEA ENATOM 2007, the CNCAN Emergency Centre will contact directly the above mentioned countries in case of a reportable event. Romania is an EU member state and complies with the ECURIE requirements. A 24 hour service is operated by MIRA as per the ECURIE reporting arrangements. The input for the ECURIE reporting is provided to MIRA directly from the County Inspectorates for Emergency Situations and by CNCAN, following the notification of the operator to CNCAN. Romania is also a part of the EURDEP environmental radioactivity data exchange platform. Gamma dose rate and other monitoring data provided by Romania are shared within the EURDEP platform and are visible for the European countries.

III. conclusion and recommendation

Regarding provision of information to the Romanian public, CNCAN is the national Competent Authority and National Warning Point for Romania. A 24 hour service is operated by CNCAN. Regarding provision of information to neighbouring and affected parties, as a part of the IAEA Convention for Early Notification in Case of a

Nuclear Accident and as a part of the IAEA Convention for Assistance in Case of Nuclear Accident or Radiological Emergency, Romania has to provide information to public of neighbouring and affected parties in the same manner as other members. The input for reporting the events in the framework of the Early Notification Convention is given by Cernavoda NPP according to the emergency plans and arrangements.

4 ADDITIONAL INFORMATION PROVIDED DURING THE VISIT

During the visit at the plant in the introduction a presentation was included concerning the Environmental radiation protection program of Nuclearelectrica. Following this presentation we asked for emission data instead of DELs, because emission data are representative for comparing the emissions to other NPPs.

A further discussion took place at the environmental radiation laboratory. This concerned tritium increase in the environment:: the EIA report compares pre-operational values of tritium concentrations in air with values during operation of NPPC-1, both at the location "Campus Cernavoda". Even if the absolut amount of tritium is small, the strong increase of concentrations of tritium in air by a factor of 50 (!) at this location near the Cernavoda town, should not be ignored.

S.N. Nuclearelectrica is responsible to install and operate a monitoring program, which is presented in the EIA report (ICIM 2007). For several media (filters, water, soil, sediment, food, milk) the type of analysis, the "minimum required detectable specific activity" and the frequencies of sampling and analysis are listed. The EIA report does not contain a map of the sampling points. The tritium detection limit in water (350 Bq/l) is too high compared to the technical possible detection limit of 10 Bq/l (BMU 2006) and, if drinking water is taken from underground water, to the EU limit of 100 Bq/l (EC/98/83).

Last but not least, the much too high detection limit (compared to technical possible detection limit and – according to drinking water – to the EU limit) should be clarified.

There are 33 measure points (gamma dose rate) within Romania.

The EIA report (ICIM 2007) states a much higher amount of tritium in the air, water and precipitation in the surrounding of the plant due to the normal operation of one reactor (unit 1). It is argued, that, regarding tritium, the dose level is within the limits. We appreciate the initiative of Nuclearelectrica to construct a tritium retention facility.

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6 GLOSSARY

AECB .... Atomic Energy Control Board

AECL.................. Atomic Energy of Canada Limited

BDBA .... beyond design basis accident

Bq/l..................... Becquerel per liter

CANDU .... Canada Deuterium Uranium (pressurized heavy-water power reactor)

CDF.................... core damage frequency

CNCAN .... National Commission for Nuclear Activity Control

CNS .... Convention on Nuclear Safety

CNSC................. Canadian Nuclear Safety Commission

CO2.................... Carbon Dioxid

COG................... CANDU owners group

Cs....................... caesium

D2O.................... heavy water

DBA.................... design basis accident

DBE.................... design basis earthquake

DEL .... derived emission limit

ECCS .... emergency core cooling system

EIA .... environmental impact assessment

ENATOM............ Emergency Notification and Assistance Technical Operations Manual

EU .... European Union

EURDEP .... European Radiological Data Exchange Platform

FSAR .... Final Safety Assessment Report

g .... earth acceleration

HTS.................... heat transport system

I .... iodine

IAEA................... International Atomic Energy Agency

ICIM .... Romanian abbreviation for "National Institute of Research and Development for Environmental Protection"

km .... kilometer

LOCA .... loss of coolant accident

LRF .... large release frequency

LWR .... light water reactor

µSv/a.................. microsievert per year

µSv/year............. microsievert per year m .... meter

m^3 .... cubic meter

ms .... milliseconds

mSv .... milli Sievert

MCR .... main control room

NPP .... nuclear power plant

NPPC .... nuclear power plant Cernavoda

PARS .... passive auto-catalytic recombiners

PAZ .... precautionary action zone

PGA .... Peak Ground Acceleration

PHTS .... primary heat transfer system

PSAR .... preliminary safety assessment report

PSA .... probabilistic safety analysis

PWR .... pressurized water reactor

R001 .... Room Zero Zero One (Spent Fuel Discharge Room)

R/B .... Reactor Building

R&D .... research & development

SAMG .... Severe Accident Management Guide

SCA .... secondary control area

SG .... steam generator

SRF .... small release frequency

SSC .... structures, systems and components

UPZ .... urgent protective action planning zone

WENRA .... Western European Nuclear Regulators Association

umweltbundesamt

Umweltbundesamt GmbH
Spittelauer Lände 5
1090 Wien/Österreich

Tel.: +43-(0)1-313 04
Fax: +43-(0)1-313 04/5400

office@umweltbundesamt.at
www.umweltbundesamt.at

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