7. RISK SITUATIONS ANALYSIS

7.1. Accidents Classification

Conforming to CNCAN Fundamental Radiological Safety Norms (Ref. 7-4) and international regulation, the nuclear accidents are defined as those nuclear events which could affect the facility and produce the irradiation or contamination of the public and environment exceeding the actual permissible limits.

Taking into account the causes, the nuclear accidents postulated during a nuclear power plant design and operation are classified in (Ref. 7-17):

- the events induced by natural phenomena;
- the events induced by human actions.

The events induced by human actions can be initiated by the activity external to the nuclear objective or the activities specific to this objective (human errors during facility operation or the random failures of the nuclear objective components).

The structure of this chapter is presented below.

The events produced by the natural phenomena on the Cernavoda Nuclear Power Plant (NPP) site are presented in Section 7.2. The sitting and design features minimizing the effects of these events on the nuclear power station safety are also presented. The external events (induced by the activities performed into Cernavoda NPP enclosure and within its influence zone) and their effects on the NPP structures integrity and personnel safety working conditions are presented in Section 7.3.

Notice that the nuclear events can have potential radiological consequences on the personnel, public and environment. Another category consists of the events without radiological consequences.

The events with radiological consequences (whose evolution and consequences will be evaluated in the safety reports) are presented in Section 7.4. The following are presented: the list of the events classified function of evaluation objectives as well as the population dose limits function of the accident occurrence frequency. The events with the most serious radiological consequences postulated for Cernavoda NPP are also presented in this section.

The Section 7.5 presents the preventive measures and the features to minimize the NPP operational risk according to CNCAN requirements; Section 7.6 presents some information related to the risk evaluation for the accidents with impact on the environment and public health, during nuclear power station construction.

The conclusions of this chapter are contained in the section 7.7.

7.2. Natural Risk

The natural phenomena that could affect the NPP structures are (Ref. 7-17):

- severe meteorological phenomena (storms, lightning, tornado and tornado induced missiles);
- flooding;
- earthquake;
- fires.

a) Events Caused by Severe Meteorological Phenomena

The severe meteorological phenomena frequency is so small that this type of events can be considered negligible for Cernavoda NPP (Ref. 7-3).

b) Flooding

The Design Basis Flood for Cernavoda site has a frequency of 1/10000 years (0.01%); the maximum water level reached (considering also the severe failure of the hydro-electrical developments situated upstream the plant) is 15,90 mBSL (Ref. 7-1). The safety related Cernavoda NPP structures were designed to this flood by constructing the plant enclosure platform on an earth filling with the general elevation of 16.30 mBSL.

c) Earthquake

The seismic design (at Design Basis Earthquake – DBE conditions) of NPP structures and systems important from the safety point of view ensures the structural integrity and operability of safety-related components in case of an earthquake. This conclusion is stipulated in Ref.7-1.

d) Fires Caused by Natural Sources

Cernavoda NPP platform is located within a zone situated faraway from the forest or other combustible vegetal; so, their potential fires do not affect the plant.

7.3. Events Induced by Human Activities External to Cernavoda NPP Units 3 and 4

7.3.1. Potential Hazardous Sources Existing within Cernavoda NPP Units 3 and 4 Site

On Cernavoda NPP site there are some potential sources of explosions, fires, missiles or toxic gases releases which may affect Units 3 and 4 nuclear safety (Ref. 7-17).

These sources are:

a) missiles generated by U1, U2, U3 and U4 turbines;

b) explosive gas tanks (hydrogen);

c) start-up thermal plant;

d) toxic gases tanks.

a) The analysis made for Unit 2 (Ref. 7-1), extrapolated to Cernavoda NPP Units 3 and 4 showed that the area affected by the rotor break or the break of a disk associated to Unit 1 and Unit 2 turbines low pressure stage does not inflict any damage on the vital areas in Unit 3 and respective Unit 4. These areas are Reactor Building, Service Building, Main and Secondary Control Rooms, Spent Fuel Bay. These vital zones of Units 3 and 4 are protected to the missiles generated by their own turbines (see Ref. 7-1, Chapter 3).

b) The Hydrogen (produced in a plant common to the 5 units and stored in warehouses specific to each nuclear unit) is used during Cernavoda NPP Unit 3 and respective Unit 4 operation. The maximum credible postulated events analyzed were:

- the explosion generated by violent brake or shattering bursting of some hydrogen flasks;
- the impact of the fragments ejected in case of explosion with various objects inside NPP enclosure;
- build-up of a Hydrogen-air mixture in closed or half-closed spaces and its explosion by taking fire.

The results of such analyses were considered to establish the protection distance and design protective measures (protection walls, restriction of the number of flask and their pressure) to ensure the integrity of NPP structures, components and systems (Ref.7-1).

c) The light liquid fuel warehouse for the thermal start-up plant consists of 2 over-ground steel tanks (2x1000m^3) containing Diesel fuel and a buffer 100m^3 Diesel fuel tank. The design measures to respect the protection distance and to use the adequate extinguishing systems will reduce the explosion-fire potential hazard of this fuel (Ref. 7-1).

d) The toxic substances, such as ammonia, sulfuric acid, hydrochloric acid, carbon dioxide are used in Cernavoda NPP. As accidental release of such gases could affect the safety of plant personnel and facilities, the measures to design and locate the toxic gas tanks for limiting the releases and ensuring the safe distance are taken.

7.3.2. Events Induced by Human Activities in Cernavoda NPP Unit 3 and respectively Unit 4 Influence Zone

The human activities (industry, transport routes, military activities) within the Cernavoda NPP Unit 2 influence zone are detailed presented in section 2.2 of Ref. 7-1. As recommended by IAEA (Ref. 7-2), the influence zone is considered to cover a 30 km radius area around the plant.

The evaluation of potential events induced by the human activities in this zone (explosions, toxic gas releases, aircraft crashes and fires) and their effects on structural integrity and personnel capacity to ensure the plant safe operation is made for Cernavoda NPP Units 1 and 2. Also the measures to prevent and/or minimize the potential risks on the plant safety were evidenced.

This analysis effectuated for Cernavoda Unit 2 (Ref. 7-1) and its conclusions are totally appropriated for Cernavoda NPP Units 3 and 4 as the design are similar and the distance between the U2 reactor and U3 and respective U4 reactors (160m and respective 360m) is small comparative with the analyzed distances.

A short presentation of human activities in Cernavoda NPP Unit 3 and respective Unit 4 influence zone as well as the results of evaluation of their effects on structural integrity and plant personnel security is evidenced below.

7.3.2.1. Industrial Activities

7.3.2.1.1. Description

The economic activity within Cernavoda NPP influence zone consists of (Ref. 7-1):

- extraction industry (i.e. quarries of limestone, sand, diatomite, bentonite, clay);
- industrial units concentrated in the existing industrial areas in Cernavoda Town, Fetesti and Medgidia;
- agro-industrial units spread in the rural settlements in the area.

The economic activities within Cernavoda NPP U3 and U4 influence zone are grouped as per the following zones (Figure 4.7-1, section 4.7):

I. 10 km radius zone

A. Cernavoda–Saligny industrial zone

B. Cernavoda-Harbour industrial zone

II. 10 - 30 km radius zone

C. Medgidia North industrial zone

D. Medgidia East Harbour industrial zone

E. Fetesti North–West industrial zone

F. Fetesti East industrial zone

Due to the small distance between the reactors of Unit 3 and 4 (160) it is not considered necessary to represent each unit influence zone on a separate figure.

In compliance with IAEA recommendations (Ref. 7-2), the economic objectives located at distance greater than 10 km away from Cernavoda NPP do not affect the plant safety. Therefore, all the economic objectives located on a radius of about 10 km around Cernavoda NPP were analyzed. For distances greater than 10 km within the considered influence zone, only the most important economic objectives in point of production capacity and hazardous substances involved in the production process have been selected (Ref. 7-1).

The territory of Cernavoda NPP influence zone is crossed by oil and methane gas pipelines; their trajectory is also represented in Figure 4.7-1 (see section 4.7). The pipelines are provided with isolation valves when crossing the main roads and railway or sub-crossing the navigable channels.

7.3.2.1.2. Effects on the Cernavoda NPP Units 3 and respectively 4 Safety of the Potential Events due to Industrial Activities in the Influence Zone

The effects on Cernavoda NPP safety due to potential events (explosions, toxic gas releases, fires in natural gas and oil ducts) involved in the influence zone industrial activities were analysed (Ref.7-1). As recommended by IAEA (Ref. 7-2) the analyses were made for dominant sources (objectives where the greatest quantities of explosives are involved located at the minimum distance from NPP).

The dominant sources within Cernavoda NPP Unit 3 and respective Unit 4 influence zone are:

a) **In the 2 km radius zone**, the greatest quantity of explosive substances is located at about 2 km SSE away from the third reactor axis (and respective 2.1 km SSE away from the fourth reactor axis) and it is concentrated at SC Tranzit SRL and SC Liviu Star gas stations. The result of evaluation conforming to IAEA methodology (Ref. 7-2) is a maximum of 1365 t equivalent TNT (and respective 1587 t equivalent TNT) that could explode at this distance without NPP structure integrity to be affected. This quantity exceeds the maximum quantity (considering 240% equivalent TNT) of explosive substances existing in the two economic units (i.e. 20x6m^3 oxygen cylinders and 1x10t gasoline tank), even in the case of their coincidental explosion.

b) **In the 2 km and 10 km radius zone** around Cernavoda NPP influence zone, the explosion of a 5000t crude oil tank at SC PECO SA Oil products Storage, located at about 4 km NW from the third reactor axis (and respective 3.9 km NW from the fourth reactor axis) is analyzed. The evaluation made conforming IAEA methodology (Ref. 7-2) demonstrates that the safety distance is about 4 km; considering the evaluation conservatism one can conclude that the distance between the reactor and explosion source is enough so that the NPP safety-related structures integrity is not affected, both for Unit 3 and Unit 4.

c) **The greatest toxic gas quantity** possible to be released at the minimum distance from the plant is used in SC VIRFRUCER, located at about 2.2 km WSW from the third reactor axis (and respective 2.35 km from the fourth reactor axis). It is sulphur dioxide that, accidentally released and taken over by the control room ventilation system, could affect the personnel capacity to ensure safe plant operation. The evaluation made according to IAEA methodology (Ref. 7-2) demonstrated that the protection by distance is sufficient even if the instantaneous release of the average consumption of the unit for 6 months is considered.

d) **Fires in natural gas and oil ducts.** The analysis demonstrated that the distance between these fire sources and Cernavoda NPP site is enough to ensure the plant structures safety and integrity.

One may conclude that the economic objectives in the Cernavoda NPP Unit 3 and respective Unit 4 influence zone do not jeopardize either the plant structures and components integrity or plant operators capacity to ensure the NPP safe operation.

7.3.2.2. Transports within the Cernavoda NPP Unit 3 and respectively Unit 4 Influence Zone

7.3.2.2.1. Description

The transport routes (roads, railways, navigation and air routes) within the Cernavoda NPP Unit 2 were described and analyzed in the Preliminary Safety Report (Ref.7-1).

The transport routes (road, railway and naval) within a zone of 30 km radius around Cernavoda NPP Unit 3 and implicit Unit 4 site are presented in Figure 4.7-1 (see section 4.7).

a) **Road transport network** is constituted by:

- A2 highway (Bucharest-Constantza) segment Fetesti-Cernavoda (to be finalized);
- National road 22C Cernavoda - Basarabi; minimum distance: 1.2 km from the third reactor axis and respective 1.3 km from the fourth reactor axis;
- County road 223, parallel with the Danube River, between Cochirleni, Cernavoda and Seimeni villages; minimum distance: about 400m from the third reactor axis and respective 450m from the fourth reactor axis;
- Village roads DC60 and DC61, within NNE and NE sectors, located at a distance greater than 5 km from the NPP enclosure.

The following main mixed bridges (on roads and railways) serve this roads network:

- Bridge on DN 22C, for Danube-Black Sea Channel crossing, located at about 1.5 minimum distance from the third reactor axis (respective 1.6 km from the fourth reactor axis);
- Crossing bridge of Cernavoda NPP intake cooling channel, located in the Unit 3, respective Unit 4 exclusion zone (1km radius).

b) **Railway transport** is represented by:

- Fetesti-Medgidia railway segment of Bucharest – Constantza main railway, served by Cernavoda Harbour station; the minimum distance from the third reactor axis is 1 km and from the fourth reactor axis is 1.2 km;
- Saligny-Cernavoda Town railway segment, located at minimum 425 m from the third reactor axis (and respective 450 m from the fourth reactor axis); Cernavoda NPP is the only beneficiary of hazardous substances traffic on this railway (Ref. 7-1).

c) Danube River and Danube - Black Sea Canal represent **the naval transport**; the minimum distance from the third reactor axis, estimated for the area without any physical obstacle between the NPP and Canal, is about 1.4 km; the similar distance from the Unit 4 is 1.380 km.

d) **Civil air transport**

d 1) Airports

Considering the information from Civil Air Department, at about 35 km distance from Cernavoda NPP the international "Mihail Kogalniceanu" airport is located.

d 2) Air routes

In point of air traffic, the Cernavoda NPP influence zone is considered a prohibited area (marked "LRP2" on the Air Passage maps) for the flights up to 4000 feet (about 1200m) encompassed in a right circular cylinder of 5 miles radius (about 10km) with its axis passing through the plant axis.

The following air routes are identified in Cernavoda NPP influence zone:

d 2.1) Low Altitude flights (Lower Limit-L):

- W 87/L851, passing right above the prohibited area LRP2 – minimum distance from Cernavoda NPP: 6.5 km;
- W 80/L601 - minimum distance: 15.0 km;
- T 100 - minimum distance: 24.0 km;

- W 84 / N 616

d 2.2) High-Altitude Flights (Upper-Limit-U):

- UL 851;
- UL 601;
- UT 100;
- UN 616.

7.3.2.2.2. Evaluation of Effects on Cernavoda NPP Unit 3 and respective Unit 4 Safety due to Potential Events on Transport Routes

The conservative assessments (Ref. 7-1) point out the potential danger associated to the transport carried out in the Cernavoda NPP site vicinity; case by case, the measures ensuring the plant nuclear safety were evidenced and analysed.

The evaluation results of the random explosions on the transportation routes in the NPP Cernavoda Unit 3 and respective Unit 4 influence zone are presented below.

a) For road transport on DN 22C, the explosion of dangerous substances carried out by a standard vehicle of 25 t solids (or 20t oil products, respectively) at the minimum distance of 1.2 km from the third reactor axis (and respective 1.3 km from the fourth reactor axis) does not impair the integrity of NPP safety related structures and components.

Regarding the transport of dangerous substances on village road DJ 223, due to the measures imposed to reduce the explosion risk (limit of 12 t for the maximum quantity carried out once and improvement of the transport security) one may consider acceptable Cernavoda NPP Unit 3 and respective Unit 4 protection against such kind of events.

b) For railway transports, the results indicate that the explosion of dangerous products transported by a railway standard wagon of 50 t solids and respectively 40t oil products on Fetesti-Constanta railway segment, at the minimum distance of 1 km from the third reactor axis (and respective 1.2 km from the fourth reactor axis) shall not damage the NPP safety-related structures and components.

As regards the transport of dangerous products on Saligny-Cernavoda Town railway segment, because Cernavoda NPP has the control upon the transport of dangerous products on this segment, the plant safety related to a potential explosion of such products is ensured by limiting the quantity carried out (to respect the protection by distance principle) or by administrative measures regarding the improvement of transport security. (Ref. 7-1)

c) For naval transports, the estimation developed has resulted in occurrence frequency of explosions on the Danube - Black Sea Canal slightly greater than the limit of 10^{-6} /year considered in the analysis (Ref. 7-1). Notice that this estimation has been made in conservative assumptions regarding the quantity implied in the explosion (barges tank loaded with 6000 t oil products, with 240 % equivalent TNT) and the generating conditions for such explosions (the following events have to be simultaneous):

- navigation failures accompanied by fire occurrence;
- temperature of about 1100 °C on board of the barges during a fire;
- the condition that the two events above may occur only at a time interval of 6 minutes as long as the barge is within the Danube-Black Sea Canal sector corresponding to the intake and discharge of the derivation channel -about 1.0 km long; a traveling speed of the barge convoy of maximum 10 km/h is considered).

In order to reduce the risk of channel explosions in the Cernavoda NPP influence zone additional navigation measures have been added (Ref. 7-1).

Considering the conservative degree of the analysis and the additional measures adopted to reduce the risk of an explosion occurrence on the Channel, one may consider Cernavoda NPP Unit 3 and respective Unit 4 protection as acceptable from that event.

d) Referring to the civil air transport, following to the developed analysis it resulted that the risk on an aircraft crash on the Cernavoda NPP due to the air traffic on the air routes and airports in the area is negligible even with the predicted future air traffic for the year 2030.

7.3.2.3. Military Objectives and Activities

7.3.2.3.1. Description

The military objectives and activities within Cernavoda NPP influence zone are as following (Ref. 7-1):

- objectives with potential explosion risk;
- objectives with potential noxious releases hazard (inflammable, toxic, radioactive);
- objectives with potential missile generation risk;
- military airdromes / airports.

7.3.2.3.2. Effects on the Cernavoda NPP Unit 3 and respective unit 4 Safety of the Potential Events due to Military Activities in the Influence Zone

The analysis of the effects on NPP safety due to military activities shows the following (Ref. 7-1):

- the potential explosions do not jeopardize the NPP structures and components integrity;
- as regards the flights of military planes in Cernavoda NPP area, the following flight restrictions are stated:

  i) on a 20 km radius measured from the Cernavoda NPP first reactor axis to all cruising altitudes – for air crafts flying with supersonic speed;

  ii) on a 10 km radius measured from the Cernavoda NPP first reactor axis to altitude below 2000m – for air crafts flying with subsonic speed.

Considering the small distance between the reactors of Cernavoda NPP Units 1 and 3, respective 4 comparative to the analyzed distances, one may consider that the above-specified restrictions are also applicable to Cernavoda NPP Unit 3 and Unit 4.

One may conclude that the Cernavoda NPP Unit 3 and respective Unit 4 external human activities (within the NPP site and in the influence zone) do not affect the plant structures integrity and the personnel capacity to ensure the plant safe operation.

7.4. Events with Radiological Consequences Postulated for Cernavoda NPP Unit 3 and respectively Unit 4

The potential events having radiological consequences are presented in this section. These events are classified in point of their occurrence frequency and doses (Ref. 7-16, 7-17).

The accident analyses made for Cernavoda NPP Unit 2 are presented in Chapter 15 of Ref. 7-1. As the plant design is similar for the both nuclear units, the results of these analyses are applicable to Unit 3 and respective Unit 4 also.

The risk of events with radiological consequences is evaluated taking into account both CANDU safety philosophy, considered in CANDU 600 plant design and Romanian Regulatory Body (CANDU) safety licensing requirements.

The Canadian Regulatory Body (AECB, actual CNSC) gives the requirements for CANDU 600 NPPs, whose design is similar with Cernavoda NPP Unit 3 and Unit 4, to minimize the risk of events with radiological consequences. A list of events to be analyzed is given in the AECB Consultative Document C-6. C-6 also requires a systematic review of the plant design to identify all additional safety significant failures and combination of failures.

7.4.1. Classification of the Initiating Events with Radiological Consequences

The initiating events postulated for CANDU 600 NPP are classified into four categories, depending on the evaluation objectives (Ref.7-4):

- **Category A events**, analyzed to assess the performance of the special safety systems (shutdown systems No. 1-SDS1 and No.2 – SDS2; Emergency Core Cooling System – ECCS; containment systems);
- **Category B events**, analyzed to assess the most probable plant response in case of an initiating event, in order to identify the dependence of that

response to operator corrective action and to demonstrate the independence between the initiating event and the mitigating system(s);

- **Category C** events, analyzed to evaluate the plant capability to ensure the safety functions (safe reactor shutdown, decay heat removal, radioactivity confinement and plant control) in case of common cause events (i.e. earthquake, flooding, fires, so on);
- **Category D events**, to evaluate the features of the plant design or operation which reduce the probability of certain postulated events to such an extremely low level that failure consequences need not be considered.

An event can be classified in more than one category. A Loss Of Coolant Accident (LOCA), for example is analyzed in categories A and B, the plant response being evaluated considering the special safety systems performance as well as the operators and other mitigating systems action to minimize the event consequences.

The evaluation methodology and acceptance criteria are different for different event categories. Briefly, the evaluation methods are:

Category A events are deterministically analyzed. Conservative assumptions are used for initial plant conditions and mitigating systems availability, which impose the most stringent conditions on safety system design. The category A events are called Design Basis Events; their analysis is the subject of Chapter 15 of a NPP Preliminary/Final Safety Report.

Category B events are analyzed probabilistically. Realistic assumptions are used to provide information to operators on the most probable plant response in case of the analysed event.

Category C and D events are qualitatively assessed. The main events postulated in CANDU design, classified into the four categories as above, are listed in Tables 7.4-1 ÷ 7.4.-5.

Category A events are subdivided into subcategories A.1 (Events with Class IV Electrical Power Available, see Table 7.4-1) and A.2 (Events with Consequential Loss of Class IV Power, see Table 7.4-2). Each category A-1 event, coincident with a special safety system unavailability (SDS1 and respectively SDS2, ECCS and

Containment Systems) is classified in one of the 5 frequency classes defined in Document C-6 and presented in Table 7.4-6. The acceptance criteria for A and B categories (occurrence frequency and dose limits) are also presented in Table 7.4-6.

The frequency limit recommended by AECB for evaluation of the events with radiological consequences is 10^{-6} events/year and thus a consequence analysis is not required for event sequences occurring with less than this frequency limit.

No quantitative acceptance criteria are specified for category C events. The evaluation, however, shall demonstrate the existence of design provisions so that, a long-term heat sink non-affected by the considered event is ensured.

There are also no quantitative acceptance criteria for category D events. However, an evaluation of these events shall demonstrate that their frequency of occurrence is low ($<10^{-6}$ events/year), based on design provisions and operating procedures.

Table 7.4-1. Category A-1 events - Events with Class IV power available

Event	SDS Impairments		ECCS impairments (1)		Containment Impairments (2)					
	SDS1	SDS2	Injection	Loop Isolation	Isolation Dampers	Deflated Airlock Seals	Open Airlock Doors	Minimum Detectable Hole Size	Partial Loss of Dousing	Local Air Cooling Loss
Large Loss of Coolant	3	3	5	5	5	5	NDB	5	5	NDB
Small Loss of Coolant	2	2	5	5	5	5	NDB	5	5	NDB
Feeder Break	2	2	5	5	5	5	NDB	5	5	NDB
Pressure Tube Rupture	2	2	5	5	5	5	NDB	5	5	NDB
Channel Flow Blockage	2	2	5	5	5	5	NDB	5	5	NDB
End Fitting Failure	2	2	5	5	5	5	NDB	5	5	NDB
Steam Generator Tube Rupture	2(6)	2(6)	NR(5)	NR(5)	NR(4)	NR(4)	NR(4)	NR(4)	NR(4)	NR(4)
Multiple Steam Generator Tube Rupture	5(7)	5(7)	NDB(8)	NDB(8)	NR(4)	NR(4)	NR(4)	NR(4)	NR(4)	NR(4)
Loss of Forced Circulation (Loss of Class IV Electrical Power)	1	1	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)
Loss of Forced Circulation (Pump Seizure)	2	2	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)

Table 7.4-1. Category A-1 events - Events with Class IV power available (continued)

Event	SDS Impairments		ECCS impairments (1)		Containment Impairments (2)					
	SDS1	SDS2	Injection	Loop Isolation	Isolation Dampers	Deflated Airlock Seals	Open Airlock Doors	Minimum Detectable Hole Size	Partial Loss of Dousing	Local Air Cooling Loss
Loss of Reactivity Control	1	1	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)
Loss of Pressure and Inventory Control	2	2	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)
Steam Main Break	3	3	5	5	5	5	NDB	5	5	NDB
Feedwater Loss (Loss of Flow)	1	1	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)
Feedwater Loss (Pipe Break)	3	3	5	5	5	5	NDB	5	5	NDB
Loss of Secondary Circuit Pressure Control	1	1	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)	NR(3)
Moderator System Failure	(9)	(9)	NR(5)	NR(5)	5(10)	5(10)	NDB(10)	5(10)	5(10)	NDB(10)
Shield Cooling System Failures	(9)	(9)	NR(5)	NR(5)	5(10)	5(10)	NDB(10)	5(10)	5(10)	NDB(10)

LEGEND:
NR - Not Relevant; NDB - Non-Design Basis Event;
Numbers not in brackets correspond to the event classification in AECB Consultative Document C-6 (1980, presented in Table 7-6);
Numbers in brackets correspond to the following notes:

Note

Failure of steam generator crash cool down is not considered since the design has two independent crash cool down systems, at least one of which can be assumed to operate.

Containment systems impairments are as follows:

Isolation dampers – failure of isolation dampers in inlet and/or outlet ducting;

Dousing – Partial loss of dousing. Half of the system (either pneumatic or electro-pneumatic) unavailable;

Local air cooling – failure of all local air coolers inside the Reactor Building;

Deflated airlock seals – failure of seals in both inner and outer doors of airlock (personnel or equipment airlocks)

Open airlock doors – both inner and outer doors of airlocks (personnel or equipment airlocks) open.

Special safety systems (ECCS or containment) are not initiated or credited; therefore, these impairments need not be considered.

This event leads to loss of coolant outside containment; therefore, containment impairment is not relevant.

ECCS is not required; therefore, its impairment need not be considered.

This event is Class 1 as per AECB Consultative Document C-6 but has been reclassified in class 2 based on PSA analysis.

This event is Class 3 as per AECB Consultative Document C-6 but has been reclassified in class 5 based on PSA analysis.

This event is Class 5 as per AECB Consultative Document C-6 but has been reclassified as NDB (non-Design Basis event) based on PSA analysis.

Loss of flow and loss of cooling (service) water to heat exchangers are classified as Class 1 events (as per C-6 document). Pipe breaks are classified in Class 3 event.

NDB classification is applicable to pipe break events; NR (Non-Relevant) classification is applicable to loss of flow events

Table 7.4-2. Category A-2 events - Events followed by Loss of Class IV Power

1. Large Loss of Coolant;
2. Small Loss of Coolant;
3. Steam Generator Tube Rupture;
4. Steam Main Break;
5. Loss of Feedwater (Loss of flow);
6. Loss of Feedwater (pipe break).

In this category there are some A.1 type events followed by loss of electric power

Table 7.4-3. Category B events (for Probabilistic Safety Assessment -PSA)

1. Failure of electric power supplies;
2. Failure of Instrument air system;
3. Failure of Service water system*;
4. Failure of plant computer control;
5. Loss of steam generators as a heat sink*;
6. Failures in Moderator and Shield cooling systems;
7. Large Loss of Coolant *;
8. Small Loss of Coolant*;
9. Failure of Fuel handling system;
10. Failures during reactor shutdown.

* flooding are addressed for each of these events.

The ten events listed above are not single initiating events but a grouping of key events; hence, an assessment of these events cover many individual-initiating events.

Table 7.4-4. Category C events

1. Earthquake;
2. Site flooding from external sources;
3. Fires;
4. Severe winds

The events caused by the natural phenomena on Cernavoda NPP site are presented in section 7.2. The external man-induced events (in NPP enclosure and in the influence zone) as well as their effects on structures integrity and personnel capacity to ensure plant safe operation are presented in section 7.3.

Table 7.4-5. Category D events

1. Steam generator support failure;
2. Steam generator shell failure;
3. Turbine break-up;
4. Massive failure of cooling water intake tunnel;
5. Massive failure of cooling water discharge duct;
6. Failure of heat transport pump casing or drive shaft;
7. Pressurizer failure;
8. Degasser-Condenser failure.

This type of events is not considered Design Basis Events, so they are NDB types, its occurrence frequency being very small; exception is the event nr. 6 that are covered by Large LOCA type events, analysed as category A or B events.

7.4.2. Acceptance Criteria for the Events with Radiological Consequences Postulated for Cernavoda NPP

In point of safety analyses the risk measures the negative effects of an activity. For a nuclear power plant the potential danger consists in radiation exposure.

To quantify the radioactive risk, the International Commission for Radiation Protection (ICRP) recommends the following definition (Ref. 7-5):

Risk = radiation exposure probability × exposure consequences

So risk is related not only to consequences but to probability also and the possibility to minimize the risk is to reduce the accident consequences as well as their occurrence probability.

Generally, the regulatory bodies for nuclear activities establish acceptance criteria for the initiating events postulated for a nuclear power plant in order to maintain the risk within the admissible limits.

Table 7.4-6 contains the acceptance criteria (occurrence frequency and public dose) established in C-6 Document for Category A and B events defined above.

Table 7.4-6. Acceptance criteria (occurrence frequency and public dose limit) for category A and B events

Event class (as per C-6 document)	Occurrence frequency (events/ reactor x year)	Public individual dose limit (mSv)	
		Whole body	Tyroid
1	$10^{-2} \leq f < 1$	0,5	5
2	$10^{-3} \leq f < 10^{-2}$	5	50
3	$10^{-4} \leq f < 10^{-3}$	30	300
4	$10^{-5} \leq f < 10^{-4}$	100	1000
5	$f < 10^{-5}$	250	2500

The inferior frequency limit considered in the Table 7.4-6 is 10^{-6} events/year; the consequence analysis of the event sequences with lower frequency is not necessary.

No quantitative acceptance criteria are defined for Category C events; the evaluation, however demonstrated the design measures existence to ensure the long-term heat removal following this type of events.

Referring to Category D events, the evaluation demonstrated that their occurrence frequency is maintained negligible, by design measures and appropriate operating procedures.

7.4.3. Radiological Consequences (Radiation Doses) of the Events Postulated for Cernavoda NPP

a) Design Basis Accidents

The chapter 15 of Preliminary Safety Report for Cernavoda NPP Unit 2 (Ref. 7-1) contains the methodology and the analysis results of Category A events (see Tables 7.4-1 and 7.4-2), defined as Design Basis Accidents (DBAs) . As Unit 3 and respectively Unit 4 design is similar, one considers, in this phase, the same dose values for these postulated events. This assumption is a conservative one, as Unit 3 and respectively Unit 4 reference design is Unit 2 design with some changes for safety improvement (Ref. 7-10, Appendix 8), resulted from operating experience of CANDU NPPs.

Table 7.4-7 contains the estimated values of radiation doses due to different types of DBAs (single process failure or coincident with a safety system unavailability), selected by considering the most severe radiological consequences criterion. These values, estimated at the exclusion zone boundary are extracted from chapter 15 of (Ref. 7-1).

Table 7.4-7. Individual doses due to the DBAs having the most severe radiological consequences, estimated at exclusion zone boundary

Event	Class as per C-6	**Individual dose** (mSv)	
		Tyroid	Effective
Large LOCA	3	1.60	0.451
Feeder break with flow stagnation	2	2.96	0.387
Fuel channel flow blockage	2	4.23	0.861
End fitting failure	2	2.10	0.393
Main steam line break outside containment	3	1.30	0.444
Steam generator single tube break followed by loss of class IV electric power	4	0.606	0.261
Large LOCA, with ECCS unavailable	5	147	17.4
Feeder break, with ECCS unavailable	5	44.2	7.10
Large LOCA, with containment isolation unavailable	5	1080	80.3
Feeder break, with containment isolation unavailable	5	1860	151
Fuel channel flow blockage, with containment isolation unavailable	5	16,5	4,08
End fitting failure, with containment isolation unavailable	5	1030	109

Notice that these estimated dose values are within the limits corresponding to the classes where the selected events are classified (see Table 7.4-6).

b) Beyond Design Basis Accidents (BDBAs)

The radiological accident analyses for Cernavoda NPP considered Beyond Design Basis Accidents (BDBAs) as well which, in accordance with the Canadian Regulatory Body AECB (currently CNSC) Consultative Document C-6 are named Non-Design Basis Accidents (NDBAs). The NDBAs considered according to C-6 are listed in Table 7.4-8 below. These events are assessed in chapter 15 of Cernavoda NPP Unit 2 PSAR (Ref. 7-1). Although there are no dose limits given in C-6 for this category of events, the estimated doses for these events are well below the dose limits specified for Class 5 events, i.e. 2500 mSv (Thyroid Dose) and 250 mSv (Effective Dose) (Ref. 7-19).

Table 7.4-8. Individual doses due to BDBAs (considered in PSAR), estimated at exclusion zone boundary

Event Description	AECB (CNSC) C-6 Class	Dose (mSv) Thyroid	Dose (mSv) Effective
Reactor main coolant system large LOCA plus loss of Class IV power plus Failure of Containment Isolation Logic	NDB	1970	171
Flow blockage in any single reactor fuel channel assembly plus total failure of containment atmosphere cooling equipment.	NDB	3.94	0.763
End fitting failure plus total failure of containment atmosphere cooling equipment.	NDB	2.04	0.404
Pressure tube/calandria tube failure plus total failure of containment atmospheric cooling equipment	NDB	2.02	0.312
Reactor main coolant system large LOCA plus total failure of containment atmosphere cooling equipment.	NDB	1.69	0.46

From Tables 7.4-7 and 7.4-8 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).

c) Fuel bundles damage

The radiological accident analysis dealing with damage of the fuel bundles is conservatively bounded by another event "End fitting failure plus failure to close of the containment isolation devices associated with a single containment subsystem for the system most critical for radioactive release from containment" that is analyzed in chapter 15 of PSAR (Ref. 7-1). This is a Class 5 event as per C-6 classification and is included in Table 7.4-7 of this study, the estimated doses being 1030 mSv (Thyroid Dose) and 109 mSv (Effective Dose). These doses are well below the dose limits specified for Class 5 events, i.e. 2500 mSv (Thyroid Dose) and 250 mSv (Effective Dose) (Ref. 7-19).

7.4.4. Analysis on the Occurrence Possibility of the events with significant Environmental Impact

Generally, in case of Design Basis Accidents (DBAs) postulated for a nuclear facility, the active and passive systems specified in the design ensure the reactor maintaining in the guaranteed shutdown state, decay heat removal and radioactivity confinement so that the consequences on public and environment are within the permissible actual limits.

In the last years, in evaluation of a NPP impact on public and the environment, an analysis of occurrence probability for severe accidents (Beyond Design Basis Events with serious core damage and great radioactive releases) has to be performed. Although generally the nuclear power plants are not provided with special means to withstand these events, measures to minimize or even prevent the public and environment radiation exposure are provided in emergency plans (see section 7.5).

Severe accidents at the nuclear reactors are events with extremely reduced occurrence probability implying multiple failures of essential systems, having consequences in important failures of the reactor and potential radioactive releases in the environment (Ref. 7-14).

Severe accident management has not yet been implemented at Cernavoda Unit 1 and Unit 2. In conformity with the international practice, a programme for the development of generic Severe Accident Management Guidelines (SAMG) for CANDU reactors has been undertaken by the CANDU Owners' Group (COG) and this development has been completed recently. SNN joined COG Severe Accident programme and have access to the results of this work.

The generic SAMGs from COG, as well as the specific SAMGs which will be developed for Cernavoda plant by Cernavoda Safety Analyses Department will be used as input data for PSA Level 2 which will be performed for Cernavoda NPP in the next years.

Based on the PSA development strategy agreed between CNCAN and SNN, SNN will produce by 2009 the PSA Level 2 that will include the analysis for Beyond Design Basis Accidents and for severe accidents for Cernavoda NPP. (Furthermore, this is a mandatory recommendation contained in the Nuclear Safety Evaluation performed by Euratom as an independent assessor at the request of the regulatory authority CNCAN, in order to provide an independent overview of all the safety aspects of Cernavoda Unit 2 and an expert opinion as to whether the completed Cernavoda Unit 2 would satisfy the current Western European nuclear safety objectives and practices).

It is important to mention that the strong concept of CANDU reactor allows a different progression of a severe accident, in case of occurrence to such a reactor, as compared to the case of a Light Water Reactor (LWR). More precisely, the moderator presence being under low pressure in the Calandria around the pressure tubes, as well as the high volume of light water in the Calandria vault provides an important quantity of cooling water, allowing transformation of a Design Basis Accident (DBA) in severe accident in a relatively long period of time.

This was confirmed by the probabilistic safety assessments performed for a generic CANDU (Ref. 7-18). The predicted accident progression for the LOCA initiating event sequence, performed using the MAAP4CANDU computer code shows that a severe accident at a generic CANDU plant (Calandria vault floor failure because of concrete erosion) could occur after more than 128 hours from the sequence initiation. That means the plant operating personnel has sufficient time (more than five days) to get alternative measures to mitigate the accident consequences and to avoid the progression of this DBA in a severe accident (Ref. 7-19).

The same AECL document estimates also that a total loss of plant power supply (station blackout) could lead to a severe accident after 133 hours, which is sufficient time for operator to avoid the progression of this event in a severe accident.

7.4.5. Transboundary Effects of Radiological Consequences Events Postulated for Cernavoda NPP Unit 3 and Unit 4

As presented in section 7.4, the CANDU design ensures the Design Basis Accidents radiological consequences mitigation. Monitoring measures and actions are provided in case of extremely unlike severe accidents. CANDU type plants (Cernavoda Unit 1 included) demonstrated the design and accident analysis conservatism (Ref. 7-17).

Cernavoda NPP Unit 3 and respective Unit 4 will be the beneficiary of all the CANDU plants experience referring to accident situations management to reduce as low as possible the population and environment impact (see section 7.5).

The safety analysis elaborated for Cernavoda NPP Unit 2 demonstrated that the population doses estimated at the exclusion zone boundary (1 km radius around the reactor) are within the limits, even for the accidents having the most severe radiological consequences (see Table 7.4-7). In these conditions there is very unlikely that Cernavoda nuclear units operation during accident conditions will jeopardize the population and environment in a 30 km radius around the Cernavoda site.

Taking into account the minimum distance between the Cernavoda site and other countries (40 km from Bulgaria) one can conclude that the transboundary effects of the Romanian nuclear units operation are insignificant even in the case of a Design Basis Accident with less than 10^{-5} events/year occurrence frequency.

7.5. Measures to Reduce the Cernavoda NPP Risk

7.5.1. Technical and Administrative Preventive Measures

Cernavoda NPP Unit 3 and respective Unit 4 design has got technical and administrative measures to maintain the nuclear facility operation risk in accordance with Romanian Regulatory Body (CNCAN) requirements (Ref. 7-16, 7-17). These measures have to prevent the radiological consequences events occurrence.

Technical preventive measures represent the technical features of Cernavoda NPP Units 3 and 4 design based on safety philosophy with protection in depth and system separation principles, requirements of systems failure frequency or unavailability according to Regulatory Body requirements.

These measures were developed to satisfy the basic safety functions after a nuclear accident:

- reactor shutdown and maintaining it in guaranteed shutdown state;
- fuel decay heat removal (cooling);
- radioactivity confinement;
- monitoring of the plant state during and post-accident.

The Cernavoda NPP Unit 3 and respective Unit 4 design is provided with process systems (one of them having also safety functions) and special safety systems ensuring the safety function as above in case of postulated events. To ensure protection against common cause events the physical separation between systems having the same safety function was applied.

The safety-related systems are forming two groups, each group being capable to ensure all the four safety functions. The systems that are part of the two groups and their safety functions are presented in Table 7.5-1.

Table 7.5-1. The two groups concept of safety-related systems

Safety function	Group 1	Group 2
Reactor shutdown	Shutdown system nr.1	Shutdown system nr.2
Decay heat removal	Normal power and cooling water supply systems	Emergency power and cooling water supply systems
Post-accident monitoring	Main Control Room	Secondary Control Area
Radioactivity confinement	Manual containment isolation valves	Containment systems

Together with the technical features of U3 and U4 NPP design, a number of administrative measures were taken to ensure the safe operation of the plant. The operational documents such as: the normal and abnormal operating procedures as well as working procedures in case of radiological or chemical emergency conditions- are all developed in order to ensure that the operation of the plant is within the Regulatory Body approved limits and in accordance with the radiological and chemical national and international norms and limits.

7.5.2. Protective measures to reduce the Cernavoda NPP Unit 3 and Unit 4 risk

For the design basis accidents, which set the criteria for special safety systems performance and also for radiological protective features, population protection is ensured by providing the following nuclear safety zones:

a) 1 kilometer unpopulated zone around each reactor (**exclusion zone**), where only operational activities related to NPP are allowed.

b) 2 km **low population zone** around each reactor, which complies with the requirement of CNCAN Romanian National Nuclear Safety Norms (NRSN), art. 18.

In the case of a severe accident (event beyond the design bases, having a very low occurrence frequency and severe radiological consequences –see section 7.4.4) the plant does not have special design features to withstand such a situation. An emergency plan is prepared, including measures to reduce or avoid population radioactive exposure in case of the severe accident. Within the emergency plan the Emergency Planification Zones are identified where pre-planification is necessary to ensure implementation of prompt and efficient population protection measures in case of a radiological incident. Conforming to the IAEA recommendations (Ref. 7-11), two distinctive zones were defined for Cernavoda NPP Unit 1 (Ref. 7-7):

- 10 km zone around the reactor – on short term, for exposure to the radioactive cloud;
- 50 km zone around the reactor – on long-term, for ingestion exposure pathways.

The protective measures which should be taken in case of nuclear accident, considering the different exposure pathways of the public are presented in Table 7.5-2.

The decision to apply one of the protective measures is taken when the expected values of doses are greater than the intervention level corresponding to the specific protective measure. The levels of intervention are presented in Table 7.5-3 (Ref. 7-13). The low level significance is that the dose values are lower than that level and therefore no protective action is needed. When the doses are greater than the high level the radiological measure must be applied. In order to avoid non-stochastic effects on public health, between these levels protective measures should be applied to keep the individual doses below the level at which such effects could appear.

The technical and administrative protective measures of Cernavoda NPP Unit 3 and Unit 4 design ensure that the risk, in the case of accidents will not be greater than the maximum admissible risk which, conforming to the requirements of (Ref. 7-12), will be defined by the Regulatory Body.

Table 7.5-2. **Protective measures in case of nuclear accident**

Exposure pathways	Time from exposure			Protective measure
	early	intermediate	late	
Direct external irradiation	x x x			Sheltering Evacuation Access control
External Irradiation from radioactive cloud	x x x			Sheltering Evacuation Access control
Inhalation	x x x x			Sheltering Stable Iodine administration Evacuation Access control
Skin & Clothes Contamination	x x x	x x x		Sheltering Evacuation Personnel decontamination
Irradiation from soil deposit material	x x x	x x x	x x x	Sheltering Evacuation Access control
Irradiation of radioactive material		x x	x x	Relocation Soil decontamination
Ingestion of contaminated food and water		x x x	x x x	Relocation Decontamination Water & food control

Table 7.5-3. **Levels of intervention and protective measures in case of a nuclear accident**

Protective Measure	Dose compared with intervention level	Intervention Level (mSv)			
		Whole body effective dose		Critical organ effective dose (thyroid, lung, skin, etc.)	
		low	high	low	high
Sheltering	External dose plus dose from intake in the first 24 hours	3	30	30	300
Stable iodine administration	Ingestion dose in the first 24 hours	-	-	30	300
Evacuation	External dose plus dose from intake in the first 24 hours	30	300	300	3000

7.5.3. Programs

Similar with Cernavoda NPP Units 1 and 2, in order to ensure that the systems will operate according to the design, Cernavoda NPP Unit 3 and Unit 4 should and will have during operation several programs to cover different aspects so that the plant is operated with a risk lower than the maximum risk allowed by the Romanian Regulatory Body.

These programs will cover the following fields:

- environmental monitoring;
- special safety systems reliability monitoring;
- periodic inspections and maintenance;
- control of design changes and configuration;
- events analysis;
- periodic safety review;
- risk monitoring;
- operation in case of radiological emergency;

- operation in case of accident;
- severe accident management.

Developing, upgrading and updating such programs will ensure an appropriate plant response in case of an accident occurrence, so that the risk on population and the environment will be within the limits established by the Regulatory Body.

The Cernavoda General Emergency Plan is in place, according to the provisions of Law no. 111/1996 on safe conduct of nuclear activities with subsequent completions and modifications, the provisions of the Government Urgency Ordinance no. 21/2004 on National System of Emergency Situation Management, endorsed by the Parliament by Law no. 15/2005, the provisions of the Law no. 48/2004 on Civil Protection and the provisions of the Radiological Safety Fundamental Norms/2000 and of Republican Nuclear Safety Norms for Planning, Preparedness and Intervention for Nuclear Accidents and Radiological Emergency/1993 (Ref. 7-15).

The Cernavoda NPP General Emergency Plan is elaborated by the NPP and is approved by the General Inspectorate for Emergency Situations (IGSU), which is the permanent working body of the Ministerial Committee for Emergency Situations (CMSU). CMSU, which has county and local commandments is led by the Ministry of Administration and Internal Affairs. CMSU has the responsibility to approve the General Emergency Plan and to manage the intervention.

The Cernavoda NPP General Emergency Plan is presented in a set of documents ensuring the precisely planning of on-site and off-site emergency response actions in case of any events with radiological consequences likely to appear during the Cernavoda NPP operational lifetime.

The set of documents contains the following (Ref. 7-7):

- On-site Radiological Emergency Plan;
- On-site Radiological Emergency Procedures;
- General off-site Intervention Plan in case of Nuclear Accident;
- Off-site Intervention Plan in case of Nuclear Accident;

- Protection and Intervention SNN-SA Emergency Protection Plan;
- Off-site Radiological Emergency Procedures;
- Other interface documents and agreements between different organizations and authorities.

The documents of the Cernavoda General Emergency Plan are interconnected and can be individually or integrally applied function of the radiological incident nature, ensuring an appropriated protection of personnel, public and environment.

Regarding the planning for radiation emergencies in the vicinity of Romanian territory Romania is a signatory of the following international emergency response agreements (Ref. 7-15):

- Convention on Early Notification of a Nuclear Accident;
- Convention on Assistance in the case of a Nuclear Accident of Radiological Emergency;
- Convention regarding the liability for nuclear damage.

Concerning the liaison across national borders, Romania has signed the Agreements for Early Notification of Nuclear Accidents with Russian Federation, Bulgaria, Greece, Hungary, Slovakia and Ukraine.

These agreements contain provisions for:

- taking all appropriate and effective measures to prevent, reduce and control adverse trans-boundary environmental impacts of major nuclear activities;
- ensuring that the parties are notified in case of nuclear accidents which could affect them.

The Romanian General Emergency Plan includes provisions for transboundary emergencies according to the provisions of national norms.

7.6. Risk Assessment of the Accidents with Impact on Environment and Public Health during Cernavoda NPP Unit 3 and Unit 4 Completion

During a nuclear unit completion period there is the probability of some accidents within the site due to the execution activities and/or materials and workers transport (Ref. 7-17).

The experience gained during Units 1 and 2 completion and operation will be used in the activities for Unit 3 and Unit 4 construction and exploitation. The management staff will have clearly defined responsibilities for approving and applying methods, practices and procedures for building, commissioning and operation, including responsibilities to develop, maintain and strengthen the specific safety objectives.

During the new construction elements completion, civil workers will take into account the chapters related to forming, reinforcing and putting in form of concrete (focused on dangers in case of working at altitude), contained in the industrial safety norms applicable to the industrial construction activities

During construction and installation activities, both the civil work companies and the owner have to consider the design recommendations and to take into account all the mandatory measures to avoid the accident hazard. The measures have not a limiting character, the owner having the obligation to establish and meet the protection norms during completion activities.

The civil work companies have to ensure all the involved workers training in the protection norms provision so that the content of these norms will be well learn.

The measures for preventing and extinguish of potential fires, provided for the entire period of completion activities will be established by the company which elaborate the site installation documentation and also by the contractor, to respect the actual norms requirements.

The building site will be provided with all the features for fires prevention and extinguish, in respect of applicable norms. Special care has to be provided for flammable materials handling and storage.

An on-site fire station, with shovels, pick-axes and water and sand buckets have to be installed, special care being taken for welding activities.

Strict working procedures will be established to avoid leaks of hazardous substances (toxic and/or explosive) during objective execution activities, as well as to promptly act should they occur. The experience gained in the two Cernavoda nuclear units shows that the leak amounts are small during the completion period, with limited extension and duration (due to the measures taken) and the adverse effects on population and environment will be reversible.

The toxic substances used during the execution activities are mainly paints. The explosive substances used during the same period are oxygen and acetylene. These substances will be stored in specially constructed locations, according to the norms in force.

7.7. Conclusions

During Cernavoda NPP Unit 3 and Unit 4 completion the measures to reduce at the minimum the risk on the workers, public and environment are taken.

The technical and administrative measures of Cernavoda NPP Unit 3 and respective Unit 4 together with the programs presented in section 7.5 will ensure the plant safe operation and a risk lower than the maximum risk allowed by the Romanian Regulatory Body.

It may be stated that the accidents with radiological consequences considered in the design of Cernavoda NPP Unit 3 and Unit 4 (Design Basis Accidents) will not induce a risk greater than the maximum risk allowed by the Regulatory Body.

In the case of severe accidents (Beyond Design Bases) the risk could be close to the maximum allowed value but the use of emergency plans and accident procedures in such cases will maintain the risk in an acceptable range.

The transboundary effect of Cernavoda NPP Unit 3 and Unit 4 operation in accident conditions is insignificant similar with the case of the other two nuclear units on the same site.

The Cernavoda NPP site and design characteristics will maintain in an acceptable range the risk due to natural phenomena (i.e. severe meteorological phenomena, flooding, earthquakes). The external human activities (within the NPP site and in the influence zone) do not affect the structures integrity and the personnel capacity to ensure the Cernavoda NPP Unit 3 and respective Unit 4 safe operation.

The risk of non-radiological accidents is limited both by design measures (i.e. possibility to collect the toxic leakage, ISCIR Norms to be used in pressure equipment design, etc.) and administrative measures (i.e. well defined procedures).

In case of accidental hazardous chemical leakage that may occur in the NPP, chemical emergency procedures were elaborated to include the actions that must be taken in order to minimize the danger to the personnel and equipment and to reduce the environmental impact.

References

7-1. SITON, CNE Cernavodă U2, *Raport Preliminar de Securitate,* Rev. 0, 2003.

7-2. IAEA, Safety Series, No. 50-SG-S5 *External man-induced events in relation to NPP siting*, Vienna, Rev.9, 1981.

7-3. ANM, *Studiul meteorologic şi de dispersie a poluanților în zona CNE Cernavodă*, iulie 2004.

7-4. Cernavoda NPP Unit 2, Completion Contract – Appendix I "Licensing Basis Document", 2003.

7-5. ICRP, Publication 60, *Recommendations of the International Commission on Radiological Protection,* 1990.

7-6. ICIM, *Studiul impactului asupra mediului al funcționării primului grup al CNE Cernavodă*, noiembrie 1994.

7-7. SITON, CNE Cernavodă Unitatea 1, *Raport Final de Securitate*, martie 2001.

7-8. AECL, 82-03702-SI-01, *Raport la studiul de impact de mediu* (traducere şi adaptare RAAN CITON), 2001.

7-9. ICIM, *Studiu de impact pentru CNE Cernavodă Unitatea 2,* 2002.

7-10. CNE Cernavodă Unitatea 3 – *Verificarea stadiului actual, U3-08230-6001-SF/SVR,* 2003.

7-11. IAEA-TECDOC-955, *Generic assessment procedures for determining protective actions during a reactor accident* , Vienna 1997.

7-12. NSR-01- *Norme fundamentale de securitate radiologică*, aprobate prin Ordinul CNCAN nr. 14/24 ianuarie 2000.

7-13. Ordin CNCAN nr. 242/1993 privind planificarea, pregătirea şi intervenția la accidente nucleare şi urgențe radiologice.

7-14. E-mail SNN of 01.02.2006.

7-15. Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Romanian National Report, Second Revision, August 2005

7-16. SITON, *Memoriu de prezentare necesar la obținerea acordului de mediu pentru CNE Cernavodă Unitățile 3 şi 4,* iunie 2006.

7-17. SITON, *Documentație U3/U4 - 08233 - 6023 - STI,* august 2006.

7-18. AECL Generic CANDU Probabilistic Safety Assessment – Reference Analysis, July 2002

7-19. E-mail SITON of 12.04.2007.