# ROMANIA

# National Report under the Convention on Nuclear Safety

**Seventh Revision, August 2016**

**FOREWORD**

This report demonstrates how Romania has fulfilled its obligations under the Convention on Nuclear Safety.

The structure of the 7th national report is similar to that of the reports previously submitted by Romania and follows the guidelines of INFCIRC/572/Rev.5. The information provided in the previous reports has been further detailed and updated, highlighting, where necessary, the most significant developments since the elaboration of the 6th national report.

This report has been prepared by the National Commission for Nuclear Activities Control, in consultation with and incorporating contributions from the National Company Nuclearelectrica.

**TABLE OF CONTENTS**

# INTRODUCTION

## 1. Current role of nuclear power in Romania

The nuclear policy of Romania encompasses the development and use of nuclear energy and other nuclear fuel cycle activities in Romania as well as oversight of the development and enforcement of nuclear legislation and regulations to ensure that all nuclear activities are strictly regulated and controlled to the highest standards to ensure public health and safety.

Romania has only one nuclear power plant, Cernavoda NPP, with two units in operation. Cernavoda NPP Units 1 and 2 cover approximately 18% of Romania's total energy production. The Government has plans to further increase nuclear generating capacity through the commissioning of Units 3 and 4 of the Cernavoda NPP. The decision to complete Units 3 and 4 was taken in June 2007. Pre-licensing reviews have been successfully completed, but no application for a construction licence has been submitted yet. The construction of Unit 5 has been cancelled by a decision of the General Shareholder Assembly of the National Company Nuclearelectrica, the owner and operator of Cernavoda NPP. The existing structures of Unit 5 will be used for different activities connected to the operation of Units 1 and 2 and, in the future, of Units 3 and 4.

**Table 1. List of Romanian nuclear installations**

| Reactor | Type | Gross Capacity MW(e) | Construction Start | First Criticality | Operating Status |
|---|---|---|---|---|---|
| Cernavoda-1 | CANDU-6 | 706.5 | 1980 | 16th of April 1996 | in operation |
| Cemavoda-2 | CANDU-6 | 706.5 | 1980 | 6th of May 2007 | in operation |
| Cemavoda-3 | CANDU-6 | 720 | 1980 | - | under preservation, plans for resuming construction |
| Cemavoda-4 | CANDU-6 | 720 | 1980 | - | under preservation, plans for resuming construction |
| Cemavoda-5 | CANDU-6 | - | 1980 | - | no plans for resuming construction;<br>the existing structures will be used for supporting activities of the other units. |

Long term commitment to nuclear power development, considered one of the drivers of the Energy Strategy of Romania, builds on the well developed national nuclear infrastructure, proven and safe technology and excellent performance of Cernavoda NPP, as well as on the positive public perception of the nuclear energy.

## 2. Main Governmental Organisations with responsibilities in the nuclear sector

The Ministry of Energy establishes the national strategy in the energy field and is the major shareholder of the nuclear energy production sector, nuclear research and engineering, nuclear fuel and heavy water production.

The National Commission for Nuclear Activities Control (CNCAN) is the nuclear safety and security regulatory authority of Romania, responsible for the regulation, licensing and control of nuclear activities, ensuring the peaceful use of nuclear energy and the protection of public and workers from the harmful effects of ionising radiation. CNCAN elaborates the strategy and the policies for regulation, licensing and control with regard to nuclear safety, radiological safety, non-proliferation of nuclear weapons, physical protection of nuclear installations and materials, transport of radioactive materials and safe management of radioactive waste and spent fuel, as part of the national strategy for the development of the nuclear sector. CNCAN reports to the Prime Minister, through the General Secretary of the Government.

The Ministry of the Environment, Water and Forests is the central authority for environmental protection and has specific responsibilities in this domain in the licensing and control of nuclear installations.

The State Inspectorate for Boilers, Pressure Vessels and Hoisting Installations (ISCIR), subordinated to the Ministry of Economy is responsible for the licensing and control of the pressure systems and equipment, including those used in nuclear installations, with appropriate consultation and collaboration with CNCAN.

The Nuclear Agency and for Radioactive Waste (AN&DR), subordinated to the Ministry of Economy, is responsible for promoting the peaceful use of nuclear energy and the related research and development programmes and for the coordination, at national level, of the safe administration process of spent nuclear fuel and of radioactive wastes, including their disposal.

## 3. Main companies in the Romanian nuclear power industry

The National Company "Nuclearelectrica" SA (Societatea Nationala Nuclearelectrica SA, further referred to in this report as SNN) is the owner and operator of Cernavoda NPP. The company includes two subsidiaries, no legal persons, one for nuclear power production (Cernavoda NPP) and one for nuclear fuel production (Nuclear Fuel Plant - FCN Pitesti), respectively. SNN is a government owned company, subordinated to the Ministry of Energy.

The company was listed on the Bucharest Stock Exchange in 2013 and, in its current shareholding structure, the Romanian state, through the Ministry of Energy, owns approximately 82.5 percent of the shares. The remaining percentage is owned by investment funds.

The Autonomous Company for Nuclear Activities (RAAN) is also a government owned company, responsible for heavy water production. RAAN is subordinated to the Ministry of Energy. It manages the Heavy Water Plant (ROMAG - Drobeta).

There are two national research and engineering institutes in the nuclear field - the Institute for Nuclear Research (ICN - Pitesti), which operates a TRIGA research reactor, and the Centre for Nuclear Projects Engineering (SITON - Bucharest). These two organizations are subsidiaries of the state owned company “Technologies for Nuclear Energy” (RATEN) which was established in 2013, by separation from the state-owned RAAN. RATEN is in charge of research and engineering activities devoted to the national nuclear power program. The two organizations are acting as scientific, technical and engineering support (technical support organizations) for the safe operation of Cernavoda NPP and for the other installations and projects that are part of the national nuclear power program.

The National Company for Uranium (CNU), also government owned and subordinated to the Ministry of Energy, is responsible for the administration of the national uranium mineral resources and performs geological research and exploitation activities for uranium ores, ores processing and concentrates refining, their transport and marketing.


Fig. 1.1 Location of nuclear installations and associated facilities

## 4. Main themes and safety issues presented in the report

The main issues addressed in the present report can be summarised as follows:

- Changes to the regulatory framework, taking account of the development of international safety standards and recognised good practices;
- Safety reviews performed and actions taken after the Fukushima accident;
- Safety improvements implemented or planned by the licence holder for Cernavoda NPP.

# SUMMARY

## 1. Summary of challenges, good practices, noteworthy items and suggestions for Romania from the 6th CNS Review Meeting

The results of the peer review of the National Report of Romania are summarized below:

### 1.1. Challenges

- Finalize implementation of the PSR actions for U1 (there were 34 corrective actions outstanding at that time). Applicability of these findings was evaluated against U2; however, a full scope PSR for U2 will be conducted in 2017.

Update as of August 2016: The implementation of the actions resulting from the PSR has progressed well. There are currently only 6 corrective actions that are still in progress, while the rest have been implemented.

- Implement the Fukushima National Action Plan by 2015.

Update as of August 2016: The majority of the actions have been implemented. Details are provided in Annex 2. Only three of the planned improvements have slipped beyond the original target date of 2015:

- Action #5 - Design modifications to replace selected doors with flood resistant doors and penetrations sealing (for improving the volumetric protection of the buildings containing safety related equipment located in rooms below plant platform level). This action is still in progress and it is estimated to be completed in November 2016. The change of the target date for finalizing the implementation was due to the complexity of the engineering solutions for penetrations' sealing.
- Action #15 – The option of charging the batteries or the installation of a supplementary uninterruptible power supply for the SCA is being considered by the licensee as a potential improvement. This action is still in progress and will be completed by the end of 2016. The change of the implementation date was due to time required to procure the new, seismically qualified, electrical panels that need to be installed.
- Action #31 - Cernavoda NPP will establish a new seismically qualified location for the on-site emergency control centre and the fire fighters. This location will include important intervention equipment (mobile DGs, mobile diesel engine pumps, fire-fighter engines, radiological emergency vehicles, heavy equipment to unblock roads, etc.) and will be protected against all external hazards. This action is in progress and it is estimated to be completed by the end of 2017. The target date for implementation has been changed due to legal and administrative issues related to transfer of property of the physical location. Until the completion of this action, equivalent measures have been implemented to ensure that all intervention equipment (mobile Diesels, Diesel fire pump, fire trucks, and so) are protected from external hazards (e.g. the equipment have been relocated so that they would not be impaired by external events).

- Finalize Level 2 fire, flood and seismic PSA

Update: The Level 2 PSA study for internal events, internal fire, internal flood events and seismic events for Cernavoda Units 1 and 2 has been finalized in 2014.

- Complete actions necessary for the 2016 IRRS Follow-up mission

Update: The IRRS Follow-up mission is currently scheduled for 2017. Many of the actions for implementing the recommendations and suggestions from the IRRS mission are completed, while a few others are in progress.

- Take measures necessary to ensure high quality staff is hired and retained for the upcoming complex projects (e.g, implementing Fukushima -lessons learned, PSR and IRRS corrective actions, WANO/IAEA peer reviews, and construction activities) will be resource intensive; these projects will require critical skills set that need to be further developed

Update: Actions are ongoing for improving staff retention in both regulatory and licensee organizations.

### 1.2. Good Practices

- Implementation of the Safety Culture Oversight Program at the NPPs. Safety culture surveys and self-assessments are issued.
- Including a summary of changes at the end of each section in the National Report is unique and has proven to be very helpful during the peer review process.
- Established a consolidated, high-level, National Strategy for Nuclear Safety and Security

### 1.3. Noteworthy Items

- Significant improvement in reporting of lower level events bringing the program in line with international practices

### 1.4. Suggestions

- Expand the scope of the IRRS Follow-up Mission to include the Fukushima module

Update: This suggestion will be taken into account for the IRRS scheduled for 2017.

- Romania was commended for their efforts in improving safety culture at the NPPs. Continuation of training efforts on safety culture oversight is encouraged. The Contracting Parties also encouraged Romania to implement a similar oversight program in the regulatory body.

Update: In 2015, CNCAN started to define its own organizational culture model, identifying the elements that promote and support safety culture. The model is based on the organizational culture model developed by Edgar Schein. Several training sessions on safety culture, as well as safety climate surveys have been used by CNCAN for its own staff involved in the regulatory oversight of nuclear installations. CNCAN staff also participates in IAEA initiatives on self-assessment of safety culture and the use of safety culture surveys for the regulatory authorities.

- Provide a progress report on the evaluation of PSA on multi-unit events during the next RM.

Update: The primary goal of the COG JP4499 Whole-Site PSA project is to develop and implement the proposed approach for site-wide characterization and assessment of Nuclear Power Plant (NPP) risk within a hierarchal safety goals framework. The purpose is to demonstrate that nuclear safety is assured and to promote public and regulatory acceptance of nuclear power by demonstrating that NPP risks are understood and managed.

Nuclear safety (low risk) is assured through a collection of safety goals and objectives, not necessarily by a single numerical value (risk metric). A hierarchal framework of safety goals can be constructed, consisting of a mix of qualitative and quantitative safety goals in different levels and logically inter-related, such that high-level public health objectives are met whilst also adequately addressing other important considerations (environment). It may be used as a basis for public communication.

Since 2015 Cernavoda NPP has joined this project to define site-based safety goals (and acceptance criteria) and whole-site PSA methodology (including risk aggregation) that are applicable to CANDU nuclear power plants. This could be achieved by proposing an approach for site wide characterization of NPP risk within a hierarchal framework founded upon defence-in-depth principles, proposed site safety goals, risk aggregation techniques and complementary approaches to risk assessment.

As a starting point, one road map was developed to provide an integrated strategy for further methodology development:

Phase A - Safety Goals Framework (completed in 2015).

Phase B - Risk Aggregation Studies (ongoing).

Phase C - Pilot Whole-Site PSA for Pickering NGS considering all reactor units, spent fuel bays, internal and external hazards, and all operating modes (scheduled for 2017).

The major steps performed in developing the Phase A - Safety Goals Framework:

1. Current industry practices and developments by the CNSC, USNRC, and international agencies (e.g., IAEA and Nordic Group) were reviewed.

2. Standalone reports were generated documenting the definition and basis for the proposed safety goals advocated in the hierarchical framework.

i) Top and Upper Level Safety Goals

ii) Intermediate Level Safety Goals

iii) Low Level Safety Goals

3. A Margin Assessment was carried out to estimate the margins between the Lower Level Safety Goals and possible Upper Level Safety Goals (i.e., Quantitative Health Objectives, QHOs).

4. The proposed safety goals and any potential regulatory risks or implementation risks were presented to senior management at COG and the member participants.

5. A Summary Report of the final accepted version of the safety goals suitable for dissemination to the general public and other stakeholders.

6. Information of the CNSC of the industry's definition of safety goals.

Instead of defining site LRF safety goal, the focus was first on determining the margin between the Lower Level Safety Goal (i.e., the surrogate Large Release Frequency safety goal) and the Upper Level Safety Goal (i.e., Quantitative Health Objectives).

Phase B - Risk Aggregation Methodology include a complementary "credible risk assessment" methodology by taking credit for actions that are not readily modeled using generally accepted PRA methods, thus limiting the core damage progression to the in-vessel retention (IVR) state, for purposes of obtaining an estimate of the aggregated whole-site risk; this implicitly accounts for SAMG and CNO/CNE BDBA principles that practically eliminate large off-site releases.

The following steps are performed in developing Phase B:

1. Catalogue of Risk Sources.
2. Risk Assessment Methodology for Non-Reactor Sources.
3. Catalogue of Operating States.
4. Effect of Habitability upon PSA Modelling.
5. Assessment of Arithmetic Risk Aggregation Options.
6. Complementary Credible Risk Assessment (CCRA).

The final steps will be to conduct whole-site PSAs for the NPP sites of the project participants, based on lessons learned from pilot Phase C completion.

## 2. Significant developments for the last reporting period

The most significant developments for the last reporting period are presented in dedicated sections of the chapters corresponding to:

Article 7 - New regulations and regulatory guides have been issued or are in process of being issued and work is ongoing for the implementation of the National Strategy for Nuclear Safety and Security in line with IAEA GSR Part 1 requirements and IAEA SF-1 Fundamental Safety Principles. Details are provided in section 7.6.

Article 8 - In 2013, CNCAN and the Norwegian Radiation Protection Authority (NRPA) have agreed to fund an IAEA Extra Budgetary Programme (EBP) on safe nuclear energy in Romania. The "Regional Excellence Project on Regulatory Capacity Building in Nuclear and Radiological Safety, Emergency Preparedness and Response in Romania" started at the end of 2013 and will be completed in 2017. Details are provided in section 8.9.

Article 10 - Developments are presented on both the regulator's and the licensee's side with regard to the assessment and improvement of nuclear safety culture. Details are provided in section 10.3.

Article 11 - The developments regard the improvements in the training programmes for Cernavoda NPP personnel. Details are provided in section 11.7

Article 12 – Section 12.8 has been revised and updated with more detailed information on the role of the regulatory authority regarding human performance issues. Details on the developments related to the licensee's human performance improvement programme are provided in section 12.9.

Article 13 - The developments are related to the improvement of the integrated management system of Cernavoda NPP. A summary of these developments is provided in section 13.8.

Article 14 - The main developments are related to the safety reviews post-Fukushima and the corresponding action plan, the implementation of the corrective actions from the first periodic safety review and the completion of Level 2 PSA and are summarized in section 14.5.

Article 15 - The main developments are represented by the reduction of the effective dose administrative limit for the occupationally exposed workers at Cernavoda NPP and by the improvement of the plant's dosimetry programme in order to introduce individual monitoring of occupationally exposed workers for alpha emitting nuclides internal contamination. There are mentioned in section 15.3.

Article 16 – The main developments in the area of emergency preparedness are summarized in section 16.5.

Articles 17, 18 and 19 - The main developments are represented by the improvement actions implemented or in progress as a result of the safety reviews performed after the Fukushima Daiichi accident. In addition, other important developments are related to design improvements based on insights from probabilistic safety assessments and operational experience feedback, as well as improvements related to the collection, processing and dissemination of operational experience processes. These are summarized in sections 17.5, 18.6-7 and 19.9.

## 3. Implementation of the principles of the Vienna Declaration on Nuclear Safety

In February 2015, the Contracting Parties to the Convention on Nuclear Safety have adopted the following principles to guide them, as appropriate, in the implementation of the objective of the CNS to prevent accidents with radiological consequences and mitigate such consequences should they occur:

1. New nuclear power plants are to be designed, sited, and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term off site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

2. Comprehensive and systematic safety assessments are to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.

3. National requirements and regulations for addressing this objective throughout the lifetime of nuclear power plants are to take into account the relevant IAEA Safety Standards and, as appropriate, other good practices as identified inter alia in the Review Meetings of the CNS.

The safety principles outlined in the Vienna declaration are implemented in Romania as follows:

**Safety upgrades** for increased protection against severe accidents have been implemented in Cernavoda NPP. These include:

- Passive autocatalytic hydrogen recombiners;
- Water make-up to ensure in-vessel core cooling;
- Filtered containment venting system to preserve containment function;
- Mobile diesel generators to ensure the power supply in case of station blackout;
- Improved instrumentation for monitoring safety parameters in severe accident situations.

Details on the safety upgrades are provided in the chapter corresponding to Article 18 and in Annex 2. Operational improvements are presented in the chapter corresponding to Article 19.

**Safety goals** currently in use in Romania include:

Dose- frequency criteria (maximum doses allowed for accidents of specified frequencies and / or maximum frequency allowed for accidents leading to doses in a certain range); these are established in the regulation on design and construction of NPPs (NSN-02);

CDF (Core Damage Frequency) and LERF (Large Early Release Frequency) values based on INSAG-12; these are not formalised in regulations, but are used in review and assessment for licensing purposes, in accordance with the principles outlined in paragraph 27 of INSAG-12.

**New regulations** have been issued that take account of the lessons learned from the Fukushima Daiichi accident. These are presented in the chapter corresponding to Article 7, in Section 7.6. CNCAN is currently in the process of finalising a regulation for transposing the Council Directive 2014/87EURATOM of 8 July 2014 amending Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations, which has a similar nuclear safety objective for nuclear installations. The revision and updating of nuclear safety regulations is a continuous activity and efforts are made to align the provisions of the national regulatory documents with the latest standards issued by the IAEA.

**Periodic safety reviews** are performed in accordance with a national mandatory regulation which is based on the IAEA safety standards and WENRA reference levels and which takes account of the international good practices in this area. Opportunities for improvement, including plant upgrades, are identified based on the review against the latest standards and implemented. In addition, safety reassessments, including new or revised safety analyses, are performed every time new information becomes available, from operational experience or from research activities, which is significant in relation to the prevention and / or mitigation of nuclear power plant accidents, including severe accidents.

Details on the safety review and assessment process, including on periodic safety reviews, are provided in the chapter corresponding to Article 14. Details on the safety reviews of the protection against external events, conducted post-Fukushima, are provided in the chapter corresponding to Article 17.

The actions taken by CNCAN and Cernavoda NPP to take account of the lessons learned from the Fukushima accident have been presented in detail in public reports:

- National Report of Romania for the 2nd Extraordinary Meeting under the Convention on Nuclear Safety (May 2012) http://www.cncan.ro/assets/Informatii-Publice/06-Rapoarte/RO-National-Report-for-2nd-Extraordinary-Meeting-under-CNS-May2012-doc.pdf ;
- Reports on the implementation of the European "stress tests" by Romania: http://www.ensreg.eu/EU-Stress-Tests/Country-Specific-Reports/EU-Member-States/Romania .

The national action plan developed for bringing together the actions identified from regulatory reviews, self-assessments, peer-reviews and generic recommendations at international level is provided in Annex 2 of this report, presenting the current status of the main actions.

CNCAN monitors the licensee's progress in the implementation of the planned improvements and continues to perform safety reviews and inspections to ensure that all the opportunities for improvement are properly addressed taking account of the lessons learned from the Fukushima accident.

# ARTICLE 6 - EXISTING NUCLEAR INSTALLATIONS

*Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shutdown may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.*

## 6.1 General Remarks

As presented in the introduction, a total of five nuclear power reactors were intended to be built in Romania on Cernavoda site. Unit 1 was first to be placed in service in 1996, while Unit 2 was commissioned and started commercial operation in 2007. The construction of the other three units on the site was stopped at different stages, and these units are currently under preservation. All units are pressurised heavy water reactors (PHWR), CANDU 6 type.

Romania has ratified the Convention on Nuclear Safety through the Law no. 43 / 24 May 1995. The reviews required under Article 6 of the Convention have been assimilated to the normal licensing process, as Unit 1 of Cernavoda NPP was commissioned between the years 1993 and 1996 and work on Unit 2 restarted in 2001.

The previous national reports under the Convention have included comprehensive information on the historical development of the Cernavoda NPP project and on the safety reviews performed. Therefore, the information previously presented has been further updated by this report and is provided under the relevant articles (mainly under Articles 14, 18 and 19).

The significant developments for the last report period have been presented in the Summary and are further detailed in the chapters corresponding to the relevant Convention articles.

## ARTICLE 7 - LEGISLATIVE AND REGULATORY FRAMEWORK

*1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.*
*2. The legislative and regulatory framework shall provide for:*
*i. the establishment of applicable national safety requirements and regulations;*
*ii. a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;*
*iii. a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;*
*iv. the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.*

### 7.1 Overview of the legislative and regulatory framework governing the safety of nuclear installations

The Law no. 111/1996 on the safe deployment, regulation, licensing and control of nuclear activities provides the legislative framework governing the safety of nuclear installations. In this report, it will be further referred to as "the Law".

The Law empowers the National Commission for Nuclear Activities Control (CNCAN), which is the national nuclear regulatory authority, to issue mandatory regulations, to issue licences for nuclear installations and activities, to perform assessments and inspections to verify compliance with the nuclear safety requirements and to take any necessary enforcement actions. The structure and content of the Law are described in Annex 1.

### 7.2 Development of regulations

CNCAN is empowered by Law to develop regulations in order to detail the general legal requirements as well as any other regulations necessary to support the licensing and control activities.

CNCAN develops regulations in accordance with the Law 24/2000, on "Legislative technique for elaboration of the normative acts" and the Governmental Decision HG 561/2009 on the approval of the Regulation regarding the procedures for elaboration of public policy documents, which establish the general provisions, technical rules and administrative procedures for the development of all Romanian regulations (normative acts).

All the regulations issued by CNCAN are mandatory and enforceable. The regulations are developed in observance of relevant international standards and good practices.

The Quality Management System of CNCAN includes also a procedure for drafting regulations and a process is in place to ensure internal consultation among CNCAN departments regarding the draft regulations. This is undertaken prior to the external consultation. The aim of the internal review is to provide an independent assessment of the scope, structure, content and implications of the regulatory documents, by persons not directly involved in their production. In some cases, external experts are also involved in the review the draft regulations developed by CNCAN staff. The correctness with regard to technical and legal aspects is observed.

The regulations in draft are published on the CNCAN website and are sent for external consultation to all interested organisations in order to receive feedback. The comments and suggestions received are analysed and discussed in common meetings. As a consequence of this review process, the regulations may suffer some amendments. Subsequently, the final revision of a regulation is approved by the President of CNCAN and then submitted for publication in the Official Gazette of Romania. Besides publication in the Official Gazette, in order to provide for broader dissemination, CNCAN publishes the regulations on its website.

In accordance with the provisions of the Law, CNCAN has the responsibility for reviewing the regulations whenever it is necessary for these to be consistent with international standards and with relevant international legislation in the domain, and for establishing the measures for the application thereof.

Various sources of information relevant for updating the system of regulations and guides are used, including the development of international legislation and safety standards, international cooperation, feedback from the industry and feedback from CNCAN inspectors based on their experience with the enforcement of the regulations, the results of research and development activities.

Besides the needs arisen from the licensing process, priorities for development of regulations were established as part of the harmonisation process in the WENRA (Western European Nuclear Regulators' Association) countries.

### 7.3 Overview of the licensing system

The licensing practice for Cernavoda NPP is based on the provisions of the Law and of the regulations issued by CNCAN. The Law clearly stipulates that the prime responsibility for the safety of a nuclear power plant rests with the licence holder. As required by the Law, a licence is needed for each of the stages of the life time of a nuclear installation. For a nuclear power plant, the licensing stages include, as appropriate: design, siting, construction, commissioning, trial operation, operation, repair and/or maintenance (as major refurbishment), modification (as major upgrades), preservation and decommissioning.

The requirements specified in the Law and the regulations are rather general and therefore a number of mechanisms are in place to ensure effective management of the licensing process. This section only gives general information on the licensing process, the more detailed aspects being addressed in the chapters corresponding to the Articles 11 - 19.

The detailed regulatory requirements, as well as the assessment and inspection criteria used by CNCAN in the licensing process are derived from a number of sources, such as:

- Romanian regulations;
- Limits and Conditions specified in the different licences;
- IAEA Safety Standards and Guides;
- ICRP recommendations;
- Regulatory documents developed by CNSC and US NRC;
- Applicable Standards and Codes (CSA, ANSI, ASME, IEEE, etc.);
- Safety related documentation produced by the licensee and approved or accepted by CNCAN (e.g. Safety Analysis Reports, Safety Design Guides, Design Manuals, reference

documents, station instructions, operating manuals, technical basis documents).

Apart from the formally issued (published) regulations, the requirements established by CNCAN in the licensing process are imposed through regulatory letters. Requirements and dispositions are stated also in the inspection reports.

Control of licensing submissions is described in the Quality Management System of CNCAN, within the framework of which a set of procedures have been established that define the different activities and tasks performed by the different organisational divisions involved in the licensing process. The licensing process is documented according to CNCAN internal procedures.

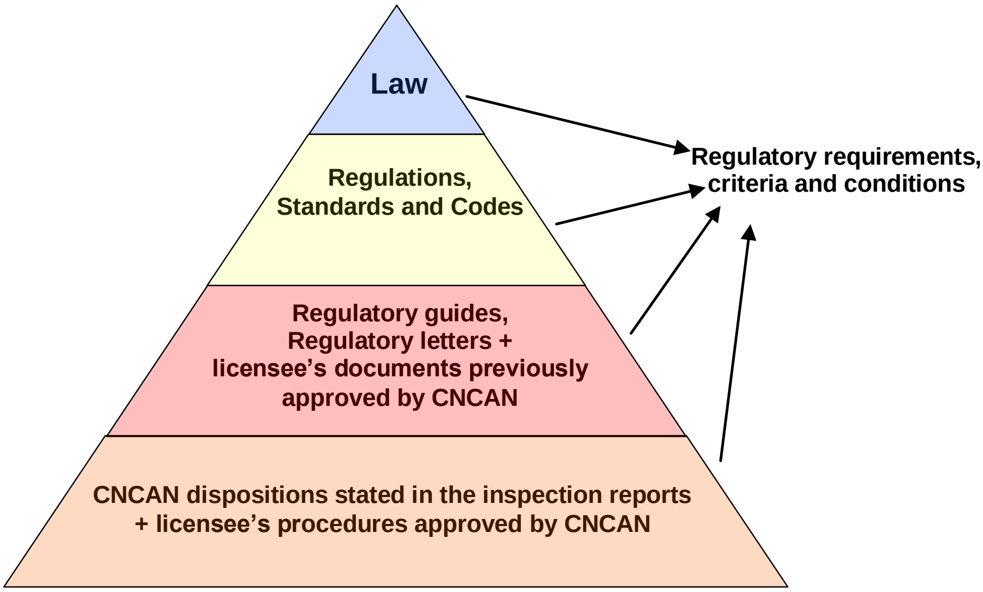



**Fig. 7.1 - Documents containing requirements used by CNCAN in the licensing**

The licensing submissions include, as the main document, a safety analysis report in accordance with the specifications established by CNCAN for each stage of the licensing process. In addition to the safety analysis reports, various supporting documents are submitted by the applicants to demonstrate the safety of the nuclear installation and the fulfilment of all the relevant legislative and regulatory requirements.

The review process performed by CNCAN is documented by one of the following means:
- evaluation reports;
- regulatory letters;
- inspection reports, containing findings and dispositions;
- written minutes as result of the licensing meetings (common meetings between CNCAN staff and the representatives of the licence holder or applicant).

If the review concludes that all the requirements have been met by the applicant, a licence is issued by CNCAN, for a specified period of time. All the limits and conditions derived for each specific case are clearly stated in the licence, which includes sections devoted to quality management, emergency preparedness, radiation protection, reporting requirements, compliance with licensing basis documents, the hierarchy of documents of the licensee, etc.

For example, the content of a licence for operation includes:
- facility and activities covered by the licence;
- period of validity, provided that all conditions are met;
- general conditions specifying the documents on which the licence is based;
- specific conditions on the facility organisation and personnel;
- specific conditions for the operation (limits and conditions);
- specific conditions related to radiation protection of the personnel, public and environment;
- specific conditions regarding approvals for design changes and changes in the operating conditions;
- specific conditions for the management of records;
- specific conditions governing the procurement, possession, use, transfer, and storage of the nuclear fuel, of the nuclear and radiological materials, etc;
- specific conditions regarding safeguards;
- specific conditions regarding physical protection;
- specific conditions regarding quality management;
- reporting requirements (incident reporting, quarterly and annual reports);
- specific conditions regarding the periodic safety review;
- status of emergency preparedness arrangements.

The licensing process for siting, construction, commissioning and operation of a nuclear power plant is detailed under Articles 17 - 19.

According to the Law, a licence for the quality management system has to be obtained from CNCAN, as pre-condition for the issuance of the construction / commissioning / operation / decommissioning licence. The licensing of the quality management systems is applied not only to the operators of nuclear installations but also to the suppliers of products and services for the nuclear installations. More detailed information on this matter is provided under Article 13 - Quality Assurance.

For detailing the requirements in the Law with regard to the issuance of practice permits, the procedures and conditions for issuing a practice permit for the personnel involved in the operation and management of the nuclear installations are established by the “Regulation on granting practice permits to operating, management and specific training personnel of Nuclear Power Plants, Research Reactors and other Nuclear Installations”. More information on licensing of personnel with safety related duties is provided under Article 11 - Financial and Human Resources.

### 7.4 Regulatory Assessment, Inspection and Enforcement

In accordance with the provisions of the Law, CNCAN is empowered to request from the licensees, or from the applicants for a licence, all the documentation needed for the regulatory decision making process on safety related matters. The documentation that needs to be submitted to CNCAN for review and approval is usually specified in the regulations.

Additional support documentation is requested on a case by case basis and specified in regulatory letters, minutes of the meetings between CNCAN staff and licensee’s representatives, etc. According to the Law, the licensees and applicants have the obligation of facilitating CNCAN inspections and access to documentation and to provide all the information required by CNCAN.

The safety related documentation made available to CNCAN includes a large variety of documents, such as safety analysis reports, (quality) management manuals, different types of safety assessments and technical evaluations, information reports and procedures (reference documents, station instructions, operating procedures, work plans, etc.).

The responsibilities for the review and assessment of the technical documentation submitted by the licensees or applicants are assigned to the different technical units within the organisational structure of CNCAN.

The regulatory review activities are planned, performed and reported in accordance with internal procedures and instructions in order to assure the availability of internal resources and, as appropriate, external resources and to establish interfaces with the licensees. Each technical unit has specific attributions and develops assessment and inspection procedures and plans in the respective areas under their responsibility.

For major reviews, such as those performed by CNCAN prior to granting a licence or an approval for a licensing milestone, interdisciplinary teams are established, which include experienced staff from all the technical units involved in the licensing of NPPs, with the necessary expertise for covering all the areas of review. Most of the experts responsible for the assessment of the safety related documentation participate also in the teams that perform the inspections. It should be noted that the assessments and inspections performed in the framework of the major reviews mentioned above are performed supplementary to the assessment and inspection activities deployed by each technical unit on a regular basis. The activities of the various technical units in the area of safety assessment and inspections for Cernavoda NPP are coordinated by the Director of the Nuclear Fuel Cycle Division (see the organisational chart of CNCAN, provided under Article 8 - Regulatory Body).

The assessment and inspection criteria are usually specified in the internal procedures of CNCAN. However, situations may arise for which more detailed criteria need to be established ad-hoc, with adequate justification based, as the case may be, on safety assessments, engineering judgement or recognised good practices.

The key objective of the CNCAN inspection programme for Cernavoda NPP is to monitor compliance with the legal, regulatory and licensing requirements, and to take enforcement action in the event of non-compliance. The inspections for Cernavoda NPP are planned in a systematic manner by the staff from CNCAN headquarters and the resident inspectors, with the aim of ensuring a proactive identification of the deficiencies and deviations from good practices that could result in non-compliances.

The inspection planning for Cernavoda NPP is periodically reviewed and modified as new information on the facility or organisation is obtained. The inspections are normally focused on those areas that would pose a significant risk, or for which a poor performance has been recorded. However, if an assessment finds good performance in an area, the results may be used to reduce the frequency and depth of the future inspections.

The inspections performed by CNCAN include:

- scheduled inspections, planned and performed either by each of the technical divisions, or jointly, with the occasion of the major licensing milestones;
- unscheduled and/or unannounced inspections, some of these being reactive inspections,

in response to incidents;
- routines and daily observation activities performed by the resident inspectors.

Examples of inspection activities and tasks performed by CNCAN inspectors are given below:
- review of plant operation reports;
- review of progress on outstanding safety issues;
- review of the past safety performance of the plant;
- review of the status of committed safety improvements;
- review of the station requests with regard to temporary deviations from conditions in the operating policies and principles;
- quality management audits;
- review of temporary and permanent modifications to ensure they are consistent with the licensing basis for the plant;
- system inspections;
- observation of operating practices and work;
- monitoring of the training programme implementation;
- monitoring of emergency drills;
- monitoring of the radiological protection practices.

Resident inspectors in the NPP Surveillance Unit have a very important role in the daily observation and assessment of the activities on site. The team of resident inspectors is responsible for producing the first draft of the annual inspection plan, which is then reviewed and supplemented by the staff in the CNCAN headquarters.

Examples of activities performed by the resident inspectors are given below:
- verification of the implementation of the dispositions and recommendations resulted from previous inspections;
- independent preliminary investigation of events significant for safety;
- inspections in the field for observing and gathering information on the general progress of plant activities;
- detailed system inspections, for observing the performance of maintenance activities and the status of related documentation;
- daily verification of the various records and reports related to the operation of the plant;
- evaluation of the practices in different areas of activity to observe adherence to procedures, with focus on radiation protection aspects, preventive maintenance activities, testing of the special safety systems, personnel training, quality assurance;
- monitoring of the emergency preparedness arrangements;
- surveillance of the performance of activities during the planned outages with regard to configuration of the safety related systems, radiation protection of the personnel, work involving contractors, elaboration and review of the safety documentation (procedures, work plans, modification proposals, etc.);
- witnessing the performance of tests or other activities performed on safety related systems, usually according to an inspection plan that includes Witness Points (WP) and Hold Points (HP) (this approach is used mainly for monitoring the activities during planned outages).

A series of routine inspections is used by the NPP Surveillance Unit to monitor the physical state of the systems and the operating parameters, that cover all safety relevant areas of the plant.

The areas covered by the routine inspections are:

- Reactor Building;
- Service Building;
- Turbine Building;
- High Pressure Emergency Core Cooling Building;
- Emergency Water System Building;
- Secondary Control Area;
- Standby Diesel Generators Building;
- Spent Fuel Bay;
- Pump House;
- Chillers Building;
- Fire Response Command Area.

During planned outages, inspections are performed also in the areas not accessible during operation at power.

Besides the routines, the resident inspectors perform daily visits to the control room, for verifying the main operating parameters and the different aspects related to work planning and control of temporary modifications. The resident inspectors participate also as observers in the daily planning meetings of the plant management. Daily reports are elaborated by the NPP Surveillance Unit and forwarded to the CNCAN headquarters for information on the plant status and for ensuring awareness of any inspection findings.

The assessment and inspection activities performed by CNCAN staff are documented by one of the following means:

- assessment reports;
- inspection reports;
- written minutes of the meetings with licensee’s representatives.

The inspection findings are categorized based on their importance to nuclear safety.

The documents resulting from the inspection activities are also distributed to the licensee, in addition to the regulatory letters that summarise the main regulatory requirements and dispositions based on findings arising from the review process.

In accordance with the provisions of the Law, CNCAN has in place a system to enforce compliance through graded measures. Therefore, the possible actions that CNCAN can take in the event of non-compliance are:

- dispositions for licensee action (these are stated in each inspection report);
- action notices/directives stated in regulatory letters;
- licence amendments;
- restricted reactor operation;
- revocation or suspension of the license;
- prosecutions.

## 7.5 Use of IAEA Safety Standards

The IAEA Safety Standards have always been considered by CNCAN as a valuable source for the development of the regulatory framework. The main IAEA documents used for this purpose are the Safety Requirements and Safety Guides, but account is taken also of the Safety Reports, Safety Practice Documents and TECDOCs.

The regulatory activities in which CNCAN makes use of the IAEA Safety Standards can be summarised as follows:

- elaboration of regulations and regulatory guides;
- establishment of assessment and inspection procedures and criteria;
- development of the regulatory management system and elaboration of internal procedures, etc.

In addition to using the IAEA Safety Standards for the development of regulations and guides, CNCAN uses these standards for developing its internal processes and procedures for review and assessment and for inspection of nuclear facilities and activities.

### 7.6 Significant developments for the last reporting period

Following the Fukushima Daiichi accident, CNCAN (the National Commission for Nuclear Activities Control – the nuclear regulatory authority of Romania) has focused initially on the technical reviews of the protection of the plant against extreme external events and of beyond design basis accident analysis, severe accident management and emergency response. After more information became available on the organizational factors that have contributed to the accident, CNCAN has used the lessons learned to improve the national regulatory framework, its practices for regulatory oversight of licensees' safety culture and its own safety culture. Several new regulations and regulatory guides have been issued in the period 2014 – 2016.

### 7.6.1. Enactment of the National Strategy for Nuclear Safety and Security

In July 2014, the National Strategy for Nuclear Safety and Security was officially approved by the Romanian Government and by the Supreme Council of National Defence, has been published and has come into force.

The work on a national strategy for nuclear safety and security started from a recommendation received from an IRRS mission. In January 2011, Romania received an Integrated Regulatory Review Service (IRRS) Mission organized by the International Atomic Energy Agency (IAEA). The scope of the review covered the nuclear regulatory framework for all types of facilities. The aim of the review was to compare the national regulatory framework with the requirements in the IAEA Safety Standard GSR Part 1, issued in September 2010.

The IAEA IRRS Mission to Romania recommended that "*The Government of Romania should issue the national policy and the strategy for safety, and implement them in accordance with a graded approach*" and suggested that "*The government should consider all fundamental safety objectives and principles, established in the IAEA Fundamental Safety Principles document, when finalizing the national policy and strategy*". The above mentioned recommendation was based on IAEA GSR Part 1 Requirement 1. Although most of the elements required by such a strategy were considered to be already in place, it was recognized that a national strategy may bring better coordination and coherence in addressing all the aspects and measures that have an impact on nuclear safety and security. Therefore, this work has been considered of added value and all the national authorities with roles and responsibilities related to the nuclear field, as well as the organizations owning and operating the major nuclear facilities, have participated in the development of the strategy, which was coordinated by CNCAN.

The development of the national strategy started in the beginning of 2013. At first, the strategy addressed only nuclear safety (including radiological protection and emergency preparedness and response), but the scope of the strategy was later expanded to cover also nuclear security (including physical protection, nuclear safeguards and cyber security). Based on the current regulatory framework and on the trends observed at international level with regard to the improvement of the synergy between safety and security, it was decided that a national strategy addressing both nuclear safety and security is justified, taking into account also the provisions in the IAEA Safety Standards.

The strategy includes a policy statement with nuclear safety and security principles, including the ten fundamental safety principles outlined in the IAEA SF-1 Publication, and takes account of the relevant provisions of the IAEA GSR Part 1 Publication.

The strategy will be reviewed and revised as necessary, at least every 5 years. A process will be established to monitor the implementation of the strategy and of its corresponding action plan, and the results would be presented annually to the Government.

The work on this strategy was briefly presented at the 6th Review Meeting of the Contracting Parties to the Convention on Nuclear Safety and Romania received a recognition of a "good practice" because we "Established a consolidated, high-level, National Strategy for Nuclear Safety and Security".

### 7.6.2. Enactment of the regulation on response to transients, accident management and on-site emergency preparedness and response for nuclear power plants

Acting upon the lessons learned from the Fukushima accident and from the safety reviews performed, CNCAN issued a regulation on the response to transients, accidents and emergency situations at nuclear power plants. The regulation was published in January 2014 and came into force in April 2014.

The new regulation on accident management and on-site emergency preparedness and response provides requirements on:

- objectives, principles and factors to be taken into account for the response to transients, accidents and emergency situations on-site;
- transient and accident scenarios to be addressed in / covered by the EOPs (Emergency Operating Procedures);
- severe accident scenarios to be covered by the SAMGs (Severe Accident Management Guidelines);
- emergency situations to be covered by the on-site emergency response plan and emergency response procedures;
- establishment of the minimum number of staff with necessary qualifications to manage all scenarios required by the regulation (including combinations of events and scenarios in which multiple units on site are affected by accidents initiated by extreme external events beyond the design basis of the plants);
- facilities and equipment to be available for accident management and on-site emergency response, including in situations caused by extreme external events;
- development and validation of procedures;
- documentation of the technical basis for the procedures;
- configuration management in relation to the procedures and systems credited for accident management and emergency response;

- training programmes and exercises;
- use of operational experience for the improvement of accident management and emergency response;
- records from exercises and from real events.

The requirements take account of the International Atomic Energy Agency (IAEA) safety standards and WENRA Reactor Safety Reference Levels, which are considered as relevant international standards and good practice documents. The international documents referenced in the regulation are listed below:

1) Safety of Nuclear Power Plants: Commissioning and Operation : Specific Safety Requirements, IAEA Safety Standards Series No. SSR-2/2, International Atomic Energy Agency, Vienna, 2011.

2) Preparedness and Response for a Nuclear or Radiological Emergency, Safety Requirements, IAEA Safety Standards Series No. GS-R-2, International Atomic Energy Agency, Vienna, 2002.

3) Severe Accident Management Programmes for Nuclear Power Plants, Safety Guide, IAEA Safety Standards Series No. NS-G-2.15, International Atomic Energy Agency, Vienna, 2009.

4) Arrangements for Preparedness for a Nuclear or Radiological Emergency, Safety Guide, IAEA Safety Standards Series No. GS-G-2.1, International Atomic Energy Agency, Vienna, 2007.

5) Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, General Safety Guide, IAEA Safety Standards Series No. GSG-2, International Atomic Energy Agency, Vienna, 2011.

6) WENRA Reactor Safety Reference Levels, Western European Nuclear Regulators' Association.

Since accident management and on-site emergency response are intrinsically coupled, it was decided that both should be addressed in the same regulation. The specifications used in the European "stress tests" post-Fukushima for the review of the severe accident management programmes have also been used for elaborating the requirements. Taking account of the recommendations from the "stress tests" peer-review, the regulation includes requirements on the development of EOPs and SAMGs for scenarios initiating from all plant states and modes of operation, including from shutdown states.

Cernavoda NPP has already taken actions to comply with the new regulatory requirements. Several review and inspection activities for assessing compliance with the new regulation have been performed. Actions taken based on the new regulation include the reassessment of the minimum shift complement and the review and revision of EOPs to address events occurring during shutdown states. The development of SAMGs to cover shutdown states had already been committed as part of the post-Fukushima action plan.

### 7.6.3. Enactment of the regulation on the protection of nuclear installations against external events of natural origin

CNCAN started to work on a regulation on the protection of nuclear installations against external events of natural origin in 2014, in order to fulfil a commitment in the National Action Plan post-Fukushima and to formalize the regulatory requirements in this area.

The new regulation “Nuclear safety requirements on the protection of nuclear installations against external events of natural origin” – NSN-06 was published in January 2015.

The regulation is based primarily on the new WENRA (Western European Nuclear Regulators Association) Reference Levels - Issue T: Natural Hazards, published in 2014.

The regulation NSN-06 does not prescribe the external events to be considered, but provides the following generic categories:

a) Geological hazards;

b) Seismotectonic hazards;

c) Meteorological hazards;

d) Hydrological hazards;

e) Biological phenomena;

f) Vegetation fires.

The regulation provides general requirements on the identification, screening, selection and analysis of external events on natural origin, for the purpose of establishing the design bases for the nuclear installations. The regulation also provides general requirements on the hazard analyses, on the definition of the design basis events, on the protection against design basis events of natural origin, as well as on the protection against events that exceed the design basis.

CNCAN has not yet issued any regulatory guides in relation to this regulation, but it has endorsed the general guide issued by WENRA / RHWG (Reactor Harmonization Working Group to support the implementation of the reference levels in Issue T.

The licensees have submitted to CNCAN self-assessments of the compliance with the new regulation. These are under review and the regulatory inspections are planned for 2016.

### 7.6.4. Enactment of a new regulation on the operational limits and conditions for nuclear installations

A new regulation on the operational limits and conditions (OLCs) for nuclear installations has been issued in 2015. Previously, the general requirements on OLCs for nuclear power plants and research reactors have been set in a regulation issued in 1975, as well as in licensing basis documents and license conditions.

The new regulation, NSN-05 – “Nuclear safety requirements on the operational limits and conditions for nuclear installations”, published in October 2015, has as main references the following documents:

1) WENRA Reference Levels published in 2015, „Issue H - Operational Limits and Conditions”;

2) „Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants, Safety Guide, IAEA Safety Standards Series No. NS-G-2.2”, 2000;

3) „US NRC 10 CFR 50.36 - Technical Specifications”.

New requirements introduced by this regulation include:

- the provision of an operator to staff the SCA (secondary control area) on a permanent basis, for each shift (this requirement had been already implemented by the licensee on a voluntary basis, based on lessons learned from the safety reviews post-Fukushima);

- the provision of two licensed control room operators for each operating shift;
- the establishment of administrative controls, as part of the OLCs, for the systems and equipment credited to support the implementation of the severe accident management guidelines.

### 7.6.5. Enactment of the regulation on the nuclear safety policy and independent nuclear safety oversight

In September 2015, CNCAN issued a new regulation, "Requirements on the nuclear safety policy and on the independent nuclear safety oversight". It applies to all licensees and applicants for a license for the phases of construction, commissioning and operation of nuclear installations, including nuclear power plants.

The first part of the regulation establishes requirements on the nuclear safety policy, covering all the current WENRA safety reference levels in Issue A. The second part of the regulation establishes requirements on the independent nuclear safety oversight.

The requirements on independent nuclear safety oversight have been established by CNCAN taking account of the international experience available in this area, including the information from various countries that have a long tradition in this practice, the conclusions in the Summary Report of the 6th Review Meeting of the Contracting Parties to the Convention on Nuclear Safety (paragraphs 21-22) and good practice guides used by the nuclear industry.

The requirements are aimed at establishing an organizational unit, inside each licensee's organization, having as an exclusive and full-time job the independent oversight of nuclear safety. This function of internal independent nuclear safety oversight is different / separate from the independent audit of the management system (which is nevertheless recognized as a form of internal independent oversight).

The intent of the regulatory requirements is that the independent nuclear safety oversight function is performed on a continuous basis. In other jurisdictions, this function is referred to informally as an "internal regulator" function. The licensees' staff performing the independent nuclear safety oversight function will be licensed by CNCAN.

The implementation of the new requirements on independent nuclear safety oversight is in progress. The implementation of these new requirements will provide additional assurance to the regulatory authority that the licensee is taking all the reasonably practicable measures to find and correct any safety significant issues in a timely manner, taking account of the best practices in this area at international level.

### 7.6.6. Enactment of regulatory requirements on the prevention of use of counterfeit, fraudulent and suspect items in nuclear installations

In December 2014, CNCAN issued some modifications / updates to the regulations on quality management system for nuclear installations and activities, to include provisions on the prevention of use of counterfeit, fraudulent and suspect items in systems, structures, components and equipment important for nuclear safety and for nuclear security.

### 7.6.7 Enactment of a regulation on ageing management for nuclear installations

In January 2016, CNCAN issued a regulation on ageing management for nuclear installations. The requirements in the regulation are based on the relevant IAEA safety standards and WENRA Safety Reference Levels.

### 7.6.8 Issuance of a new regulatory guide on industrial codes and standards for nuclear power plants

In 2014, CNCAN started to work on a regulatory guide (GSN-01) on the industrial codes and standards for nuclear power plants. After consultation with the stakeholders, the guide was published in March 2015.

This guide is aimed to improve the regulatory control over the entire set of industrial codes and standards used for safety-related systems, structures, components and equipment and associated activities, for the stages of siting, construction, commissioning and operation of a nuclear power plant, as well as for the process of periodic safety review.

It provides a list of recommended codes and standards, including the ASME code and CSA, IEEE, IEC and ISO/IEC standards. Cernavoda NPP has to develop its own list, taking account of the standards recommended in this guide, and submit it for regulatory review.

### 7.6.9. Issuance of a new regulatory guide on the independent verification of nuclear safety analyses and evaluations

The regulatory guide on the independent verification of nuclear safety analyses and evaluations for nuclear installations (GSN-02) was published in September 2015, following consultation with the stakeholders.

This guide was issued in relation to the general requirements on independent verification that already existed in the nuclear safety regulations and in the regulations on quality management systems for nuclear installations and activities.

The independent verification in this context refers to the independent verification referred to in the IAEA safety standard GSR Part 4 - Requirement 21 and paragraphs 4.66 – 4.71.

The provisions of the GSN-02 guide apply to the independent verification activity for the following categories of nuclear safety analyses & evaluations (NSA&E):

> a) NSA&E which are part of the licensing basis for the nuclear installations, including analyses and evaluations supporting the initial, preliminary and final nuclear safety analysis reports that are submitted to CNCAN in the licensing process.
>
> b) NSA&E which are at the basis (which support) the proposals for design modifications of a nuclear installation already licensed by CNCAN, for the systems, structures, components and equipment with nuclear safety functions and / or for the technical limits and conditions for operation (operational limits and conditions / technical specifications).

NSA&E include deterministic safety analyses, probabilistic safety assessments and hazard analyses.

The provisions of the guide apply to both NSA&E performed by the licensee’s / applicant’s own staff and to those performed by external organizations for the licensee / applicant.

The guide includes a recommendation that the licensee / applicant establishes policies, principles and requirements on the objectives, scope, depth and degree of detail of the independent verification of NSA&E, to reflect a graded approach, taking account of the following factors:

a) the specificity and complexity of the nuclear installation;

b) the importance of the NSA&E, taking account of the intended application / use and of the impact on the design basis and / or licensing basis for the respective nuclear installation;

c) complexity of the NSA&E;

d) novelty or unicity of the NSA&E or of the methods of analysis and evaluation used.

It is recommended that the licensee/applicant plans and establishes the necessary procedures for the systematic approach to the independent verification of NSA&E, including for documenting the results of the independent verification in specific reports. It is recommended that the independent verification reports present at least the following information:

a) purpose and objectives of the independent verification;

b) limitations of the independent verification;

c) verification methods, tools and criteria used;

d) any non-conformities identified and the corrective actions implemented to ensure the adequate quality of the NSA&E.

e) conclusions on the fulfillment of applicable requirements and on the acceptability of the NSA&E.

For ensuring a systematic approach to the independent verification of NSA&E, it is recommended that the licensee/applicant uses checklists with acceptance criteria. The annex to the guide presents a checklist with generic acceptance criteria, which are not exhaustive. It is recommended that the licensee/applicant develops its own checklists, specific for the respective nuclear installation and for the type and intended use of NSA&E and updates them periodically to take account of the accumulated experience, results of research activities and of the newest standards and good practices recognized at international level.

### 7.6.10. Issuance of a new regulatory guide on the format and content of the Final Safety Analysis Report for Nuclear Power Plants

The new regulatory guide on the format and content of the Final Safety Analysis Report for Nuclear Power Plants (GSN-04) has been published in October 2015, following consultation with the stakeholders. The provision of GSN-04 applies to the FSAR editions submitted in the licensing process for the commissioning and operation stages of a NPP.

Up to date, the structure and content of the FSARs have been established taking into account the provisions of US NRC RG 1.70 - Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (17 Chapters). The main change from the existing practice is the addition of 2 new chapters (18 and 19 – with the scope similar to the corresponding chapters in US NRC NUREG-0800).

The FSAR structure recommended in the new guide includes the following chapters:

- Chapter 1 - Introduction and general description of the NPP
- Chapter 2 - Site Characteristics (including site evaluation)
- Chapter 3 - Design of Structures, Components, Equipment, and Systems important to nuclear safety
- Chapter 4 - Reactor
- Chapter 5 - Reactor Coolant System and Connected Systems
- Chapter 6 - Safety Systems
- Chapter 7 - Instrumentation and Controls
- Chapter 8 - Electrical Systems

- Chapter 9 - Auxiliary Systems
- Chapter 10 – Electrical power production systems / Turbine, generator and auxiliary systems
- Chapter 11 - Radioactive Waste Management
- Chapter 12 - Radiation Protection
- Chapter 13 - Conduct of Operations
- Chapter 14 – Commissioning program
- Chapter 15 – Design basis nuclear safety analyses
- Chapter 16 - Technical limits and conditions for operation
- Chapter 17 – Management System
- Chapter 18 - Human Factors Engineering
- Chapter 19 – Probabilistic safety assessments and severe accident analyses.

### 7.6.11. Further work on the development and improvement of the regulatory framework

In 2015, CNCAN elaborated a draft regulation "Fundamental Nuclear Safety Requirements for Nuclear Installations" and issued it for public consultation. This regulation includes requirements transposing the provisions of the Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations. The regulation includes the provision in Article 8a of the new directive - Nuclear safety objective for nuclear installations:

*[…] nuclear installations are designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoiding:*

*(a) early radioactive releases that would require off-site emergency measures but with insufficient time to implement them;*

*(b) large radioactive releases that would require protective measures that could not be limited in area or time.*

In accordance with the provisions of the directive, this objective will apply to nuclear installations for which a construction licence is granted for the first time after 14 August 2014 and will be used as a reference for the timely implementation of reasonably practicable safety improvements to existing nuclear installations, including in the framework of the periodic safety reviews. This approach is fully in line with the principles in the "Vienna Declaration on Nuclear Safety".

The draft regulation is currently under revision to address the comments and suggestions received from the stakeholders. It is estimated that the regulation will be issued in early 2017.

Work on the development of new / revised regulations on other topics, such as operational experience feedback, configuration management, maintenance, surveillance, testing and in-service inspection and on a regulatory guide on human factors engineering has continued during the last reporting period. The issuance of these new regulatory documents is planned for 2017.

In addition, CNCAN is in process of reviewing the new safety standards issued by the IAEA in 2016, in order to identify opportunities for improvement for the regulatory framework and practices.

# ARTICLE 8 - REGULATORY BODY

*1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.*
*2. Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilisation of nuclear energy.*

## 8.1 Description of the Attributions and Responsibilities of CNCAN

The general attributions and responsibilities of CNCAN are stipulated in the Law, and are further detailed in the Regulation for Organisation and Functioning of CNCAN, approved by Governmental Decision.

The mandate of CNCAN can be summarised as follows:
- CNCAN is the national authority competent in exercising regulation, licensing and control in the nuclear field, for all the activities and installations under the scope of the Law.
- CNCAN elaborates the strategy and the policies for regulation, licensing and control with regard to nuclear safety, radiological safety, non-proliferation of nuclear weapons, physical protection of nuclear installations and materials, transport of radioactive materials and safe management of radioactive waste and spent fuel, as part of the National Strategy for the development of the nuclear sector, approved by Governmental Decision.
- CNCAN is responsible to ensure, through the regulations issued and the dispositions arising from the licensing and control procedures, that an adequate framework is in place for the deployment of activities under the scope of the Law.
- CNCAN is responsible for revising the regulations whenever necessary for the correlation with the international standards and ratified conventions in the nuclear field and for establishing the necessary regulatory measures for their application.

CNCAN has the following main attributions and responsibilities:
- Initiates projects for normative acts in its areas of competence and issues regulations in the nuclear field, consulting as necessary the other authorities with attributions in this domain, according to the Law;
- Reviews and consents to all the normative acts with implications for the nuclear field, prior to their entering into force;
- Approves, in accordance with the law, the intervention plans for nuclear and radiological accident situations and participates in the intervention;
- Collaborates with the central authority for environmental protection and controls the implementation of the activities of the environmental radioactivity monitoring network;
- Requests to the competent authorities in the field of national security to perform the necessary checks for the persons with responsibilities in the field of nuclear activities, in compliance with the specific regulations;
- Initiates, with the consent of the Ministry of Foreign Affairs, activities for cooperation with IAEA and with other international organisations specialised in the nuclear field;

- Cooperates with similar institutions/authorities from other states;
- Controls the implementation of the provisions of international treaties and agreements in force, with regard to safeguards, physical protection, illicit trafficking, transport of nuclear and radioactive materials, radiation protection, quality assurance in the nuclear field, nuclear safety, safe management of spent fuel and radioactive waste, and the intervention in case of nuclear accident;
- Establishes and coordinates the national system for evidence and control of nuclear materials, the national system for evidence and control of radiation sources and of nuclear and radiological installations, and the national registry of radiation doses received by the occupationally exposed personnel;
- Cooperates with other authorities that have, according to the law, attributions with regard to the safe operation of nuclear and radiological installations, correlated with the requirements for the protection of the environment and the population;
- Ensures public information on matters that are under the competence of CNCAN;
- Organises public debates on matters that are under the competence of CNCAN;
- Represents the national point of contact for nuclear safeguards, for the physical protection of nuclear and radiological materials and installations, for the prevention and combat of illicit trafficking of nuclear and radioactive materials, and for radiological emergencies;
- Orders the recovery of orphan sources and coordinates the recovery activities;
- Licenses the execution of nuclear constructions and exercises control over the quality of constructions for nuclear installations;
- Carries out any other duties stipulated by the Law, with regard to the regulation and control of nuclear activities;
- Transmits notifications and presents reports to the European Commission on the status of the implementation of the Council Directives;
- Approves the national strategies for the development of the nuclear sector and for the safe management of the spent nuclear fuel and of the radioactive waste;
- Organizes periodically, at least once every 10 years, self-assessments and international peer-reviews of its activities, as well as of the national regulatory framework.

## 8.2 Position of CNCAN in the Government Structure

CNCAN reports to the Prime Minister, through the Prime Minister's Chancellery. CNCAN is completely separated and independent from all the organisations concerned with the promotion or utilisation of nuclear energy. The responsibilities assigned to CNCAN by the Law are concerning solely the regulation, licensing and control of nuclear activities.

CNCAN exercises its functions independently from the ministries and other authorities of the central public administration, subordinated to the Government. The companies and organisations that operate or own the main nuclear and radiological installations are subordinated to the Ministry of Energy, to the Ministry of Economy or to the Ministry of National Education.

CNCAN is chaired by a President nominated by the Prime Minister. The position of the CNCAN President is assimilated to that of State Secretary. The President of CNCAN, with the advice of the General Secretariat of the Government, organises the subsidiary structures of the divisions of CNCAN depending on actual needs and conditions of the activities of CNCAN. The organisational structure of CNCAN and the modifications thereof are approved by Governmental Decision.

## 8.3 CNCAN Organisational Structure and Human and Financial Resources

The current organizational structure of CNCAN is shown in Fig. 8.1.

As described under Article 7, CNCAN staff evaluate and process applications for CNCAN licences; develop and prepare licensing recommendations; administer CNCAN policies and procedures; monitor, audit and inspect nuclear facilities and activities; draft and administer licenses; evaluate the qualifications and performance of licensees and their staff; prepare documents and reports; review reports and records; develop and enforce regulatory standards and requirements.

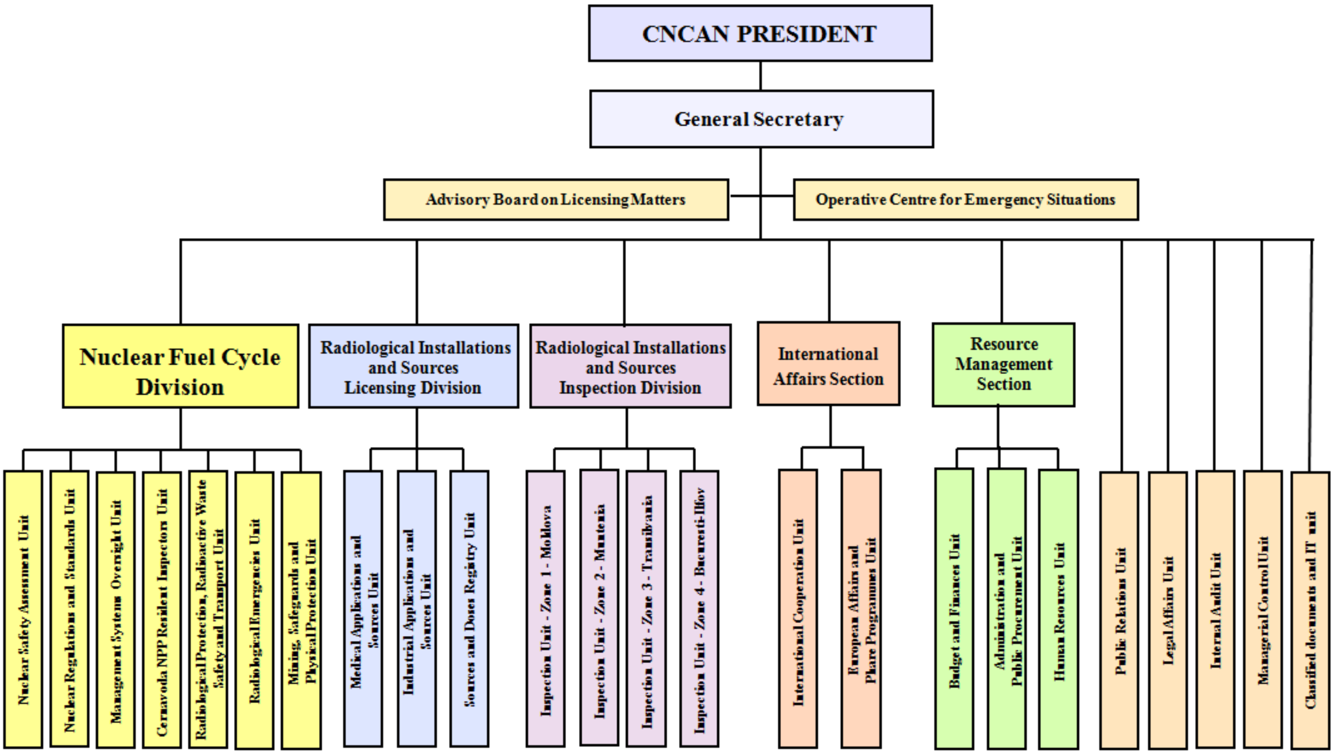



**Fig. 8.1 CNCAN Organizational Structure**

The division in charge of the regulation, licensing and control of nuclear installations, including Cernavoda NPP, is the Nuclear Fuel Cycle Division, composed of the following units:

- Nuclear Safety Assessment Unit;
- Nuclear Regulations and Standards Unit;
- Cernavoda NPP Residents Inspectors Unit;
- Management Systems Oversight Unit;
- Radiological Protection, Radioactive Waste Safety and Transport Unit;
- Nuclear and Radiological Emergencies Unit;
- Mining, Safeguards and Physical Protection Unit.

There are currently 30 staff members working in the Nuclear Fuel Cycle Division of CNCAN, most of them being involved in regulatory activities related to Cernavoda NPP.

In specific cases, external consultants are also employed to assist CNCAN staff in review and assessment activities. In addition, CNCAN benefits from external expertise, when necessary, through IAEA technical co-operation projects and bilateral agreements with regulatory authorities from other countries.

CNCAN has plans to increase the numbers of its technical staff in order to be able to improve the regulatory framework and processes, in line with the best international practices and has officially requested an increase in staffing numbers based on the current and foreseen workload.

As regards the financing, before November 2009, CNCAN was collecting money for its budget from fees charged for performing inspection activities and technical assessments and for granting licences, permits and authorisations and was self-financed. Starting with November 2009, all the money collected from taxes and tariffs for CNCAN activities have become revenue to the state budget and CNCAN is currently financed from the state budget through the General Secretariat of the Government (SGG). This has lead to a reduction in the budget available to CNCAN in comparison to the period when self-financing was implemented.

### 8.4 Management System

CNCAN has established and implemented a Management System in accordance with international standards and is currently revising it in order to implement the requirements in the IAEA GSR Part standard – Leadership and Management for Safety.

The Management Manual of CNCAN describes the policies with regard to the regulation, licensing and control activities, the strategic objectives and plans, the interfaces at national and international level, the responsibilities of the organisational units of CNCAN, the mechanisms for measuring, evaluating and improving the effectiveness and efficiency of the regulatory activities, etc. It also provides a set of general requirements applicable to the performance of activities within all organisational units and the specific requirements applicable to the assessment and inspection activities performed by the technical divisions.

The more detailed requirements and criteria are set in the procedures defining the various regulatory processes. In order to ensure the adequate implementation and improvement of the management system, the relevant procedures are sent for review and approval to all the divisions and departments. The Management Manual and all the internal procedures are available in electronic format on the local area network.

For the improvement of the Management Manual and of the operational procedures, CNCAN experts have received assistance through several IAEA technical cooperation projects. Work continues in this area, although the progress has been slow in the last reporting period. This was due to the available resources being focused on the follow-up of the safety reviews post-Fukushima and on the improvement of the legal and regulatory framework.

### 8.5 Cooperation with other national authorities

The licensing system is administered by CNCAN in cooperation with other governmental authorities (ministries and agencies) in such areas as environment, health, transport, industrial safety, security, etc. The issues raised by these authorities are taken into account before licences are issued by CNCAN, providing that there is no conflict with the provisions of the Law and CNCAN regulations. All other licences granted by other governmental authorities are prerequisites to the CNCAN licences. An exception would be the environmental authorisation issued by the Ministry of Environment after the issuance of the operation licence by CNCAN. The environmental agreement, issued by the same ministry is however a prerequisite to the siting licence issued by CNCAN.

The Law gives a list of authorities having attributions in controlling various aspects related to nuclear activities. Although their attributions and responsibilities are established by the legislation in force, CNCAN has also signed formal Memoranda of Understanding with each of these organisations, for ensuring the prevention of potential gaps and overlaps in the implementation of their respective duties and responsibilities. The responsibilities and attributions of the other authorities empowered by the Law to control specific activities in the nuclear field have been described in detail in the previous reports and remain unchanged.

For ensuring transparency of its activities and decision making process, CNCAN routinely consults with and ensures information of all the organisations that have an interest in its regulatory activities, including licensees and other nuclear industry representatives, governmental, local and municipal authorities, departments and agencies as well as interest groups and individual members of the public.

### 8.6 International cooperation and exchange of information

In the area of international cooperation and exchange of information, CNCAN maintains relations with a number of nuclear regulatory authorities and organisations worldwide, through bilateral arrangements and commitments under international conventions in the nuclear field.

The international activities in which CNCAN is involved include the participation in the activities of WENRA and its technical working groups, the annual meetings of the Senior Regulators from countries that operate CANDU NPPs, the biannual meetings of the European High Level Group on Nuclear Safety and Waste Management (ENSREG) and its working groups, the contribution to the initiatives at European Union level and the participation in various IAEA activities. CNCAN also participates, as observer, in the annual session of the Nuclear Law Committee (NLC) of the NEA/OECD (Nuclear Energy Agency of the Organisation for Economic Co-operation and Development). Starting with 2010, CNCAN has been accepted as an observer also in the CNRA (Committee of Nuclear Regulatory Activities) and CSNI (Committee on the Safety of Nuclear Installations) committees of NEA/OECD.

In order to ensure the exchange of information relevant to nuclear safety, CNCAN has a number of bilateral agreements with regulatory bodies from other countries. Also, CNCAN has established agreements or arrangements with neighbouring countries on notification and assistance in case of nuclear accidents.

With regard to technical assistance received from international organisations, CNCAN is a beneficiary of technical cooperation projects managed by the IAEA, at national and regional level. Through these projects, CNCAN received expert missions and support in the organisation of international and national seminars. Technical assistance was received by CNCAN also from the European Union, through nuclear safety projects approved through Financing Agreements concluded for each programming year.

In 2013, CNCAN and the Norwegian Radiation Protection Authority (NRPA) have agreed to fund an IAEA Extra Budgetary Programme (EBP) on safe nuclear energy in Romania. The "Regional Excellence Project on Regulatory Capacity Building in Nuclear and Radiological Safety, Emergency Preparedness and Response in Romania" started at the end of 2013 and will be completed in 2017. The project has a budget of 4.2 million euro, where 85% is covered by Norway Grants and 15% covered by Romania. The entire project is organised through an IAEA extra-budgetary programme. This project is a continuation of a similar project with the same partners that was successfully implemented in the period 2009-2011. More information on this project is provided in section 8.9.

## 8.7 Training and qualification for the regulatory staff

CNCAN has a process to develop and maintain the necessary competence and skills of regulatory staff of the regulatory body, as an element of knowledge management. The required technical education, knowledge and experience, as well as the necessary skills and abilities are documented in the job descriptions for each job position with regulatory duties. To maintain an appropriate competence level, an annual plan for staff training is in place and each staff member has an individual training plan, elaborated by their respective line manager.

Training for CNCAN staff is provided either in-house or through technical cooperation programmes with the IAEA and with other states and organizations. Members of the technical staff attend training courses, workshops, technical meetings, expert meetings and conferences that are relevant for their professional development in relation to their current and foreseen duties. CNCAN has made arrangements for specific staff training using training courses and programs provided by international organizations such as the IAEA. Efforts are on-going for implementing a formalized knowledge management process and an improved, more systematic, training and qualification process for inspectors.

The "Regional Excellence Project on Regulatory Capacity Building in Nuclear and Radiological Safety, Emergency Preparedness and Response in Romania" is currently in progress and aims to enhance the capabilities of CNCAN in eight specific functional areas of work through exchange of experiences, best practices and capacity building with the Norwegian Radiation Protection Authority (NRPA) and the IAEA. This project is under implementation until April 2017 and represents a continuation of the project conducted by CNCAN, NRPA, and IAEA during the previous cycle of Norway Grants in 2009-2011. A significant number of training and experience exchange activities have been implemented in the framework of this project.

CNCAN also receives assistance through the International Regulatory Development Partnership (IRDP), sponsored by US NRC. In the period 2014 – 2016, CNCAN staff received training through several activities organized in the framework of the IRDP, including workshops on the regulatory use of codes and standards for nuclear power plants, construction permit application review process and construction and vendor inspection.

## 8.8 Information to the public

The general Romanian legislation on public information and on transparency in the decision-making process of public authorities applies also to the regulatory activities of CNCAN. The main relevant laws are:

- Law 544/2001 on free access to public information;

- Law 52/2003 on decisional transparency in public administration.

In addition, the Law 86/2000 for ratification of the Convention on access to information, public participation in decision-making and to justice in environmental matters, done at Aarhus, on 25 June 1998 is also of relevance.

CNCAN responsibilities as established in the Law 111/1996 on the safe deployment, regulation, licensing and control of nuclear activities explicitly include:

- ensuring public information on matters that are under the competence of CNCAN;
- organizing public debates on matters that are under the competence of CNCAN.

For emergency situations, CNCAN has the responsibility to support the national authorities in providing the public with accurate, timely and comprehensive information regarding the emergency, trough their representatives in the national committee for emergency situations.

The main means used by CNCAN for the current information of the public on regulatory activities and developments is the website (http://www.cncan.ro). Information available on the website includes:

- laws, governmental decisions and regulations applicable to the regulatory activities;
- laws and regulations in force, applicable to nuclear installations and activities, as well as draft regulations;
- annual reports on CNCAN's activity;
- reports submitted to international organisations;
- information about the history, organization and functioning of CNCAN;
- information on licensed installations and activities;
- press releases and information about conferences;
- forms for submitting requests for information.

Prior to the enactment of new or revised regulations, CNCAN posts the proposed drafts on its website and sends them for consultation to all interested organizations, for gathering information from the public, from licensees and applicants and from other interested parties.

Requests for information come mainly from non-governmental organisations and, to a lesser extent, from members of the public. CNCAN provides all the necessary data and clarifications, except for information that is classified due to security reasons.

The annual reports produced by CNCAN on its activities are published on its website and summary reports are published also in the Official Gazette of Romania.

### 8.9 Significant developments for the last reporting period

Significant developments include the assistance received by CNCAN, for the improvement of the regulatory capability, in the framework of technical cooperation programs, such as the “Regional Excellence Project on Regulatory Capacity Building in Nuclear and Radiological Safety, Emergency Preparedness and Response in Romania” funded by NRPA and CNCAN and managed through an IAEA EBP and the International Regulatory Development Partnership sponsored by the US NRC.

Priority sectors of the “Regional Excellence Project on Regulatory Capacity Building in Nuclear and Radiological Safety, Emergency Preparedness and Response in Romania” include the following subprojects:

- CNCAN 1 - Enhancement of CNCAN capabilities for safety analysis;
- CNCAN 2 - Enhancement of CNCAN capabilities for integrated management systems and knowledge management;
- CNCAN 3 - Enhancement of CNCAN capabilities for inspections;
- CNCAN 4 - Enhancement of CNCAN capabilities for safety and security of transport and transit of radioactive and nuclear materials on the Romanian Territory;
- CNCAN 5 - Enhancement of CNCAN capabilities for emergency preparedness and response;
- CNCAN 6 - Enhancement of CNCAN capabilities for ionizing radiation sources control;
- CNCAN 7 - Enhancement of CNCAN capabilities for radioactive waste, spent nuclear fuel management and decommissioning activities;
- CNCAN 8 - Enhancement of CNCAN capabilities for safeguards.

Some of the most important activities of the projects are related to the development and updating of the Romanian regulations in line with the international standards and guidelines as well as to the training of CNCAN staff using effective knowledge transfer methods that will ensure sustainability.

The regulations, methodologies, procedures and guidelines that have been developed or revised during the project are in accordance with international standards and developed with the help of participation of international experts with special expertise in relevant areas.

Examples of new regulatory guides, procedures and tools that have been developed in the framework of this project include:

- a regulatory guide on deterministic safety analysis for design basis accidents and beyond design basis accidents;
- a regulatory review guide for seismic margins assessments;
- new procedures for regulatory review and inspection of emergency operating procedures and severe accident management guides;
- revised procedures for the core processes of CNCAN (e.g. licensing process, review and assessment process, inspection process, enforcement process, etc.);
- new procedures for the process for training, qualification and certification of inspectors and for the knowledge management process;
- new emergency response procedures for severe accident situations at CANDU reactors, including results of nuclear safety assessments from IAEA Guidelines and dose calculations in different meteorological conditions;
- revised process procedure for the regulatory oversight of licensees' safety culture;
- a model and associated guidelines for a national system of nuclear safety competences;
- a knowledge management portal.

Apart from the tangible results / project deliverables consisting of new or revised regulations, procedures, training materials and equipment, the project offers the following benefits:

- CNCAN specialists interact with senior experts from the IAEA, from NRPA and from nuclear regulatory authorities and industry organizations from other countries and learn from each other by exchanging practical experience on various topics;

- The experience sharing leads not only to improved technical knowledge but also to a better understanding of the cultural diversity and of the way in which national and organizational cultures influence the regulatory approaches and practices; this is important for understanding the background for the good practices identified as applicable for use in our national regulatory framework;
- This project also helps CNCAN implement lessons learned from the post-Fukushima safety reviews. In addition, this project contributes to the implementation of several activities that are part of the action plan associated with the National Nuclear Safety and Security Strategy of Romania.

# ARTICLE 9 - RESPONSIBILITY OF THE LICENCE HOLDER

*Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.*

## 9.1 Definition of the legal responsibilities of the licence holder

The Romanian Law on the Safe Deployment, Regulation, Licensing and Control of Nuclear Activities, further referred to as the Law, clearly stipulates that the prime responsibility for the safety of a nuclear power plant rests with the licence holder.

As required by the Law, a licence is needed for each of the stages of the life time of a nuclear installation. The general conditions that an applicant shall fulfil in order to obtain a licence are presented in Annex 1, where the structure and content of the Law are described and further detailed under Articles 17, 18 and 19. Compliance with the general licensing conditions, as well as with all the provisions of the Law that are directed to the licensee, with the provisions of the applicable specific regulations and with the conditions embedded in the licence, is mandatory and enforceable.

The clear definition of legal obligations ensures that by no means the licensee's responsibility for safety could be diminished or shifted towards the regulatory authority. Compliance with the legislative and regulatory requirements does not relieve the licensee of its responsibility to ensure that safety is maintained and continuously improved.

The attributions and responsibilities of CNCAN are also stated in the Law, defining the role of the regulator in ascertaining that the licensees are taking all the necessary measures to ensure and maintain the safety of the nuclear installations. The regulatory system and processes for licensing, review, assessment, inspection and enforcement, as well as the attributions and responsibilities of CNCAN have been described under the Articles 7 and 8.

The main responsibilities of the licence holder are stated in Chapter III of the Law and are further detailed in the specific regulations issued by CNCAN and in the conditions attached to each licence. The articles 25 - 28 from the Law, relevant to licence holders for activities directly related to nuclear power plants, are given below, for illustration.

*Art. 25. - (1) The licence holder has the obligation and the responsibility to take all necessary measures for:*

*a) ensuring and maintaining:*
- *nuclear safety, protection against ionising radiation, physical protection, on-site emergency preparedness and the quality assurance for the activities deployed and/or the associated radiation sources;*
- *a strict record of the nuclear and radioactive materials, as well as of all radiation sources used or produced in the activities under the licence;*

*b) complying with the technical limits and conditions stipulated in the licence and for reporting any deviations, in accordance with the specific regulatory requirements;*

*c) deploying only activities covered by the licence in force;*

*d) developing its own system of requirements, rules and instructions as to ensure that the licensed activities are carried out without posing an unacceptable risks of any kind.*

*e) ensuring and maintaining adequate human and financial resources for fulfilling its*

*obligations under the law.*
*(2) The liability for nuclear damage, caused during or as a result of an accident that could arise from the deployment of the licensed activities or of other activities resulting in the death, injury to the corporal integrity or health of a person, destruction, degradation, or temporary impossibility of using any goods, rests entirely with the licence holder, under the terms established by law and by the international agreements to which Romania is a party.*

*Art. 26. - For the deployment of any nuclear activities generating or having generated radioactive waste, the licence holder shall:*
*a) be responsible for the management of radioactive waste generated by the licensed activities;*
*b) bear the expenses related to the collection, handling, transport, treatment, conditioning and temporary or permanent storage of the waste;*
*c) pay the legal contribution to the Fund for the management and final disposition of the radioactive waste and spent fuel and for the decommissioning of the nuclear installations.*

*Art. 27. - The licence holder shall:*
*a) develop and submit for approval to CNCAN a programme for the preparation of the decommissioning;*
*b) produce the proof of having paid the legal contribution to the Fund for the management and final disposition of the radioactive waste and spent fuel and for the decommissioning of the nuclear installations.*

*Art. 28. - (1) The expiry, suspension or withdrawal of the licence does not exonerate the licence holder or the person having taken over the property title over the nuclear or radiological materials and installations covered by that licence, from the obligations stipulated under Articles 25 - 27, nor from those deriving from the conditions stipulated in the licence.*
*(2) Prior to the termination of the activities or decommissioning of nuclear or radiological installations, as well as prior to any transfer, partial or whole, of the nuclear or radiological installations and materials, the licence holder shall apply and obtain, under the terms stipulated in the present Law, a licence to own, preserve, decommission or transfer the respective installations and materials, as applicable.*
*(3) The licence or practice permit issued on the grounds of the present Law does not exonerate the licence or permit holder from observing the legislation in force.*
*(4) The termination of nuclear activities shall take place in compliance with the provisions of the specific regulations issued by CNCAN.*
*(5) CNCAN establishes the concrete modality of application of the present law whenever its provisions cannot be applied simultaneously with other legal provisions in force, with the consultation of the relevant public administration authorities, giving priority to the observance of the conditions for the safe deployment of the nuclear activities.*

### 9.2 Mechanisms by which the licensees ensure and demonstrate the effective fulfilment of their prime responsibility for safety

In fulfilling its prime responsibility for safety, beyond simple compliance with the legislative and regulatory provisions in force, the licensee has developed and implemented its own system of requirements, rules, procedures and instructions, with the objective of ensuring that any risks associated with its activities remain acceptable and are minimised to the extent possible. This system is described in documents that form part of the licensing basis, for each stage of the lifetime of the nuclear installation, such as the Safety Analysis Reports and the Integrated Management Manual.

The safety related activities contracted to the external organisations are effectively controlled by the licensee, who acts as an intelligent customer and remains fully responsible for the implications of the work performed. The interfaces with the external organisations are described in the Integrated Management Manual and the licence holder has in place a system for selecting contractors, monitoring and assessing their performance and maintaining effective communication with the aim of ensuring the consistent application of high standards of safety and quality.

The safety demonstration for licensing purposes has been addressed under Article 7 and is presented in detail under Article 14. Further information on the Integrated Management System of the licensee, including aspects related to the use of contractors, is provided under Article 13.

The licence holder for Cernavoda NPP is the National Company Nuclearelectrica (SNN - Societatea Nationala Nuclearelectrica S.A.), which is the corporate organisation having juridical personality. Although the authority for plant operation has been delegated to Cernavoda NPP Branch, the statutory responsibility for safety rests with the SNN.

In this respect, SNN is responsible to ensure that all the requirements deriving from the applicable legislation are fulfilled and to provide resources and support for the safe and reliable operation of Cernavoda NPP. The responsibilities discharged by SNN include the strategic planning and assignment of technical and financial resources necessary for the safe and reliable operation of the NPP, the fuel production and the research and development programmes, the promotion of the safety and organisational culture, the provision of legal support, the administration of relations and interfaces with external organisations and regulatory authorities, and the information of the mass-media and the public.

Various mechanisms are in place to ensure awareness of safety issues at the corporate level and to inform and influence business decisions. Through the audits and independent assessments conducted by the Safety Department and the Quality Management Department, SNN ensures that the safety and quality policies are observed and applied to the expected standards and that the programmes for the improvement of safety and quality are effectively implemented. The attributions and responsibilities of these organisational units are defined in specific procedures at corporate level. The corresponding activities and responsible units (e.g. independent assessment function, safety oversight, etc.) at the plant level are defined in the Integrated Management Manual of Cernavoda NPP and its specific plant procedures (these are further detailed under Article 13).

The plant safety is assessed quarterly by the Plant Safety Oversight Committee (PSOC). The role of this committee is to maintain awareness of the plant safety issues at the plant management team level, recommendations and expectations being provided to the managers, who subsequently inform the employees in their areas of activity. The strategy in place is to evaluate and review the plant safety performance, programs, actions and indicators. It initiates reviews and actions to improve and maintain high standards of safety and Safety Culture at the station. The Senior Superintendent of the Safety Department of SNN attends regularly these meetings and informs the SNN's CEO of the most important findings.

An agenda of a PSOC meeting usually includes the following items:

- Health Report for safety & safety related systems;
- Status of specific (individual) and generic safety related systems problems (specific and generic safety related and process equipment failures that have a potential negative

impact on overall reactor safety);
- The plant risk report for the previous quarter and the past 12 months, using the Risk Monitor for Equipment out of Service (EOOS tool);
- Review of permanent design changes and temporary modifications status;
- Review of the status of operating instructions and manuals for safety related systems;
- Review of planned or implemented significant changes to any APOP (emergency operating procedures);
- Review of operational experience feedback and corrective actions - review of reportable events (since last meeting and trend report), trend of events reporting for different categories, significant external operating experience reported, status of root cause investigations;
- Review of regulatory actions resulting from the review, inspection and licensing processes, status of documents requiring regulatory approval;
- The progress of open Technical Operability Evaluation/Operational Decision Making (TOE/ODM) actions and the actions closed in the last quarter;
- The progress of open actions resulted from NSRB report.
- Nuclear Safety Performance Indicators and Safety Culture;
- Any new items, as proposed in advance by PSOC members.

In addition, an Oversight Committee has been established at corporate level, which meets in quarterly meetings in order to analyze, validate and approve the reports submitted by the internal oversight team. After approval, the quarterly reports are presented, through the SNN Nuclear Safety Advisory Committee, to the Board of Directors for endorsement.

The means through which the licensee demonstrates its commitment to maintaining and continuously seeking the improvement of safety, include:
- initiating and establishing safety enhancement programmes and ensuring the allocation of adequate resources;
- fostering the involvement of all plant personnel in the development of the management system;
- monitoring, reviewing and assessing the safety performance and taking timely actions to correct and prevent reoccurrence of any situations detrimental to safety;
- the effective use of the operating experience feedback and of the results of the safety reviews and assessments in developing and maintaining up to date the safety related policies, programmes, procedures and instructions, taking into account also the evolution of international standards and good practices.

As a member of international nuclear operators’ organisations, such as COG (CANDU Owners Group) and WANO (World Association of Nuclear Operators), the licensee has the opportunity to participate to the various programmes and projects coordinated by these organisations, in order to enhance safety in plant operation through the exchange of information on operating experience. Examples of these activities are:
- exchange of abnormal condition reports;
- exchange of different type of reports on specific issues and of periodic information bulletins;
- receiving peer reviews and also participating as team members in the peer reviews for other NPPs.

In accordance with the reporting requirements imposed through regulatory documents and the licensing conditions, the reports submitted to CNCAN by the licensee for an operating nuclear installation include the following:

- Assessment Event Reports - to describe and assess the unplanned events impact on nuclear safety;
- Quarterly Technical Reports (QTRs) - to present the overall technical performance and general information related to station operation for a period of three months; these official documents are based on and issued in addition to the monthly reports from each division of the operating organisation the fourth QTR of the year is issued as annual report. The QTRs provide information on safety systems reliability performance, dose statistics and radioactive effluents emissions, performance indicators, a review of process, safety and safety support systems including the design changes, a review of the nuclear fuel and heavy water management, the results of the chemistry control, radiation control, a review of the emergency planning, a reactor core safety assessment, etc. These reports include also information on the personnel training and authorisation;
- Radiological Environmental Monitoring Reports - submitted periodically to present the results of the off-site radiological environmental monitoring program and any corresponding calculated doses;
- Periodic Inspection Programme Reports - submitted within 90 days from the completion of any inspection carried out in accordance with the Periodic Inspection Programme;
- Reliability Reports - submitted to provide an evaluation of the reliability of any safety related system that has specific reliability requirements stated in the licensing documents. A review of the updated documents is provided with the focus on the design changes and their impact on the analysis results;
- Reports on the status of the training programme for the licensed operations staff;
- Reports on the status of the Plant Systems Surveillance;
- Report on the status of the Systematic Assessment of Critical Spare Parts Programme;
- Report on the status of the Preventive Maintenance Programme;
- Report on the status of the Plant Life Management Programme;
- Report on the status of the Safety Analysis Strategic Programme;
- Report on the status of the Configuration Control Programme;
- Report on the status of the In-service Inspection Programme;
- Report on the status of the safeguards;
- Reports on the plant physical protection;
- Reports on the status of the actions resulted from the Periodic Safety Review;
- Reports on the status of the actions resulted from the post-Fukushima Stress Test;
- Updates of the Final Safety Analysis Report;
- Internal and external audit reports.

### 9.3 Interface between the licence holder and CNCAN

The various interfaces needed to support the continuous communication between the licensee and the regulator are well established and described in specific procedures for all the safety related activities of the plant, which are subject to licensing, require approval from or notification to CNCAN, or that are under regulatory surveillance.

The regulatory activities related to Cernavoda NPP and the licensing process are coordinated by the Director of the Nuclear Fuel Cycle Division of CNCAN, which is responsible for integrating the activities of the various organisational units involved in safety review and assessment and in inspections and enforcement.

On the side of the licence holder, the interface activities are formally managed by SNN CEO or by the Cernavoda NPP Director. The responsibility for maintaining the interface with CNCAN for the licensing activities has been delegated by the CEO of SNN to the Cernavoda NPP Director, who will be further referred to as the Site Manager.

Cernavoda NPP, primarily through the Safety, Licensing & Performance Improvement Department, has a daily dialogue with the regulatory authority through the CNCAN site inspectors. Formal correspondence is exchanged as needed to clarify and resolve issues and to ensure that all requirements are met as required to obtain licences, approvals and authorisations. In addition, working meetings are established at the local level to promote a free flow of information and to resolve small issues expeditiously.

In SNN Head Office the interface activities with CNCAN are coordinated and ensured by the Safety Department, and Quality Management Department. When necessary, the technical support is ensured by Cernavoda NPP specialists.

The main interface activities consist of:
- Licensing meetings;
- Regulatory inspections;
- Plant procedures and documents review and approval process;
- Investigations related to abnormal occurrences;
- Meetings for discussion of draft regulations;
- Development of Licensing Basis Documents and Licensing Programme for future units;
- Regular information meetings for discussing the progress of various plant programmes.

Maintaining a continuous communication with the licence holder is of vital importance for CNCAN in discharging its statutory responsibilities. CNCAN receives annually, quarterly and monthly reports about the plant activities and there are periodic licensing meetings that ensure effective means for communicating to the applicant the findings arisen from the evaluation of the documents submitted and for receiving feedback.

# ARTICLE 10 - PRIORITY TO SAFETY

*Each Contracting Party shall take the appropriate steps to ensure that all organisations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.*

## 10.1 Safety Policy of Cernavoda NPP

In accordance with the Law, the licensee has the prime responsibility to ensure and maintain the safety of the nuclear installations. Regulatory provisions are in place requiring the licensee to develop and implement policies that give safety the highest priority.

The general safety principles governing the activities performed by all site personnel performing activities related to the operation of Cernavoda NPP are stated in the Nuclear Safety Policy document and in the Integrated Management Manual. The principles stated in the Nuclear Safety Policy are reiterated and the specific means for their implementation are detailed in other station procedures (RD - reference documents, SI - station instructions, PSP – process specific procedures, etc.), with clear definition of the responsibilities of the station personnel for each operation. The implementation of these principles is ensured also by the provision of specific initial and refreshment training courses aimed at enhancing safety culture.

The major administrative control for the implementation of the Nuclear Safety Policy is the reference document entitled "Operating Policies and Principles" (OP&P). The OP&P is part of the licensing basis for the plant, and its initial issue, as well as modifications are subject to regulatory approval. This document describes how the utility operates, maintains and modifies the safety-related systems in order to maintain the nuclear safety margins. The OP&P contains the clear definition of the authorities and responsibilities of managers and operating staff. Also, it defines the specific operating limits for safety related systems, which must be maintained all the time to ensure that the plant always complies with its analysed operating envelope.

In addition, to prevent, mitigate and accommodate any potential nuclear incident or accident, the OP&P require compliance with the following principles:

- operating limits affecting public safety must be adhered to;
- defence-in-depth shall be maintained;
- fall back actions/countermeasures must be established;
- conservative decision making for improved overall safety must be applied.

In accordance with the conditions stated in the licenses for the units of Cernavoda NPP, compliance is mandatory with the provisions of the Nuclear Safety Policy, Operating Policies and Principles, the Integrated Management Manual, as well as with the provisions of any other procedure or document pertaining to the licensing basis.

As stipulated in the Nuclear Safety Policy, the governing principles in the OP&P shall not be intentionally violated under any circumstances. An overview of the principles stated in the Nuclear Safety Policy of Societatea Nationala Nuclearelectrica , and of the means by which they are implemented, is given as follows.

a) *Nuclear Safety has the utmost priority, overriding if necessary the demands of production or project schedule. All decisions shall be made and reinforced consistent with this statement.*

This key principle of nuclear safety culture is governing the decision making processes and all the activities of Cernavoda NPP. The Nuclear Safety Policy document states the responsibilities for all employees (Station General Manager / Managers / Supervisors / Individual employees) and is communicated to all site personnel, including contractors, as part of their training.

The training syllabus includes specific requirements as to the know-how of the station objectives regarding nuclear safety, quality, personnel health and safety. The knowledge of these objectives and the associated requirements is annually refreshed for the personnel involved in the performance of safety related activities. The communication of the safety principles relevant for the performance of any task is also done as part of any pre-job briefing.

The mission, the vision and the objectives of the operating organisation are communicated to all the personnel, published and clearly displayed throughout the site and on the utility intranet site that is available to all employees, as to ensure that all the individuals are conscious that through the correct and timely fulfilment of their assigned duties they contribute to the safe and reliable operation of the plant.

b) *To compensate for potential human or equipment failures, a defence in depth concept shall be implemented and maintained, applied at multiple levels of protection (prevention, surveillance, mitigation, accident management and emergency response), including successive barriers for the prevention of the release of radioactive materials into the environment.*

The plant design incorporates the various features of the defence in depth concept intended to provide adequate coverage for possible equipment failures. Station procedures are intended to maintain or enhance this through configuration control programme, which provides the framework for the review and control all the proposed modifications. Human factors considerations are adequately taken into account in the design of the plant and in the development of procedures.

A comprehensive set of procedures covering all situations from normal operation to accident management is in place, structured, developed and maintained in accordance with the requirements of the management system and administrative controls are implemented, for adequate staffing, reviews and checks of activities prior to, during and after implementation, as appropriate. A graded approach for the application of the management system requirements is implemented to ensure that the extent of approvals and reviews required is dependent upon the importance of the planned activity especially with regard to its impact on nuclear safety.

c) *Personnel engaged in safety related activities shall be trained and qualified to perform their duties. Taking into account the potential for human error, actions shall be established for facilitating correct decision-making by the operator and for limiting the possibility for wrong decisions, by providing the necessary means for detecting and correcting or compensating for errors.*

The overall training policies and the means for their implementation are defined in the reference documents “Station Training Concept” and “Systematic Approach to Training”.

In accordance with the licensing conditions, the Nuclear Safety Policy and the provisions of the Integrated Management Manual, all managers and supervisors shall ensure that the staff is fully competent for their assigned duties. This includes training to ensure that individuals understand the safety significance of their duties.

Training of all new employees is provided according to the station instruction "Orientation training program for new employees". The training program includes the provision of refresher courses to ensure that expertise is maintained at the required level. Each job position (or group of similar positions) has its own Job Related Training Requirements (JRTR) providing information about both the initial and continuing training needed for the specific job. Each department has the responsibility to prepare a generic JRTR for its staff. JRTRs for each job position are reviewed by the line managers at least once per year based on the results of the staff performance evaluation. Training records are maintained and stored in the training archive. A database containing all the information from the files is provided to ensure easy access.

The training received by contractors at the organisation they belong to is verified as part of the evaluations / audits that the utility is regularly performing for all their suppliers of services, in order to ensure that they continue to maintain adequate standards of quality and safety and provide the expected level of performance. The licence holder has also adequate arrangements to provide additional training for the contractors with regard to nuclear safety and safety culture aspects, plant specific features, etc.

More detailed information on the qualification and training of plant personnel is provided under Article 11.

d) *A strong organisational structure with well defined responsibilities for nuclear safety at all levels shall be established and maintained.*

The Station Organisational Chart and associated Job Descriptions document the general areas of responsibility. The responsibilities and lines of authority are clearly defined in the Integrated Management Manual and also included and detailed, as appropriate, in the Reference Documents and Station Instructions, including those activities, checks, reviews and approvals needed to ensure that safety is properly taken into account in all activities.

The operating licence includes specific conditions on the plant organisational structure and staffing, requiring that these shall be in accordance with the provisions of the approved Integrated Management Manual and that the modifications to the organisational structure and staffing levels shall be adequately justified and documented and shall be reported in writing to CNCAN within 30 working days prior to their implementation, for regulatory review and approval. Further information on the management of organisational change is provided under Article 13.

e) *Operation of the plant shall be conducted by authorised personnel following administrative controls and adhering to approved procedures.*

Training and qualification programs have been in place to ensure that staff can be authorised for their assigned duties. All formal authorisations for personnel required to be licensed by CNCAN for station operation have been received.

The station system of documents providing administrative instructions and operating procedures includes the Integrated Management Manual, Reference Documents, Station Instructions, Operating Manuals, Maintenance Procedures, etc. These documents are issued and kept updated to ensure an adequate procedural framework for the conduct of plant activities in a safe manner.

All managers, senior superintendents and superintendents are responsible to ensure that the staff is fully competent for their duties, that tasks are carried out as defined in procedures and that procedures are complete, clear and unambiguous. This includes training, observation and coaching to ensure that individuals understand the safety significance of their duties.

f) *The safety review of procedures, analyses and design changes shall be completed before the effective commencement of the work.*

This requirement is generally included as a responsibility of those who prepare and those who verify any safety related documents and is specifically addressed and detailed by the various station procedures. In particular, the Safety and Compliance Department is given a special responsibility to review station documents, such as Operating Manuals, Operating Instructions and Design Manuals, to ensure that all the safety requirements are met.

The different stages of review and testing of modifications provide reassurance that the safety is not adversely affected. Further information on the safety categorisation and the assessment of modifications is provided under Article 14.

By maintaining an effective communication with the plant vendor and other utilities operating and providing support for the operation of CANDU NPPs worldwide and participating in the research and development projects within the CANDU Owners Group (COG), the utility ensures that the current state of the art for safety is also taken into account when planning and designing any important plant modifications.

g) *Procedures will be followed and, when unexpected situations arise, appropriate expert assistance shall be obtained before proceeding. In such cases, the safety intent of the procedures shall be maintained.*

For cases in which situations may occur which had not been previously analysed and for which no adequately clear and detailed procedures had been prepared, conservative decisions are required to ensure that no activities are initiated which could have a negative impact on safety. Asking for guidance from more experienced or qualified persons when facing an unfamiliar task or situation is required at all staff levels. The importance of asking for guidance from the immediate supervisor when unsure what to do is emphasized during staff training.

Any activity that would imply a deviation, even temporary, from a procedure or work plan has to be assessed from the point of view of its impact on safety, justified and planned in detail, and the approvals needed for its performance need to be obtained from the same level of authority as for the procedure or work plan that would have been normally followed. The elaboration, verification and approval of any special procedures which would be needed for the performance of such activities would follow the normal process in accordance with the provisions of the Integrated Management Manual.

The procedures "Abnormal Condition Reporting" (ACR), “Technical Operability Evaluation (TOE)” and “Operational Decision Making” (ODM), together with their supporting documents (such as process specific procedures - PSPs and information reports - IRs) giving further detailed guidance for their implementation, contain provisions for the actions to be taken in cases where unexpected situations arise (in this context meaning situations pertaining only to normal operation, including power manoeuvres, maintenance, testing, refuelling, and not to the occurrence of initiating events or accident situations, which are dealt with by using the emergency operating procedures), or for cases not fully covered by specific and explicit procedures (situations which could be regarded as deficiencies in plant documentation).

h) *A set of operational limits and conditions shall be defined to identify safe boundaries for plant operation.*

The boundaries for safe operation, based on the safety analyses for the plant, are included in the appendixes of the OP&P. The technical basis for the operating limits and conditions in the OP&P are provided in Chapter 16 of the FSAR.

OP&P documents the safe envelope within which the plant is to be operated, setting the limits and conditions for normal operation and the actions to be taken by the operating staff in the event of deviations from the OLCs (Operating Limits and Conditions).

Operating Policies and Principles (OP&P) covers all operational states and temporary situations arising due to maintenance & testing, containing administrative controls, the limiting safety system settings and the limiting conditions for operation and stipulating the minimum amount of operable equipment.

Actions to be taken in case of deviations from the OLCs and the time allowed to complete these actions are provided in the “Impairments Manual”. References to this document are made in OP&P and the Impairments Manual is available in the control room.

Detailed surveillance requirements, design specific features and specific administrative controls are provided in the system Operating Manuals (OMs), Operating Manual Tests (OMT) and Standard Operating Sequences (SOS).

i) *Events significant for safety shall be detected and shall be subject to in-depth evaluation, and measures shall be implemented promptly to correct the root causes, to disseminate the lessons learned and to monitor the effective implementation of the corrective actions. Plant management shall have access to safety relevant operational experience from other nuclear power plants around the world.*

The Reference Document "Operating Experience Programme" contains the Plant policies for Operating Experience. Specific guidance is given in other documents, such as Station Instructions (SI), Process Specific Procedures (PSP) and Internal Department Procedures (IDP), which include provisions for the reporting, analysis of events (including low level events) and the determination and tracking of corrective measures required.

The Operating Experience (OPEX) Programme is defined and supported by the following set of station procedures:

- SI "Abnormal Condition Reporting" (ACR)
- SI "Reportable Events to CNCAN"
- PSP "ACR Process Guidance"
- IDP "Processing ACRs"
- PSP “The Root Cause Analysis”
- IDP "Trend Analyses"
- SI "Operating Experience Feedback"
- IDP "Processing External Information"

- IDP" Processing WANO SOER's"

The procedure "Abnormal Condition Reporting" describes the process of identification, evaluation and analysis of the Abnormal Conditions occurred at Cernavoda NPP or at other nuclear power plants worldwide, in order to determine adequate corrective actions to preclude occurrence of major events or their recurrence in case that they already have occurred.

The plant personnel is responsible for:

- Identifying and reporting the abnormal conditions occurred at the plant;
- Maintaining a focus on lessons learned from in-house and industry experience and actively promoting the use of operating experience in current activities;
- Implementing the corrective actions resulted from operating experience process;
- Reporting of the actions implemented to the next level of management.

The list of ACR Initiation Criteria is given in an annex to the procedure "Abnormal Condition Reporting", with the specification that it represents only the main groups for classification of the problems defined in abnormal condition report, more details on the criteria inside each group being included in ACR Process Guidance procedure.

Any person that identifies something abnormal should define the problem and evaluate the impact on nuclear or personnel safety, or production. When there is not clear that the event has no impact, the person shall initiate an ACR, completing the necessary forms in accordance with the procedure and classify the condition in one or more of the groups in the list, which is reproduced below for exemplification:

1. Equipment/ Component failures (critical equipment list);
2. Materials/components deficiencies (installation/functioning)
3. Procedures/ Manuals/ Documentation discrepancies;
4. Drawing discrepancies;
5. Procedural Violations;
6. Inadequate Review/ Resolution;
7. Discrepancies Associated with alarms, setpoints, calibrations;
8. Personnel Error/ Work Practice deficiencies;
9. Incorrect scoping of systems, equipments, and components;
10. Un-analysed conditions, safety analysis discrepancies, safety issues not previously identified or reviewed;
11. Radiological event;
12. Any violation of OP&P specifications;
13. Procurement/ Spare Parts deficiencies;
14. Industrial Safety deficiencies;
15. Deficiencies, concerns or issues resulting from regulatory authorities, industry and internal operating experience, inspections, observations or publications;
16. Reportable events to CNCAN or to other regulatory authorities;
17. Fire Protection deficiencies;
18. Deficiencies that have a potential for affecting the environment;
19. Deficiencies/problems occurred in the normal processes of the station;
20. Modifications of chemical parameters;
21. Rework.

The abnormal conditions discovered in the plant which can or could have effect on nuclear safety, personnel safety, environment or production are registered, classified by their importance and systematically analysed. Actions resulting from the analysis of the plant events are concurred by management and have assigned responsibilities and target dates for completion. The corrective actions address causes and contributors, and they might be corrective, preventive or for improvement.

Specific activities are formalised within departments/sections, through which information and lessons from internal and external operating experience are systematically searched and used within current activities (jobs evaluation and planning, pre-job briefing, modification processing, training, industrial safety, etc).

The reports for events meeting the criteria in the procedure “Reportable Events to CNCAN” are issued to the Regulatory Body in a written format, in accordance with the provisions of this procedure.

Further information regarding the investigation of abnormal events and the dissemination of lessons learned is provided under Article 19.

j) *A questioning attitude when dealing with safety issues is expected from every employee and shall be encouraged. Recognition of, and admitting to mistakes shall also be encouraged. When sanctions are necessary, these shall not be applied in such a way as to encourage the concealment of errors.*

Management does not use direct sanctions against individuals as a result of incidents or errors. Any repetition of problems or individual patterns of poor performance are dealt with collectively, through interviews and performance appraisals with the objective of determining the cause and helping the individual to make corrections. Any punitive measures taken are not connected to specific incidents. As a result, an open environment has been created for reporting problems and errors by various levels of staff.

When the employees engaged in activities affecting safety related functions or structures, systems and components believe that a deficiency in nuclear safety exists, they are responsible for notifying their Supervisor, the Safety & Licensing Manager and/or the Station Manager. If in the employee's opinion the notification does not receive appropriate attention, the employee has the right and obligation to contact successively higher levels of management (an escalation process has been implemented) Also, a procedure for reporting employees’ concerns is implemented.

k) *Cernavoda Operating Policies and Principles (OP&P) shall not be knowingly violated. If conditions are found to exist which conflict with the OP&P, the affected system(s) shall promptly be placed in the normal configuration or in other known safe state or the reactor shall be promptly placed in a safe shutdown state.*

Where deviations from the Operating Policies and Principles are needed, justification is properly documented and CNCAN approval is obtained prior to the event. Unplanned violations of the limits are promptly dealt with using Operating Manuals and Impairment Manual guidelines for ensuring the correct course of actions and meeting the appropriate time limits. Such violations are reported to the regulatory authority in accordance with the reporting requirements.

l) *A set of nuclear safety standards shall be established against which the safety performance of*

*Cernavoda NPP shall be assessed. Where these standards are not met, corrective action shall be implemented.*

The policy statements of the operating organisation with regard to health and safety, quality and environmental protection are given in the Integrated Management Manual of Cernavoda NPP. The authorities and responsibilities of the management at all levels are also defined, with the senior management being responsible for the development and the implementation of the Integrated Management System for Cernavoda NPP, aligned with the requirements of the Quality Management System of SNN and in compliance with all the regulatory provisions and the applicable standards. The connection between the safety of the plant and its reliable operation is recognised and reflected in the policies of the operating organisation.

Senior management is also responsible for establishing measurable objectives, consistent with the policies of the operating organisation, and for ensuring that adequate mechanisms are in place for the assessment of safety and quality performance in achieving these objectives. Such mechanisms include the use of indicators and trends for plant performance and the conduct of regular reviews and assessments of various types and scope, including external peer reviews, for specific areas of activity and also for assessing the effectiveness of the management system as a whole.

The safety and quality objectives for Cernavoda NPP include:

- preventing the occurrence of abnormal events;
- enhancing safety culture;
- ensure that the safety and reliability targets for the safety related plant items are met;
- maintaining strict control of design configuration in compliance with the design basis;
- maintaining the competence and qualification of the personnel;
- ensuring compliance with the applicable legislative and regulatory provisions;
- ensure effective use of the operating experience;
- eliminating work accidents and severe injuries;
- minimising doses to occupationally exposed personnel;
- protection of the ecosystems, efficient utilization of natural resources and prevention of pollution;
- maintaining effective emergency preparedness.

Specific objectives and performance criteria are established for each area of activity within the management system for Cernavoda NPP and their achievement is periodically evaluated, according to plant procedures, with the results documented and reported monthly to the management.

The overall indicators used for plant performance are those established by WANO. Also, specific indicators for monitoring current performance in specific functional areas were established by Cernavoda NPP. The performance indicators data is reported monthly in a graphical format to indicate trends, allow comparisons of actual versus expected results. Whenever targets are not met or adverse trends are observed, actions are initiated for determining the reasons and for implementing corrective actions. The performance indicators and trends are also included in the quarterly reports submitted to CNCAN.

Improvement initiatives are defined within a series of plant improvement programs, each of them having an assigned responsible and objectives defined, scheduled and budgeted for each calendar year. The stage of these programs is reported monthly to management in a dedicated meeting.

The initiatives are oriented into 5 key results area, namely:

- Work force management (KRA # 1) - for the development and optimization of the station and staff;
- Operations & safety culture (KRA # 2) - for enhancing the safety and reliability of plant operation and improving the safety culture;
- Work processes & programmes (KRA # 3) - for improving the quality of processes and work system;
- Equipment reliability (KRA # 4) - for increasing station and equipment performance
- Financial performance (KRA # 5) - for improving economic efficiency.

The improvement programmes are part of the Strategic Development Plan of Cernavoda NPP, which clearly identifies the plant objectives and how they will be achieved and is formally distributed to each plant employee. The progress of this strategy is discussed monthly with the Plant Divisions Managers and an action program schedule is prepared with all the actions and responsible groups to meet the improvement plans of the plant.

m) *The station shall comply with all regulatory nuclear safety requirements. The station shall resolve with the regulatory authority any requirements or interpretations of these that would not appear to be beneficial to the health and safety of the public or the workers.*

The licence holder retains the primary responsibility for the safety of the plant when implementing any changes to processes or systems that may affect safety. The changes resulting from regulatory review and inspection activities follow the normal plant processes for the initiation, assessment and implementation of modifications.

The various regulatory requirements that are integrated in the framework of the management system are carefully reviewed to ensure that their intent is fully understood and that there are no conflicting requirements. Clarification is sought from CNCAN and the other regulatory authorities, as the case may be, for any requirement the interpretation of which needs further detailing.

(n) *Managers at the most senior level shall demonstrate their commitment to nuclear safety by giving continuous attention to the processes that have a bearing on safety and by taking immediate interest in the significant safety issues when these occur.*

The primary responsibility for nuclear safety at Cernavoda NPP resides with the senior management, who initiates regular reviews of the safety performance of the organisation and of the practices contributing to nuclear safety with the objective of achieving and maintaining an effective safety culture and a high level of operational safety. Adequate arrangements are in place to ensure that safety significant issues are timely brought to the attention of the senior management. Specific processes, such as “The safety assessment by management (Plant Safety Oversight Committee - PSOC)”, “Operational Decision Making” and “Technical Operability Evaluation” are established and implemented to ensure that due priority is given to any safety significant issues.

The management team of the plant meets daily to focus on the safety and production issues and the Site Manager provides context and direction to the team. Information on the regular reviews of the management system is provided under Article 13.

(o) *Managers shall ensure that the staff respond to and benefit from established practices (culture) and by their attitude and example shall ensure that their staff is continuously motivated towards high levels of performance in discharging their duties.*

Management oversight and feedback is provided daily in a field observation program. All management levels act as role models with regard to the implementation of the safety policy of the plant. The Manager's field assessment programme requires the managers to inspect the plant areas according to a specific monthly programme. After finishing the assessment, the manager has to discuss issues with the participants of the evaluation and also reinforce the management expectations such as work quality, safety, conservative decision-making, reactor safety and public safety, depending on the involvement of the workers. Information on the observation and coaching by managers is provided under Article 12.

## 10.2 Overview of the regulatory activities for the evaluation of the safety management of the plant

CNCAN staff routinely audits the license holder's compliance with the OP&P and the Nuclear Safety Policy and perform regulatory inspections to ensure adherence to station procedures. In order to evaluate the safety management at the plant, CNCAN checks the compliance with the regulatory requirements following the regulatory procedures established for assessment and inspection, as described under Article 7.CNCAN verifies that the licensee has accomplished its responsibility, to ensure the continuous availability of safety-related fundamental resources, including adequate management, operation and support personnel, and the various physical plant resources needed for the safe design, testing, operation, and maintenance of the plant. The results of CNCAN assessment and inspections are incorporated into the licensee's overall plant management and corrective action programs. The issues and findings are viewed in terms of trends as well as their apparent risk.

The results of plant continuous monitoring and periodic safety assessment by the licensee are available to the regulator by means of Shift Supervisors Log, Quarterly Technical Reports, Surveillance Programmes, results of Probabilistic Safety Assessments and Deterministic Nuclear Safety Analyses and also by communication with CNCAN site-dedicated inspectors, on daily basis.

In monitoring the licensee's arrangements for managing safety, CNCAN reviews the use of indicators throughout a licensee's organisation to improve safety and the measures taken to prevent adverse trends in any of the safety related indicators. However, in the licensing process, the performance indicators are used by CNCAN only as support information.

## 10.3 Significant developments for the last reporting period

### Regulatory developments

The Safety Culture Oversight Process (SCOP) and the associated procedure and guidelines developed by CNCAN have been reviewed and updated in 2015 to improve their effectiveness, taking into account the experience with the implementation of the process, the current international standards and good practices and the lessons learned from the Fukushima Daiichi accident.

The development of the SCOP started in 2010, building on the existing regulatory inspection and review processes, and produced SCOP guidelines based on the IAEA safety guides on management systems for nuclear installations (GS-G-3.1 and GS-G-3.1), which provide a framework for the assessment of safety culture, based on a set of 37 attributes, grouped into 5 areas corresponding to safety culture characteristics:

- Safety is a clearly recognised value;
- Leadership for safety is clear;
- Accountability for safety is clear;
- Safety is integrated into all activities;
- Safety is learning driven.

This action started due to a recommendation received by Romania in 2008, resulting from the peer review in the framework of the Convention on Nuclear Safety, for developing dedicated diagnostic tools in order to improve the effectiveness of regulatory assessment of safety culture. This action has been addressed, with support from the IAEA, through an Extra Budgetary Programme (EBP), funded by CNCAN and the Norwegian Radiation Protection Authority.

The SCOP guidelines have been designed to enable data gathering for the assessment of each safety culture attribute and include, as applicable:

- regulatory expectations relevant to the attribute;
- documentation to be reviewed;
- questions to be asked;
- observations to be made;
- elements necessary for considering an attribute fulfilled;
- warning flags.

A few examples of generic data sources for regulatory assessment of safety culture, which are applicable regardless of the technical area of inspection, are provided below:

- policy documents emphasising priority to safety;
- procedures that describe safety-related processes and activities;
- self-assessment guidelines;
- self-assessment reports and safety performance indicators for various processes (e.g. training, maintenance, etc.);
- results of (quality) management system audits and reviews, reports from external reviews;
- previous inspection reports;
- records of past events and corrective actions implemented;
- interviews with licensee’s staff at various levels (managers, supervisors, workers) during the inspections; observations during common meetings;
- observation of activities in the field (e.g. corrective maintenance work, preventive maintenance work, chemistry activities - sampling/analyses; surveillance/testing; nuclear plant operator rounds; new fuel receipt and inspection; shift turnover; control room and simulator evolutions; system/component clearance activities; hold point activities; training – initial / refreshment; maintenance planning meetings; outage planning meetings, etc.).

It should be noted that the findings resulting based on this approach (i.e. assessing the review and inspection findings against the IAEA attributes for a strong nuclear safety culture) reflect the subjective opinion of the reviewer, the relevance of the attribute in the specific area of technical assessment or inspection and the means for gathering the information. While a specific finding could not provide a view on the safety culture of the organisation as a whole, evidence of certain attributes not being met for several functional areas and processes would provide a clear indication of a problem that would warrant increased regulatory surveillance.

The implementation of the SCOP proved that all the routine regulatory reviews and inspections reveal aspects that are of certain relevance to safety culture. Interactions with plant staff during the various inspection activities and meetings, as well as the daily observation by the resident inspectors, provide all the necessary elements for having an overall picture of the safety culture of the licensee. Systematic planning of regulatory inspections to cover all areas important to safety should ensure that safety culture aspects are timely observed. However, significant regulatory resources and a large number of review and inspection activities are required, over a relatively long period of time, to gather sufficient data in order to make a judgement on the safety culture of an organisation as a whole. Training of the reviewers and inspectors is essential for achieving consistency in the regulatory approach to safety culture oversight.

Although nuclear safety culture cannot be regulated as such, the organizational and human factors that support a healthy nuclear safety culture are subject to regulatory requirements. Formalizing the requirements on some of the artifacts that influence nuclear safety culture, CNCAN issued a new regulation, “Requirements on the nuclear safety policy and on the independent nuclear safety oversight”. Details on this regulation have been provided in the chapter corresponding to Article 7.

In 2015, CNCAN started to define its own organizational culture model, identifying the elements that promote and support safety culture. The model has been developed using the organizational culture model developed by Edgar Schein. This action has been taken based upon a recommendation received from the 6th Review Meeting of the Contracting Parties to the Convention on Nuclear Safety, to have assessments of the safety culture of the regulatory authority, acknowledging that the culture of the regulator may have an influence on the safety culture of the licensees. A limited exercise for a safety climate survey has been implemented for CNCAN staff involved in the regulatory review and inspection activities for nuclear installations. The same 37 attributes of a strong safety culture promoted by the IAEA have been used, in a slightly adapted form, also for the safety climate survey for CNCAN staff. Several training activities for the staff in the area of organizational culture and nuclear safety culture have been implemented and others are planned for 2016.

**Developments on the licensee's side**

The Cernavoda NPP Safety Culture Framework was developed in 2006 starting from the 3-layers organizational culture model (Edgar Schein, 1992) and a set of observable characteristics which include shared beliefs and assumptions, principles which guide decisions and actions, management systems and controls, patterns of behaviour of leaders and employees and the physical state of the working conditions and equipment. The framework was constructed based on international guidance of IAEA, INPO and WANO in this area, so the observable characteristics are in accordance with those described in the reference documents issued by these organisations. The safety culture framework is documented in a station Information Report.

In 2012, a review of the Safety Culture framework was performed, taking into account the new document INPO 12–012 Traits of a Healthy Nuclear Safety Culture, which highlights the behaviours and actions that are most critical to creating and maintaining a healthy nuclear safety culture in a nuclear organisation. Further, in 2013, WANO has published WANO PL 2013-1 Traits of a Healthy Nuclear Safety Culture reiterating the same principles. A cross-reference analysis between the Safety Culture Framework characteristics and INPO/WANO Traits and attributes was performed, showing that Cernavoda Safety Culture Framework covers all aspects included in the "Traits…" documents and it is a consistent working model for safety culture.

The framework consists of the following characteristics of the safety culture:

- Objectives and results indicate a strong regard for safety;
- Equipment is in good condition, core reactivity is managed and physical working conditions are safe;
- Management systems are effective;
- Leadership behaviours show the regard for safety;
- Individual behaviours show the regard for safety;
- Organizational learning is embraced.

The safety culture staff surveys were developed based on the Safety Culture Framework, using questionnaires delivered via web-based applications that allow for anonymous results. This method gives management the flexibility to modify survey questionnaires as the program evolves. The questions were established to present concepts in clear, common language. Data collection and interpretation of the results has been performed by plant specialists, with consideration toward the workforce's norms, behaviours and perceptions.

The results of all activities performed for the assessment and monitoring of safety culture are provided to management review during periodic meetings. Along with the annual staff survey, there are other methods used, like document reviews, observations, interviews or focus groups, analysis of events from the point of view of safety culture characteristics, etc. Improvement actions were taken as a result of the surveys.

The station has implemented a detailed plan for conveying the nuclear safety culture message and developing the behaviours of a learning organisation. Methods used vary for different groups of personnel and include Safety Culture Training. All new employees receive initial safety culture training, which is one full day course on nuclear safety culture principles. Contractor personnel are fully integrated into staff nuclear safety culture training. An annual computer-based refresher training regarding healthy safety culture traits is requested for all personnel. Also training was provided for all station personnel on the attributes of a "no-blame" culture to encourage the reporting of issues.

The persons who enter in the licensing program for operators take a two-day, advanced level course on safety culture comprising ten case studies. All personnel complete an annual requalification on safety culture training that includes recent operating experience.

Case studies for "engaged thinking organizations" were developed and discussed with the personnel. These case studies emphasize that leaders and supervisors maintain their oversight roles; behaviors and performance of all personnel are maintained at the highest level; risk is recognized, understood and managed and workers understand and anticipate the effects of their actions. The use of relevant operating experience and recognition and challenge of consequences of repetitive or long-standing issues are also highlighted by these case studies.

These training activities consolidate the characteristic of a "learning organization" and sustain the emphasis placed on safety in every activity at Cernavoda NPP.

## ARTICLE 11 - FINANCIAL AND HUMAN RESOURCES

*1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.*
*2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.*

### 11.1 Legal Provisions Stating the Obligation of the Licensee for Ensuring the Availability of Adequate Financial and Human Resources

As required by the Law, the licensee is responsible for ensuring both adequate financial and human resources to support the safety of the Cernavoda NPP throughout its lifetime.

The relevant paragraphs of the article 18 of the Law are quoted below:

*Art.18. "A licence for deployment of activities involving nuclear installations (as specified in the art. 8 of the Law) shall be granted only if the applicant fulfils the following conditions:*
*a) is capable of demonstrating the professional qualification, for all job positions, of its own personnel, the personnel's knowledge of the nuclear safety and radioprotection regulatory requirements, the probity of the personnel that have authority for decision making in managing the work deployed during construction and operation of the nuclear installation or in managing other activities in the nuclear field (of which mentioned at art. 8 of the Law);*
*b) is responsible to ensure that the personnel, permanently or temporarily employed, which deploys professional activities in vital points of the nuclear installation or has access to classified documentation, is reliable and licensed by the competent authorities in this regard;*
*c) is capable of demonstrating that has all the human and financial resources, the technical resources, technologies and material means necessary for the safe deployment of its activities.*
*[…]*
*e) is responsible that the personnel assuring the operation of the nuclear installation have the necessary knowledge, as appropriate for the position assigned, with regard to the safe operation of the installation, the risks associated, and the applicable nuclear safety measures.*
*f) takes all the necessary measures, at the level of the current technological and scientific standards, to prevent the occurrence of any damage that may result due to the construction and operation of the nuclear installation;*
*[…]*
*j) has adequate and sufficient material and financial arrangements for the collection, transport, treatment, conditioning and storage of radioactive waste generated from the licensed activities, as well as for the decommissioning of the nuclear installation upon termination of operations, and has paid the contribution for the establishment of the fund for the management of radioactive waste and decommissioning*

These obligations are also stated and further detailed in the conditions of each of the licenses granted by CNCAN. The status of the financial and human resources is periodically reported to CNCAN through the Quarterly Technical Reports (QTRs).

## 11.2 Availability of resources to support the safety of Cernavoda NPP throughout its lifetime

The licence holder for Cernavoda NPP is a government owned company. It has the authority to raise revenue through the sale of electricity in order to ensure that adequate financial resources are available to support the operation and the safety of Cernavoda NPP throughout its lifetime.

Based on actual rate changes and the predictions for the future, detailed analyses have shown that sale of energy on the market will ensure in Romania enough financial resources to operate the plant and support improvement programmes as necessary.

Cernavoda NPP maintains one budget structured as Operation and Maintenance and Capital Improvement respectively. The plant budget is based on the budgets prepared by each plant division, which include salaries, training, investments, consumables and services. The Site Manager, the Administration Board and the Ministry of Economy and Finances, approve the plant budget, based on the capacity of energy production of the plant and in an amount that guarantees the safe operation of the plant, including the necessary investments to maintain and improve the plant performance.

The budget for Operation and Maintenance usually covers most of the safety improvements to the plant. However, if the need arises for improvements at a larger scale, as for example as an outcome of the Periodic Safety Review, it is expected that these will be covered by the Capital Improvement section of the budget. Such situations are factored in for establishing the future electricity rate to be charged to the customers.

The expenditures of SNN are dictated by the company's financial position, current and planned performance, service obligations (load forecast), and financial and business strategies. These inputs are used to develop a set of affordability envelopes, one for ongoing operating expenditures, and one for capital investments.

## 11.3 Financing of Safety Improvements

As a rule, ongoing safety-related programmes are financed from the operations and maintenance envelope, and large scale improvement projects, including safety related projects, are financed from the capital envelope. In either case, the costs of safety improvement programmes / projects would become part of the base rate and recovered through rates charged to customers.

Within each envelope, programmes/projects are ranked in accordance with prioritisation criteria that reflect the corporation's operating, business and financial objectives. The licence holder assigns a high priority to safety-related programmes and projects and ensures that adequate financial resources will be provided to support the safety improvements throughout the life of the nuclear power plant.

Starting with 2006, by signing an agreement to join the R&D Programme within the COG, SNN became a participant member, obtaining access to the results of the research performed after the date of the agreement coming into force. Starting with 2007, SNN acquired the voting right and participates actively in the COG R&D Programme.

In order to make more effective use of the research results, as well as for promoting work in areas of special interest for Cernavoda NPP, the licensee has established the procedural framework for developing the related projects and has nominated a project responsible in his own organisation, as well as in the structure of the COG. The specialists from the Romanian research institutes are also involved in the activities of evaluation and assessment of the results made available through the COG R&D Programme.

## 11.4 Financial Provisions for Decommissioning and Radioactive Waste Management

Up to present, the licensees, including Cernavoda NPP, had to pay an annual contribution for supporting the activity of the Nuclear Agency and for Radioactive Waste (AN&DR, which is the competent authority for the coordination, at national level, of the safe management of spent nuclear fuel and of radioactive waste, including disposal) and for deployment of activities mentioned in the annual plan for waste management and decommissioning.

At Cernavoda NPP, the costs of the current activities for the management of spent fuel and radioactive waste, including the costs associated with the Intermediate Spent Fuel Dry Storage Facility, are included in the operational costs.

For the costs associated with the long term management, such as disposal of spent fuel and radioactive waste management, including decommissioning costs, SNN pays the financial contributions to the Fund for Radioactive Waste Management and Decommissioning.

The annual contributions of the licensees to the fund have been set by the Governmental Decision regarding the establishment and the administration of the financial resources necessary for the safe management of the radioactive waste and for the decommissioning of nuclear and radiological installations.

## 11.5 The Rules, Regulations and Resource Arrangements Concerning Qualification, Training and Retraining

Romanian regulations related to Training, Qualification and Retraining for operating personnel for research reactors and nuclear power plants have been in place since 1975, well before starting the construction of Cernavoda NPP. When Romania bought the CANDU technology, the training issue had been considered since the early phase of the contract negotiations. The initial training for management, operation, technical and maintenance key personnel was provided in Canada. More than 100 persons were trained in an operational Canadian nuclear power plant prior to be assigned to any commissioning / operation activities, in order to allow them to fulfil their position responsibilities safely, effectively and efficiently.

Together with the technical design, Romania bought the training concept and training programmes for operation, fuel handling, maintenance, and radiation protection staff. The adopted programmes have been continuously adapted and improved based on IAEA Guides related to NPP Personnel Training & Qualification, and INPO / WANO recommendations related to Training System Development. In this way, a Systematic Approach to Training (SAT) has been implemented in Cernavoda NPP training activities.

Reference Documents (RD), Station Instructions (SI), Process Specific Procedures (PSP), and process specific procedures (PSP) have been put in place to establish a structural Training Process for NPP Personnel.

### 11.5.1 Training Organisation and Facilities

The complexity of the facilities and equipment of a nuclear power plant requires high quality manpower and its preservation in time. Therefore, the licence holder considers the work performed in the human resources field as a priority and particular attention is paid to the strategy related to personnel recruitment and personnel loyalty / jobs stability, as well as to the sustained improvement of training quality.

The plant organisational structure includes a Training Department, headed by a Training Senior Superintendent who reports directly to the Site Manager. The Site Manager has the overall responsibility for the qualification of plant personnel and supports the Training Department with the necessary resources including staffing and facilities.

The Training Department provides support for plant departments to achieve the station goal of having competent and qualified staff capable of ensuring the safe and reliable operation of the Cernavoda NPP and is in charge of coordinating all the training activities at the plant through the departmental Training Coordinators. All the training programmes are approved by the Training Senior Superintendent.

The structure of the training organisation, the accountability, functional responsibilities, level of authority and lines of communication facilitate the accomplishment of established training goals and objectives.

The responsibility of identification and ensuring the relevant training to a particular position rests with the direct supervisor of that position. This responsibility is extended for any job change that arises in his/her department. The Training Senior Superintendent helps supervisors to identify future needs for training and development by monitoring personnel performance, training and work activities, plant and external operating experience.

The managers and supervisors are responsible to ensure that production requirements do not interfere with the need for personnel to be trained. In order to allow the entire personnel to fulfil their position responsibilities safely, effectively and efficiently, all staff is provided with appropriate opportunities to take the relevant training, before they are assigned to carry out tasks that require the corresponding knowledge or skills.

The Training Department is organised in six groups: Operations Training, Simulator, General Training and Skills, Training Programs Coordination, Orientation and Authorization Training, and Public Relations.

The Training Senior Superintendent ensures that the department is organised and administrated such that following specific activities are conducted effectively and efficiently:

- Development of the training process and procedures in accordance with the Systematic Approach to Training methodology;
- Identification of training requirements (initial and continuing) for all plant positions as a result of job and/or task analysis;
- Definition, development and implementation of training and qualification programmes to meet the training requirements for plant staff and contractors;
- Provision of qualified classroom and on-the-job instructors, of the training facilities i.e. classrooms, instruction books, simulator, mock-ups, training aids and equipment;

- Processing and maintaining documents and records generated by training activities;
- Evaluation and reporting on training performance and training processes or/and programmes improvements based on their results;
- Ensuring Simulator Maintenance and Operability and maintaining up-to-date configuration control of the simulator and other training facilities and equipment;
- Information of the public and authorities on specific nuclear power issues and the preservation of a positive image of Cernavoda NPP inside the country as well as abroad;
- Developing and maintaining a proper internal communication and suitable relationships with the mass-media, as well as good cooperation with professional and industrial associations that activate in the nuclear domain.

The Training Centre has 24 classrooms that are well equipped with white boards, smart boards, flipcharts, video projectors and computer systems. Some of them have equipment, spare parts, and mock-ups that represent plant components or are equipped with computers for Computer Based Training. Also, some of the classrooms are used as study rooms and are equipped with current reference documents, procedures, and training manuals.

Maintenance training facilities were built for mechanical, electrical, C&I, general services activities. A series of mock-ups were built-up (steam generators, fuel channels, etc.) which have increased opportunities for equipment familiarization and practice prior to important or infrequent jobs.

A Full–Scope Simulator is mainly used for the initial and continuing training of licensed personnel, Shift Supervisors and Control Room Operators, in order to provide them with the necessary knowledge and skills to conduct plant operation from the control room in a safe, reliable, and professional manner, both in normal and abnormal conditions. Taking into account that the Full-Scope Simulator has operating characteristics similar to those of the Unit 1, in order to be used for Unit 2 operators' training, the differences between Unit 1 and Unit 2 were analysed and documented. Subsequently, during the training development phase, the different tasks were identified and suitable training methods were built into the program. Also, the simulator is used for the regulatory examinations of the personnel applying for the practice permits issued by CNCAN.

Before the implementation of any modification at the plant, all the necessary safety assessments and evaluations are made and if the modification influences the simulator proper actions are established. Physical fidelity of the simulator is maintained by analysis of the changes made after each outage at the plant Main Control Room (MCR) and providing appropriate remedies.

The simulator facility is equipped with video cameras that provide the possibility to record all the training activities made during each session. It is also possible to record all the major parameters during the training session and to keep the data for debriefing purposes.

### 11.5.2 Training Programmes for Cernavoda NPP personnel

According to Cernavoda NPP training policy, the plant staff shall be qualified for the tasks that they are assigned to perform. The training programmes are performance based and linked directly to the tasks that an individual is expected to perform as part of the job.

Training programmes are based on SAT principles and address the essential capabilities and qualifications to support the safe and reliable operation of the plant.

The application of SAT principles involves the following stages:

- Analysis of training requirements
- Design of training programmes
- Development of training programmes
- Training implementation
- Training evaluation.

Each department of Cernavoda NPP performed a job analysis, identifying initial and continuing training requirements for effective job performance, and then documented training requirements by preparing a generic Job Related Training Requirements (JRTR) or Qualification Guide for each position, or group of similar positions. Particularly, for some positions, the training requirements were identified based on reviewing task analyses of similar job positions performed by nuclear industry.

Having the training requirements for each position, the training objectives have been established and the training materials developed. Based on this, it was possible to design and implement training programmes for all plant personnel. In addition to the knowledge and skills required to ensure and maintain the technical competence, the training requirements related to development of managerial and supervisory skills are also included in JRTRs or Qualification Guides.

In order to ensure that all plant personnel have sufficient understanding of the plant and its safety features, the Initial Training Programme for plant personnel consists of two main parts:

- General training programme;
- Specific training programme.

The general training programme is provided to all employees in order to familiarise them with the plant, its physical layout, its basic operation, the station organisation and the basic administrative procedures which govern its day to day operation. In addition, the program provides an introduction to industrial safety, nuclear safety, the quality assurance program, the requirements for radiation protection and actions in the event of an emergency situation on site.

The specific training program is based on job specific courses and activities in order to provide the knowledge and skills, as well as familiarisation with the reference documents, station instructions and work procedures, for a particular job. Science fundamentals and nuclear technologies, plant systems training and on-the-job training are the main parts of the specific training program. Most of the specific training is performed on the job.

After completion of the training, written and, as necessary, practical tests are provided to ensure mastering of the acquired knowledge by the trainees and their ability to perform work safely. In addition, an evaluation of the trainees' performance at the work place is made by their supervisors to assess and correct the knowledge assimilated and skills achieved.

Continuing training programmes were defined and implemented in order to maintain and improve employee's job performance and to develop their position-specific knowledge and skills. Continuing training programmes cover re-qualification for any qualifications that have a specified lifetime, refresher training to maintain and improve skills, lessons learned from industry operating experience, update training derived from plant systems/equipment modifications and procedure changes, performance improvement training to correct performance problems or identified weaknesses in knowledge and skills related to their duties.

### 11.5.3 Overview of the Training Programmes for the major categories of Cernavoda NPP personnel

**Control Room Operators and Shift Supervisors**

The scope of the programmes and the content of the specific training courses are based on the Job and Task Analysis completed for the respective job positions.

In order to be selected in the training programme for initial authorisation the candidate for the Control Room Operator (CRO) position must meet a number of requirements such as:

- Medical and psychological exams passed successfully.
- Successfully passed a defined number of courses and be already internally authorized in radiation protection, field operations in all areas of the plant, electrical authorization, Control Room Assistant position, Work Control Area position.
- Successfully performed all the Advanced System Field Check-outs.
- Successfully completed the Core Generals Training Program (Science Fundamentals and Nuclear Technologies training courses that have been deemed as essential knowledge requirements for Control Room Operators).

The Initial Licensing Training Program for CRO is 22 months long and consists of:

- Systems specific training – advanced system training, control programs training, Romanian laws, Operating Polices and Principles, Abnormal situations and transient response. The duration of this training is 10 months. At the end of this training, the candidate has to pass a written and oral exam administered by the national regulatory body - CNCAN.
- Simulator training on operator response to normal operation and to major transients and abnormal operating procedures. The duration of this training is 6 months. At the end of this training, the candidate has to pass a simulator-based test administered by CNCAN.
- Co-piloting – practical training related to Main Control Room panel configuration, systems test and operation under direct supervision of an authorized person. The duration of this training is 6 months.

For the Shift Supervisor (SS) position, the Initial Licensing Training Programme prerequisite is a valid license as a Control Room Operator for at least two years. The structure of the Initial Licensing Training Program for SS is similar to that for CRO. In addition, it contains a "Specific Training for SS Position" module which addresses the specific knowledge and capabilities related to this position (ex.: Fuel handling procedures, operation limits, conservative decisions, abnormal operation management, plant modification approval process, nuclear safety management, etc.). The duration of Initial Licensing Training Program for Shift Supervisor is 9 months. Also, the candidate for the Shift Supervisor position has to pass written, oral and simulator exams administered by CNCAN.

In order to retain a current authorisation, Cernavoda NPP licensed personnel (CRO and SS) has to attend a continuing training program (refresher courses - at least 4 weeks per year, emergency training courses, qualifications - radiation protection, electrical, Secondary Control Area, etc.) and to work on shift on the authorised position for at least 5 shifts every quarter of the year.

Re-authorisation of the Control Room Operator and Shift Supervisor is required at every 5 years. The candidate has to pass the re-authorisation examinations conducted by CNCAN.

**Field Operators**

The training topics for the field operators training and qualification programme are established based on the training objectives coming from the results of job analyses made by the Training Department and Operations Department and from performance evaluations. The training programmes and related materials are developed by the Training Department and validated by the Operations Department. Along with the courses provided by the Training Department, skills checks are conducted in the field by an OJT (on-the-job training) instructor. At the end of every training session, the operators are evaluated by written tests (following classroom training), or by field and practical evaluation (following the on-the-job training).

The training and qualification programme for plant operators allows for streaming of operators into separate qualification (duty) areas of plant operation, such as Balance of Plant, Common Support Systems, etc. Each operator has to pass yearly refresher training in the emergency preparedness, safety culture, environmental safety, and work protection. In case of modifications, continuing training is provided for field operators to inform them on the plant status. This training is done before the modification is implemented.

**Maintenance Personnel**

The Training and Qualification Programmes for maintenance personnel were developed based on training requirements resulted from Table Top Analysis and contain the classroom training (orientation, science fundamentals, equipment and nuclear technology, plant systems), organised and delivered by the Training Department instructors, and skills training, organised and delivered by the Maintenance Department as On-the-Job Training. At least once per year, the OJT instructors are evaluated and results are recorded to monitor performance.

All the maintenance staff is monitored by management and supervisors to ensure their qualifications are adequate for the assigned duties.

The continuing training is split into training courses that are provided in classrooms and practical training provided at the mock-ups or plant equipment in the workshops to maintain necessary skills and qualifications.

**Technical Support Personnel**

The Training and Qualification Programme for the Technical Engineers follows the philosophy of Duty Area training and qualifications set out in INPO ACAD 98-004 - Guidelines for Training and Qualification of Engineering Personnel.

Orientation and general technical training (science fundamentals, nuclear technologies, basic systems etc) are delivered by the Training Department. Duty Area Mentoring training is done via the Technical Department.

Duty areas have been defined for System Engineers, Design Engineers and Component Engineers. Within each duty area, a set of tasks has been established. Skills and abilities have been identified for each task and the supporting courseware to provide the underlying knowledge and skills has been specified in Qualification Guides. A formal evaluation covering tasks in a duty area is required before the engineer is qualified to work in that specific area.

**Instructors**

Instructors' tasks and activities are analysed to identify the knowledge and skills needed to perform their instructional responsibilities. The products of this analysis are the Job Related Training Requirements for instructors. These are reviewed periodically to ensure they are the current basis of the instructional knowledge and skills training programme.

An initial training programme is designed to ensure that instructors possess the technical competence and instructional skills necessary to conduct high quality training. This training programme is intended to prepare a competent, full-time instructor. Continuing training programmes are aimed at maintaining and improving the instructional and technical skills following initial instructor qualification.

Considering simulator training of the licensed operators as a very important part of their development and for maintaining ability to fulfil the responsibilities dictated by their position, the Simulator Instructor positions are staffed with experienced operators, who are currently or have been previously authorized as Control Room Operators.

Part-time instructors from plant departments are involved in OJT and some specific training courses (radiation protection, management system, emergency response etc). All of them are experienced people that have passed through the trainers' qualification programme.

Periodically, the Training Senior Superintendent and the training supervisors monitor and evaluate instructors' performance to ensure that training staff possess and maintain the technical knowledge appropriate for their positions and the instructional capabilities appropriate for their training functions. Feedback forms from observations and self-assessments are also used to check the quality of the training provided.

**Management Personnel**

Cernavoda NPP managerial staff has an essential role in setting the standards and expectations for all personnel in all aspects of organisation's activities. In addition, it is essential that management staff themselves visibly meet these standards and help their staff to understand why these standards are appropriate. Also, Cernavoda NPP managers have a major influence on organisational culture. They are expected to maintain high levels of nuclear safety and at the same time to be more efficient in reducing the cost of production. Such circumstances underline the need to give managers of all levels the necessary training to succeed in such a demanding environment.

Based on the necessary competencies, roles and responsibilities required for the management staff, a Development and Training Programme is established and implemented. The content of the management staff training programme was established in order to allow for individualised development, having mandatory development components at various management levels and also to support the identification of the specific individual manager's needs.

The focus of the training is on management and leadership courses in order to achieve, maintain and improve the managerial and supervisory abilities and leadership skills. The courses are developed and delivered in relation with two management categories: supervisory and senior management and their respective roles, responsibilities and competencies.

The content of the training has two major components: Initial and Continuing training. Both of them comprise Classroom training, and On-the-job training.

Classroom training includes internal courses delivered by Cernavoda NPP instructors, plant Subject Matter Experts (SMEs) or by external experts and external courses provided, on or off site, through international organizations (COG, WANO, IAEA etc).

Continuing training is designed to assist the managerial staff to maintain and improve their job performance and to develop their position-specific knowledge and skills. It is based on job performance and consists of: refresher training, update training *(*derived from changes in the legislative and regulatory framework or in the licensing conditions, plant modifications, procedures changes, etc.), operating experience training, performance improvement training, and developmental training (based on self-directed improvement programmes such as attendance in miscellaneous courses, workshops, forums, coaching activities etc. and on self-study).

**Contractors**

All contractor personnel should be trained and qualified to perform their specific task for which they are contracted. Training and qualification of contractors to perform their specialised tasks are typically provided by their parent company. Cernavoda NPP, with the involvement of the department responsible for the contractors' work, has the obligation of evaluating the formal training and qualification of the contractor personnel, in order to verify and guarantee their competence.

A training programme is also provided for contractor personnel before they are allowed to work on site, which includes basic knowledge of plant layout, the basics of plant operation, station organisation and administrative procedures governing its day-to-day operation. In addition, the programme provides an introduction to conventional and nuclear safety, safety culture, the relevant requirements of the plant's management system, the requirements for radiation protection, and action in the event of an emergency situation on site. Additional training is also provided for some of the contractors, as necessary, on selected parts of the position-specific initial training.

Continuing training programme for contractor personnel includes lessons learned from industry operating experience, applicable equipment modifications or procedural changes related to their work, radiation protection re-qualification, as well as additional training on selected subjects of the initial specific training.

**Personnel with emergency response functions**

For plant management, technical and operating staff with emergency response functions, the training programme includes basic topics related to: typical scenarios for nuclear accidents and potential threats / consequences, differences between Design Basis Accidents, Limited Core Damage Accidents and Severe Core Damage Accidents, decision making criteria in the early phase of an accident, the use of the Severe Accident Management Guides etc.

**Radiation protection training**

According to the provisions of the Law, any licensee has to use, in its activities, only personnel possessing a practice permit, valid for these activities. This practice permit is issued, after an evaluation and an examination, by CNCAN or by the licensee, according to specific regulations, namely Regulations regarding the issuing of practice permit for nuclear activities and the designation of Qualified Experts in Radiological Protection (CNCAN, 2002). These regulations establish the requirements on qualification, examination and the practice permits issuing procedures, for the professionally exposed workers, radiological protection officers and qualified experts in radiological protection.

Furthermore, according to the provisions of the Basic Standards on Radiological Safety, the licensee must ensure the information of the professionally exposed personnel with regard to the radiological risk on their health due to the activities performed, the general procedures and the necessary measures on radiation protection, as well as the importance of observing the technical, medical and administrative measures. Also, the licensee has to ensure the adequate training of the professionally exposed personnel, in the field of radiological safety and the refreshment of the training, every 5 years, with 2 practical evaluations in this period, through a training system recognised by CNCAN.

Thus, Cernavoda NPP has in place a training programme on radiation protection, for all the personnel working on site, not only its own employees, but also external workers. In 2007, following a CNCAN audit, Cernavoda NPP was designated as accredited body for the certification of the training of personnel in the field of radiation protection at Cernavoda NPP.

### 11.5.4 Review and Update of the Training Programmes

The training programmes are periodically evaluated and revised to maintain and improve personnel training. The evaluation of training performance is provided by managers, supervisors, and the Training Department, according to the plant procedure "Training Evaluation Process".

The evaluation of the training programmes is based on:

- feedback from management and first line observation of the training activities;
- feedback from trainees;
- feedback from evaluation of classroom instructors or on-the-job instructors;
- feedback from post-training evaluation;
- feedback from self-assessment of training activities;
- analysis of training indicators.

The Training Senior Superintendent, line managers and supervisors periodically observe training activities (classroom, simulator, on-the-job training etc.). Personnel performance is observed periodically, as part of Human Performance Programme, to verify that training and qualification programmes are producing competent workers. During evaluation, the management pays special attention to the trainees' awareness of their safety roles, Stop-Think-Act-Review (STAR) principles, their understanding of the intent of the procedures, cases when the work should be stopped, safety rules, and the application of the ALARA principle. Feedback from participants and their supervisors on training content and how well the training programme prepared the personnel to perform their jobs is used to revise and improve the training programme.

If the personnel's training is identified as causal factor for performance deficiencies, the scope of corrective actions is to bring the current level of personnel performance to the desired level and includes, as appropriate:

- changes in training programmes;
- changes in training materials;
- refresher training programmes;
- conduct of a job or task analysis or a training needs analysis.

Analysis of results of post-training evaluations and observations of the employees' performance at the work place help to determine potential training improvements. The areas for improvement identified are analysed in the Curriculum Review Committee and the approved corrective actions are monitored through the Corrective Action Process.

Any changes in plant procedures, processes and systems/equipment modifications are analysed to identify any impact on training programmes, materials and settings and to initiate and implement the necessary corrective or improvement actions.

### 11.5.5 Training through external organisations

This category includes training courses in cooperation with external organizations (IAEA, WANO, COG, EPRI, manufacturers, equipment suppliers etc.) and development activities (fellowships, workshops, etc.) organised or sponsored by above-mentioned organisations.

Also, Cernavoda NPP has a good cooperation with Romanian specialised organisations which provide training for plant personnel in the areas of technical and skills training to meet the national legal requirements related to qualification and authorisation of plant staff.

Training provided by external organisations is well controlled according to the plant procedure "Training through outside organisations". Feedback forms filled out by trainees are analysed to make a decision about future needs.

## 11.6 Regulatory activities for assessing training effectiveness

Specific requirements in the area of training are provided in the "Regulation on granting practice permits to operating, management and specific training personnel of Nuclear Power Plants, Research Reactors and other Nuclear Installations", the "General Requirements for Quality Management Systems Applied to the Construction, Operation and Decommissioning of Nuclear Installations" and in the "Specific Requirements for the Quality Management Systems Applied to the Operation of Nuclear Installations", as well as in the "Fundamental Requirements on Radiological Safety" and the "Regulations on issuing Working Permits for nuclear activities and designation of Qualified Radiological Protection Experts".

The "Regulation on granting practice permits to operating, management and specific training personnel of Nuclear Power Plants, Research Reactors and other Nuclear Installations" defines the conditions that the applicants shall fulfil in order to obtain a practice permit from CNCAN and contains also detailed requirements on the training programmes for the categories of licensed personnel, with special focus on the control room operators.

The categories of licensed personnel for NPPs, as stated in the above-mentioned regulation, together with the corresponding job positions for Cernavoda NPP, are listed as follows:

a) The Nuclear Power Plant Personnel for operating activities in the Main Control Room - Control Room Operators and Shift Supervisors.

b) The Nuclear Power Plant Personnel for Management activities:

1. Site Manager;
2. Station Manager;
3. Production Manager;
4. Technical Manager;
5. Health Physics Senior Superintendent;
6. Operation Senior Superintendent;
7. Training Senior Superintendent;
8. Management System Superintendent;
9. Safety and Compliance Senior Superintendent;
10. Maintenance Senior Superintendent;
11. Physical Protection Superintendent.

c) The trainers/ instructors involved in the specific training activities for operators.

The regulation establishes:

- The qualification requirements for the operating personnel, starting from the commissioning phase of the nuclear installation up to complete removal of the nuclear fuel from the core, the management personnel and the specific training trainers/instructors;
- The steps of the licensing process for each category;
- The methodology of granting the practice permits for the above mentioned personnel and covers:
    - Objectives of candidate’s assessments;
    - Content and phases of evaluation;
    - Methodology of examinations by CNCAN;
    - Criteria and performance indicators.

CNCAN examinations are performed in accordance with the provisions of the regulation and the internal procedures which are part of the Quality Management System of CNCAN and the directives issued by the CNCAN senior management with regard to the nomination of the members of the examination board and the rules for conducting the examination.

The general subjects/topics for the examination of Operating Personnel (CRO & SS) are chosen to be relevant for the knowledge of nuclear installation safety systems, operating limits and conditions, capabilities to operate under normal conditions, abnormal conditions or emergency conditions, team working skills, communication and coordination skills. The examinations consist of written and oral tests and practical examination at the Full Scope Simulator (static and dynamic tests). An independent evaluation of the co-piloting training in the NPP Control Room is also done by CNCAN.

Regarding the examination of the instructors, the technical knowledge, skills, attitudes and instructional capabilities in their assigned areas of responsibility (classroom, simulator etc.) are evaluated.

The examination objectives in the evaluation of managerial personnel are chosen to reflect the performance associated with the job at all three levels: organisational, as part of a process, and at individual level. The content of the examination is established to give an overview of the candidate's knowledge, skills, attitudes and capabilities in specific areas of responsibility.

The examination consists of an interview covering different aspects related to the organisational structure, responsibilities and levels of authority, human performance issues, safety culture, work planning, coaching, and observation of their subordinates.

The practice permits granted by CNCAN following the satisfactory performance of the candidates in all the subjects/tests of the examination, are valid for a definite period of time, provided that the licensed person has continuity in the same activity and a good performance on the respective job.

The training programmes for the licensed personnel are submitted to CNCAN for review and approval. The implementation of the training programmes for all personnel with duties important to safety and the observance of the station training policy are also extensively reviewed and assessed by CNCAN through periodic audits.

### 11.7 Significant developments for the last reporting period

Since 2013, progresses have been made in improving the training programmes for Cernavoda NPP personnel in order to achieve a high level of performance in training and qualification of plant staff with duties important for the safe and reliable plant operation.

Continuing Training Plans covering a new five-year period (2016-2020) were developed for each job family ensuring the coverage of the Continuing Training Curriculum established by Curriculum Review Committees. Annually, plant personnel is required to complete a minimum 32 hours of continuing training.

The evaluation of training programmes health was improved according with the nuclear industry best practices. The performance indicators were revised to minimize administrative burden by selecting data that is already available or easily obtained and to better reflect the revised INPO accreditation objectives and criteria. Shortfalls in training programmes' effectiveness are evaluated and presented to plant management in TOC (Training Oversight Committee) meetings together with the corrective actions taken to ensure training improves performance.

In order to improve workers performance, Dynamic Learning activities were used intensively in 2014 / 2015, especially by maintenance and operation staff. These were focused on Event Free Tools, Foreign Material Exclusion, rigging/ lifting, radiation protection. Since implementation, the number of consequential events has been reduced and the performance in maintenance and operation has been improved.

## ARTICLE 12 - HUMAN FACTORS

*Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.*

### 12.1 Managerial and Organisational Issues

The organisational and managerial philosophy adopted at Cernavoda NPP takes into account the capabilities and limitations of human performance and the responsibilities for ensuring and improving the quality of the human performance are established hierarchically.

Clear lines of authority and communication throughout the organisation are established so that each individual is aware of his accountability and responsibility in ensuring nuclear safety.

The station management is responsible for establishing a safety culture that emphasises to each individual engaged in an activity related to the safety of the plant the necessity for their personal commitment and accountability.

The management provides the necessary expectations, facilities and tools to support human performance. Examples of responsibilities of the management with regard to the improvement of human performance are given below:

- Clearly communicating performance expectation through meetings, policies and procedures;
- Emphasising the reasons behind the established safety practices and procedures, together with the consequences for safety of shortfalls in personal performance;
- Providing sufficient and proper facilities, tools and equipment, and support to the staff;
- Conducting self-assessments;
- Conducting field observations and coaching the personnel to use the best work practices.

In addition, for each level of management the specific level of authority is defined in the station Operating Policies and Principles (OP&P), the Nuclear Safety Policy and the Integrated Management Manual and detailed in other station procedures and documents, to ensure that individuals are aware of their responsibility and of the limits of their authority with regard to decision-making on safety issues.

### 12.2 Human Performance Programme

The main objective of the Human Performance (HU) Programme is to improve the behaviour of all personnel, including contractors, resulting in safe and reliable station operation. Behaviours that contribute to excellence in human performance are reinforced to continually strive for event free operation.

Human Performance procedures, based on best industry standards have been produced to define the framework of the programme and to support its implementation and continuous improvement. The status of the programme is periodically reviewed, during regular meeting of the Human Performance Oversight Committee, chaired by Station Manager, and Human Performance Working Committee (HPWC) where station, and department performance is reviewed, and adverse trends are discussed and action taken to ensure consistent standards and expectations are adhered to across all departments. In addition, HU indicators and performance are reviewed at each department management review meeting to ensure performance meets expectation and corrective action is taken and ensure there is alignment between managers and supervisors.

The main components of the programme are:
- Training (theoretical and practical);
- Observation and coaching;
- Use of Event Free Tools (EFT);
- Event and trend analysis;
- Communication of HU aspects

**Training**

Station personnel as well as permanent contractors are included in the Human Performance training programme, for familiarisation with the terminology, the framework of the HP Programme, the different aspects of using the EFT, the expected behaviours and the role of initiatives in the framework of the HP Programme, according with their work within the organisation.

Human Performance Training has been improved and extended to include classroom courses, practical "hands-on" (skills) and Dynamic Learning Activities. Training also is delivered to technical personnel with specific EFT.

**Observation and Coaching**

Using the Human Performance Programme, several levels of managers and supervisors perform field observation and coaching.

The objectives of Observation and Coaching are to:
- emphasise the expectations with regard to behaviour and attitudes;
- correct work practices that are below the expected standards;
- identify and eliminate event precursors;
- obtain feedback from the employees in order to initiate improvement processes towards enhanced safety performance.

For the area being observed, the supervisor verifies the strengths and the aspects that need to be improved. After finishing the observation, the supervisor discusses the issues with the observed personnel and also reinforce the management expectations such as work quality, safety, conservative decision-making, reactor safety and public safety, depending on the involvement of the workers.

There are two distinct web-based applications for O&C: one is for production and a new one for engineering activities.

**Event Free Tools**

The use of Event Free Tools (EFT) has been established at Cernavoda NPP, through which emphasis can be made on the reduction of events and errors. The EFT include the Pre-Job Briefing and the Post-Job Debriefing, three-way communication and usage of phonetic alphabet, use of and adherence to procedures, STAR principle, conservative decision-making, questioning attitude, peer check/independent verification/concurrent verification, two minutes' rule, etc.

The use of the EFT is now embedded in the thinking process of plant personnel as well as permanent contractors. The implementation of human performance indicators demonstrates the improvement made and the acknowledgement of the usefulness of those tools by the staff.

The latest revision of Human Performance procedures includes specific EFT for engineering personnel: PJB for engineering activities, STAR principle, questioning attitude, signature, decision making, problem solving, etc.

**Event and trend analysis**

HU indicators were updated according to latest revision of INPO documents and COG Guideline "Leading Indicators for Human Performance".

The performance indicators for the Human Performance Programme are:
- Average number of days between most recent six events;
- Human Performance error rate;
- Number of clock resets due to human error;
- Observation and Coaching Process Adherence;
- HU events rate;
- HU conduit;
- HU training adherence;
- Incidence of first three causal factors
- Observation & coaching quality.

The degradation of the indicators is reported through the abnormal conditions process.

Trend analysis at the plant level is documented as an informative report which is distributed to all departments involved in human performance improvement program. Trend analysis presents the evolution of selected aspects over a period of 4 quarters (three quarters preceding the quarter reviewed and the analyzed quarter) in a graphic format. For the adverse trends of aspects identified during the O&C process, as well as for recurrent causal factors, a detailed analysis is performed, to identify the most correct causes and appropriate actions to improve. For trend analysis, the licensee uses the information recorded in the 'Observation and Coaching' database, in the 'Operating Experience' database and the 'EFD clock reset' application.

Trend analyses at department level are also performed to identify timely any possible performance degradation and to establish applicable measures that will prevent the performance at the plant level to be affected.

**Communication of HU aspects**

Focus of the month, Info Supervisor, INFOPLUS-HU bulletin constitutes additional means for good work practices and management expectations reinforcement.

The proposals for Focus of the month are analysed during HPWC meetings based on the incidence of causal factors and performance indicators' trends. Once the subject is established, a written material, including relevant internal and external operating experience is submitted to working groups.

Currently a general subject is established, applicable for all station personnel and additionally there is a subject of the month for engineering personnel. Both "focus of the month" titles are posted on the front page of the daily planning meeting agenda.

Info Supervisor is a written material, issued at department level, used to inform the staff on topics that contribute to enhancing / improving performance for events occurred due to human error (experience internal and external) and lessons learned applicable to the department activities to prevent recurrence.

INFOPLUS-HU bulletin is a written material, issued at plant level, used to inform the plant staff about good catches, positive behaviours, issues or relevant information's about the HU programme. A specific Infoplus-HU Bulletin is issued when EFD clock is reset at plant level.

## 12.3 Analysis of human errors

The Abnormal Condition Reporting programme has been enhanced through replication of good practices from various benchmarking exercises and technical support missions. Self-assessments revealed that the majority of staff recognised the need for a comprehensive reporting programme that included low-level event reporting.

The aspects related to encouraging the initiation of Abnormal Condition Reports (ACRs) for low-level events and near-misses determined an increased participation of plant staff into the process and resulted in a continuous increase of the number of ACRs. The mentality was smoothly shifted from reporting only significant events to report low-level occurrences. In the current stage, the objective is to obtain concurrence for reporting near-misses and other "soft" human performance issues.

Any deficiency in the practices or observed human error is immediately recorded and as appropriate an Abnormal Condition Report is issued for comprehensive evaluation and correction of the cause.

Systematic root cause analyses of the events based on the ASSET and HPES methodologies are conducted and the personnel from various compartments of the plant are involved in the performance of the necessary investigations.

The Human Performance Enhancement System methodology is a method to identify the various contributing factors and root causes of events that have been originated by human errors. The thoroughness with which an error or a human performance problem will be investigated and analysed depends upon the perceived significance (e.g. safety, potential economic impact, etc.) of the event sequence in which the error occurred or the potential for harm that an adverse human performance trend presents.

In addition, the role of the error in an event sequence will also influence the extent to which an error is investigated. An error that was the root cause of an event will likely receive more attention than an error that only contributed to the event. Factors that would be assessed would be work organization and planning, work practices, man-machine interfaces, work place factors and hazards, personal factors, but also organisational factors like resource management, change management and managerial methods.

Event and causal factors charts used in support of this analysis method identify all those contributors so that corrective actions can be developed to minimise recurrence of the same and similar problems.

Also, the events that had direct impact on nuclear safety, personal safety or production and have been directly caused by an inappropriate human act would reset the Event Free Clock, which is an indicator of the station human performance events.

More information regarding the investigation of events is provided under Article 19.

### 12.4 Consideration of human factors and the human - machine interface in the design

The design of the plant ensures that most regulation and control functions are automatic in order to reduce effort of the operating staff and the probability of human errors.

Automatic actuation of control or protection systems is provided to respond to equipment failure or human error which could cause a plant parameter to exceed normal operational limits or a safety system trip set point. The overall plant design and the specific design of protection systems ensure that operator intervention is only required in cases where there is sufficient time for the diagnosis of plant conditions and the determination and implementation of operator actions.

The design of the control room incorporated a strategic placement of the instrumentation and controls used in safety related operations and in accident management. Specific attention was provided to device grouping, layout, labelling and annunciation. Appropriate attention to human factors and man-machine interface concerns ensured that the information available in the control room is sufficient for the diagnosis of anticipated events or transients and for the assessment of the effects of any actions taken by the plant operators.

Most of the information related to the Nuclear Steam Plant (NSP) status and part of the Balance of Plant (BOP) side is provided to the operator via the two station control computers (DCCs). The BOP and Common Systems control and monitoring is achieved by a DCS (Distributed Control System) and the relevant alarms or control signals important for the safety of the plant are transferred from the DCS to the DCCs.

The functions of the Control Computer System are:

- Control / Monitoring;
- Alarm / Annunciation;
- Display / Data Recording.

The information important for the safety of the plant must remain available to the operators at all times so that they won’t exclusively count on the control computers. Normal parameter limits exceeding and abnormal states of the equipment are annunciated to the MCR operator. Alarm windows located on the different MCR panels work simultaneously with the alarm messages given by the control computer system.

The operator in MCR is provided with all necessary information that allows a safe control of the plant for all operation modes, including for the cases when the dual computer system is lost and only conventional control devices remain available. In case of dual control computer system unavailability, the alarm windows become the sole source of annunciation. However, these are required for monitoring the safe shutdown of the plant, as fast shutdown is actuated in the event of dual control computer failure.

A Secondary Control Area (SCA) enables the operator to take all the necessary measures for maintaining the plant in a safe shutdown condition for the events in which the MCR would become unavailable.

The environmental conditions in the MCR are equivalent with those for an office. A radiation monitor is in place to prevent access contaminated personnel and equipment to the MCR area. In addition to these standard conditions, in order to maintain and extend them in case of emergency, functional isolation was provided to ensure MCR operating capability.

The access route from the MCR to the SCA, and related areas to which the operator must have access, are adequately qualified to be maintained for events causing the MCR to become unavailable. The systems that provide working/habitability conditions in SCA are designed to ensure adequate protection to the operator when he is in the SCA, against accidental radioactive releases. SCA is provided with ventilation/ air conditioning system, seismically qualified and independent from the other ventilation/air conditioning systems of the plant. Working/habitability conditions are maintained by conventional strainers, radiation shielding, portable equipment for monitoring the radiation level and portable breathing equipment, smoke and fire detectors, drinkable water and first aid equipment.

More detailed information on how the human factors are taken into account in the design is provided under Article 18.

### 12.5 Procedural aspects

The development of procedures considers both the correctness of the technical information provided, and the format in which the information needs to be organised and presented to the user in order to ensure a clear understanding and to minimise the potential for errors.

Technical aspects were built in the initial operating procedures, whereas the format was changed following INPO standards. Changes to the operating procedures are allowed respecting the rules established through station procedures and providing that the proposed change would have no appreciable impact on the validity of the documents supporting the operating license.

The types of procedures used for plant operation consist of Operating Manuals, Operating Manual Tests, Operating Instructions, Abnormal Plant Operating Procedures and other applicable procedures which describe different station activities associated with plant operation. The above procedures state the responsibilities, authorities, and the necessary steps to develop the operating documentation including methods for use.

Operating procedures (for both normal and abnormal conditions) and maintenance procedures provide detailed instructions for the completion of assigned tasks. The availability of accurate and clear information in the procedures minimises the possibility for human error and supports the man-machine interfaces.

Controls in the main and secondary control rooms, and the associated Control Equipment Rooms, are only operated by, or under the direction of, authorised personnel, in accordance with the approved station procedures, distributed in accordance with the procedure for the control of documents and marked-up as Master copies. Effective use of communication protocols (3-way communications, phonetic alphabet) and operating personnel's familiarisation with the operation of systems and the location of the system controls minimises the chances of human errors.

The training and qualification programmes, as well as the mentoring and coaching programmes, ensure that the field operators can easily ascertain the status of an individual plant systems or equipment and perform the necessary tasks, in accordance with the approved procedures and work plans. System alignment verifications and post-maintenance testing are routinely performed to detect and correct human errors that may occur during system manipulation or maintenance.

Any work to be performed within the station is assessed and a work package is prepared. Based on station processes related to work evaluation, all information existing in the station OPEX database are reviewed and, as appropriate any concern or errors related to work practices or human errors are addressed within the work package and in pre-job briefing in order to avoid their recurrence. Also for human error that reset Error Free Day clock, a specific “just in time” material is prepared for the involved groups in order to avoid future occurrence of the same issue.

Any modifications to the plant SSCs, including to plant documentation, are done in accordance with written approved procedures which describe in detail the change control process. In order to ensure that all aspects related to safety, quality, environment, finances, etc. are taken into consideration when evaluating a modification, a control checklist is used for screening all requirements to be addressed. Factors directly linked to human performance and man-machine interface are included in the modification control review screen. Criteria are specified for classifying the modifications, and the potential for affecting human factors leads to the classification of a proposed modification as “major”, to ensure that comprehensive assessments are performed and that all the applicable requirements are met for all the stages of the implementation. Modifications classified as “major” are also submitted to CNCAN for review and approval.

Further information on the different categories of procedures is provided under Article 19.

## 12.6 Shift staffing

As required by the Law, the specific regulations and the licence conditions, the nuclear power station must have on duty sufficient qualified operating staff at all times, to ensure that the station, whether running or in shutdown, is operated in a safe and reliable manner.

Shift staffing is defined by a Station Instruction which specifies the process of managing the activities of the operating shift crews (including responsibilities of the operators and maintenance shift personnel) and also specifies the number of persons required to be at station and their responsibilities to cover different situations. The various members of the shift crew shall have, besides their normal duties, responsibilities for responding to various abnormal events such as fire, personnel injury, etc. The shift personnel receive special training as required for these additional duties.

Shift staffing has been reassessed and revalidated in the period 2015 – 2016, based on new regulatory requirements issued after the Fukushima accident. An external company was hired to evaluate the ability of the minimum shift complement to respond to design basis and beyond design basis events. The shift staffing was tested for highly resource-intensive bounding scenarios. These exercises were used for the revalidation of the shift staffing as well as for identifying improvements with regard to resources allocation on shift.

Besides the shift personnel, an “on-call” list is at all time available for the Shift Supervisor. The list includes both the personnel nominated for technical and administrative problems, and member of the Command Unit for Emergency Situations (unit / site / general emergency).

### 12.7 Fitness for duty

Cernavoda NPP has regulations and station procedures which describe the fitness for duty policy and principles for all personnel. Fit-for-Duty definition involve workers reporting at work without being under influence of illegal drugs, or under influence of medical drugs that may affect their ability to focus and to perform duties as per job-description. Also, Fit-for-Duty involves workers being in good physical condition.

All NPP employees must be medically and psychologically examined according to the safety and health management system (as part of the integrated management system) and Human Resources station instructions. The main procedures setting requirements on the fitness for duty are as following:

- “SNN personnel code of conduct” (corporate level document)
- Station Instruction “Site access control”
- Departmental “Code of Conduct” documents
- “Shift Turnover” procedure

These procedures and instructions contain responsibilities for:

Employees, who have the obligation to:

- manage their health in a manner that allows them to safely perform their job responsibilities.
- come to work fit for duty (without being under the influence of any substance such as drugs or alcohol) and perform their duties of the job in a safe, secure, productive, and effective manner during the entire time they are working
- notify their supervisors when they are not fit for duty and when they observe a co-worker acting in a manner that indicates the he or she may be unfit for duty.

Managers, who have the obligation to:

- observe the attendance, performance, and behaviour of the employees under their supervision.
- follow the specific plant procedures when an unusual behaviour is identified.

The compliance with the rules of the fitness for duty, as mentioned above, starts from the hiring process when the medical records, criminal records and psychological profiles are verified. During the employment period, periodical mandatory medical and psychological checks are performed with for the entire personnel. Same rules are applied for contactors. For workers with rheumatologic issues, Cernavoda NPP developed a special health recovery programme. Also, as per International Health Organisation recommendation, an influenza prevention programme was implemented. This programme has a vaccination component and a medical assessment at the beginning of each working day.

Preventive random checks for alcohol and drug intoxication are carried out as per station instruction “Site Access Control”. Annual evaluation of personnel performance is performed as per station instruction “Staffing and Staff Development”.

Regulatory requirements on fitness for duty, with focus on the control room operators, are stated in the “Regulation on granting practice permits to operating, management and specific training personnel of Nuclear Power Plants, Research Reactors and other Nuclear Installations”.

### 12.8 The Role of the Regulatory Authority Regarding Human Performance Issues

One of the roles of CNCAN is to ensure that the licence holder adequately includes human factors in the design, assessment and operation of nuclear facilities. This role is accomplished by directly interacting with the licence holder in activities related to design (including design changes) and modifications to procedures and processes. This is done through the normal process for review and assessment of safety documentation submitted by the licence holder or applicant for a licence, as well as through the regulatory audits and inspections.

The regulatory oversight exercised by CNCAN in the area of human and organizational factors covers the following:

- Human factors in design – consideration of human factors in design is reviewed as part of the regulatory assessment of design modifications for the existing nuclear installations (or as part of the regulatory assessment of the overall design, in case of a new reactor);
- Human factors in safety analyses – considerations of human performance are reviewed as part of the regulatory assessment of deterministic and probabilistic safety analysis i.e. as regards:
    - the assumptions made in the analyses regarding human actions,
    - the time when they are performed,
    - the probability of human error,
    - the conditions in which the actions are to be performed,
    - the “habitability” analyses, etc.
- Human factors in procedures - procedures for normal operation as well as emergency operating procedures are subject to regulatory review and human factors considerations are part of the assessment e.g.:
    - format and style of the procedures,
    - place keeping,
    - compatibility with the number of staff and the environment in which they are to be used,
    - validation of operation and maintenance procedures,
    - validation of emergency operating procedures, including feasibility of various actions in different locations – Main Control Room, Secondary Control Area, local panels, etc., validation of minimum shift complement,
    - legibility of printed procedures, etc.
- Operational performance - human performance considerations are reviewed as part of the following activities:
    - the examination of control room and shift supervisors on the full-scope simulator, for licensing purposes;

  - the interview of plant managers, for licensing purposes;
  - the analysis of significant events which have human factors as a contributing cause;
  - the observation of various activities of the operating staff, such as shift-turnover, performance of testing and maintenance activities, training activities;
  - the assessment of training and qualification programs and procedures;
  - the assessment and inspection of human resources management (staffing, selection and recruitment, promotion, succession planning);
  - the assessment of organizational changes planning and implementation;
  - the implementation of fitness-for-duty.

- Emergency planning and preparedness - considerations of human factors are reviewed as part of the regulatory assessment and inspection of emergency response plans, procedures and arrangements; this includes:
  - use of lessons learned from major nuclear and industrial accidents to improve emergency arrangements;
  - observation activities during emergency response exercises;
  - use of experience from exercises to improve emergency response plans and procedures and emergency preparedness training.

- Organizational structure and staffing of the licensee – the regulatory reviews focus on:
  - the assessment of the staffing needs;
  - the procedures for recruitment and for training and qualification of staff;
  - licensees' self-assessments on the sufficiency and adequacy of the staffing; succession planning is also reviewed;
  - changes to the organizational structure or resources require regulatory approval before implementation and monitoring after the implementation.

- Management system and its processes – the management system manuals and procedures of the licensees, their management, core and support processes are reviewed, audited and inspected by CNCAN; the reviews cover the self-assessment and independent assessment processes, the use of operational experience feedback and the management of non-conformances and corrective actions.

- Safety conscious work environment – in 2015, CNCAN has issued explicit regulatory requirements on the licensees' obligation to encourage staff to report concerns without fear of repercussions/retaliation, to resolve such concerns and to provide feedback to the staff that raised the issues.

- Implementation of the nuclear safety policy – in 2015, CNCAN has issued explicit regulatory requirements on the establishment, communication, display and implementation of the nuclear safety policy.

- Implementation of the internal independent nuclear safety oversight – in 2015, CNCAN has issued new requirements on the independent nuclear safety oversight within licensees' organization ("internal regulator").

- Nuclear safety culture – the regulatory oversight of safety culture has been formalized in a Safety Culture Oversight Process (SCOP), with detailed guidance for the assessors and inspectors, based on the 37 safety culture attributes in the IAEA safety guides.

## 12.9 Summary of significant developments in the area of Human Performance

The importance of the human performance in ensuring safe operation of a nuclear power plant is recognised by both the licence holder and CNCAN. While the importance of human factors for the design is considered as vital, the focus has been lately shifting towards the human performance issues associated with the construction, the commissioning and the operation stages.

Efforts are made to continuously enhance human performance, by means of:

- developing and improving the mechanisms by which the human errors can be detected, analysed and corrected;
- developing and enhancing the training programs to effectively incorporate the operating experience feedback;
- develop and enhance means to correctly evaluate human performance.

Notable progress has been made with regard to the development of the Human Performance Programme for Cernavoda NPP, which started in 2004 as a pilot project in the Production Department (Operations, Maintenance, Chemistry and Fuel Handling) of Unit 1 and has been subsequently extended to all plant departments and permanent contractors.

Cernavoda has extended the HU program to include EFTs for Engineering and Technical staff and a specific training course has been developed and delivered.

The adherence to the O&C (Observation and Coaching) programme has been very strong by staff and supervision resulting in staff being more receptive to coaching. The quality of the O&C reports has also been improving as evidenced by station and department indicators. To record the positive aspects or the improvements identified, a new web-based application for production activities was developed to help improve the O&C quality and the trend analysis, to include “paired observations”, “coach the coach”, “What It Looks Like” observation sheets or scheduled observations for operation and maintenance personnel. A new application for engineering O&C was developed, to help technical staff record the O&C using specific Error Prevention Techniques for engineering activities.

Cernavoda has also continuously improved the communication of HU aspects which includes monthly bulletins, intranet site, HU booklets for staff and contractors. Also prior to the annual outages there is an increased focus on the need to reinforce EFTs and O&C during the execution of the work. Rapid trending and increased reporting is implemented during such periods of high activity.

The human performance training courses (classroom, practical training courses and Dynamic Learning Activities) have been extended with new courses, especially regarding practical human performance skills, in order to train plant personnel on human performance best practices and Event Free Tools.

Shift staffing has been reassessed and revalidated in the period 2015 – 2016, based on new regulatory requirements issued after the Fukushima accident.

The developments in the area of personnel training, reported under Article 11, are also a significant contributor to the improvement of human performance.

## ARTICLE 13 - QUALITY ASSURANCE

*Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.*

### 13.1 Legislative and Regulatory Provisions

The Romanian legislative and regulatory framework relevant to quality assurance for activities related to nuclear installations has been subject to continuous development since 1982, when the law regarding Quality Assurance for Nuclear Installations (Law 6/1982) was issued under the directions of the former State Committee for Nuclear Energy (CSEN). The Law No. 6/1982 was abrogated when the Law 111/1996 came into force.

As required by the Law, any organisation deploying activities important to nuclear safety shall establish Quality Management Systems (QMS) and shall submit an application to CNCAN for obtaining the relevant licence.

In accordance with the provisions of article 24 of the Law, the QMS in the nuclear field for the design, siting, procurement, construction, installation, commissioning, operation, decommissioning or conservation phases of a nuclear installation are subject to licensing.

The licences are granted by CNCAN in accordance with the provisions of the Law and the Romanian regulations on QMS. The conditions that the applicant has to meet in order to obtain a licence, as stated in the law, are:

a) to demonstrate the professional qualification, for all job positions, of its own personnel, the personnel's knowledge of the nuclear safety requirements, as well as the probity of the personnel that have authority for decision making in managing the activities to be performed under the licence;
b) to ensure that its own personnel involved in the activities to be performed under the licence has the necessary knowledge and awareness of the impact that the deviations from the quality standards and specifications for the products and services supplied to nuclear installations would have with regard to nuclear safety;
c) to establish and maintain a controlled quality management system in its own activities, and to ensure that its suppliers of products and services, as well as their sub-contractors along the whole chain, establish and maintain controlled quality management systems.

All the above mentioned licensing conditions are further detailed and supplemented with specific requirements established through the set of regulations on QMS. The current Romanian regulations on QMS for nuclear installations and activities have been developed by CNCAN based on the Canadian Standards series N286 ed. 95 and Z299 ed. 85, ISO 9000/2000, IAEA 50-C/Q SG and the drafts of GS-R-3 and GS-G-3.1 (DS-338 and DS-339 from 2003).

The list of QMS regulations is given as follows:
1. Licensing of the quality management systems applied to the construction, operation and decommissioning of nuclear installations (NMC-01);
2. General requirements for quality management systems applied to the construction, operation and decommissioning of nuclear installations (NMC-02);

3. Specific requirements for the quality management systems applied to the evaluation and selection of the sites for nuclear installations (NMC-03);
4. Specific requirements for the quality management systems applied to the research and development activities in nuclear field (NMC-04);
5. Specific requirements for the quality management systems applied to the design of nuclear installations (NMC-05);
6. Specific requirements for the quality management systems applied to procurement activities for nuclear installations (NMC-06);
7. Specific requirements for the quality management systems applied to the manufacturing of products and the supply of services for nuclear installations (NMC-07);
8. Specific requirements for the quality management systems applied to the construction and assembling activities for nuclear installations (NMC-08);
9. Specific requirements for the quality management systems applied to commissioning activities for nuclear installations (NMC-09);
10. Specific requirements for the quality management systems applied to the operation of nuclear installations (NMC-10);
11. Specific requirements for the quality management systems applied to the decommissioning activities for nuclear installations (NMC-11);
12. Specific requirements for the quality management systems applied to the activities of producing and using software for research, design, analyses and calculations for nuclear installations (NMC-12);
13. Requirements for the establishment of classes for the graded application of the quality management system requirements for manufacturing of products and supply of services for nuclear installations (NMC-13).

The QMS of each participant in a nuclear project (owners, operators, contractors, suppliers, etc.) are developed and implemented in accordance with the provisions of the above mentioned regulations, providing an adequate framework to ensure that all activities important to nuclear safety are properly managed throughout the life of a nuclear installation.

CNCAN has prepared and is planning to issue a revised set of regulations to align the requirements on management systems in the nuclear field to the latest IAEA Safety Standards. Until the new regulatory documents are issued, the provisions of the regulations on QMS are in force and considered to be applicable also in the context of the integration of the management systems.

### 13.2 Development of the integrated Management System for Cernavoda NPP

In accordance with the Law, the provisions of the regulations on QMS for nuclear installations (NMC series issued by CNCAN), the licence conditions and the requirements of the SNN Quality Management Manual, Cernavoda NPP has established a Management System which integrates the requirements of regulations and standards applicable to nuclear and conventional industry, regarding nuclear safety, radiological protection, quality assurance, environment management, health and personal safety, physical protection and safeguards.

The integrated Management System currently in place builds upon the Quality Management System implemented in accordance with the CNCAN regulations and is aligned to the GS-R-3 standard issued by the IAEA.

The latest revision of the Cernavoda NPP’s Integrated Management Manual (IMM) has been issued in 2015 and has been approved by CNCAN. The structure of the document is mainly based on the IAEA GS-R3 and includes specific chapters to cover the requirements of the ISO 14001, ISO 17025 and OHSAS 18001 standards. The IMM describes the Management System applicable for the operation of Cernavoda NPP, and includes policies, principles and processes through which the organisation's mission and objectives are achieved.

### 13.3 Management Responsibility

To ensure the fulfilment of its mission to operate Cernavoda NPP in a safe and efficient manner, the licensee has established and implemented clear policies, in compliance with all the requirements deriving from the applicable laws, regulations, standards and other specific written requirements and dispositions issued by CNCAN.

All the organisation policies in the field of nuclear safety, quality, environment, personnel health and safety are communicated to the personnel by training programmes (initial and periodic knowledge refreshing) and by posting at working places.

The strategic plan of Cernavoda NPP is established for 5-year periods, with clear objectives in line with the station policies. Specific procedures have been developed describing how the strategic plan, goals and objectives are established and periodically re-assessed in order to ensure that the organisation policy is adequately understood and implemented.

Management at all levels is responsible for the implementation of the Management System requirements. Senior management (the Site Manager) is ultimately responsible for the effective implementation of the management system requirements. Management expectations are clearly stated and supported by a comprehensive observation programme which involves all managers and supervisors.

An independent Department for Developing and Monitoring Management Systems reporting to the Site Manager, is established and appropriately staffed for developing and monitoring the implementation of the Management System.

All documents developed under the Management System specify the management responsibilities related to the allocation of resources for the implementation and supervision of the addressed activities.

In order to ensure that adequate resources (human, financial, material, etc.) are allocated to implement and continuously improve the Management System, all station activities are grouped in basic and improvement programmes. Each basic or improvement programme is developed based on specific procedures and has a predefined structure. For each programme an owner is assigned, who has the responsibility to establish the necessary human and material resources for implementation. Each programme has a budget allocated, and the budget consumption is periodically reviewed and reported to the management level.

The amount of resources necessary to perform the activities of the organisation and to establish, implement, assess and continually improve the management system is determined and provided by the senior management of the licence holder, based on the assumptions made and needs identified by the programmes' owners. The general information on the management of resources has been provided under Article 11.

## 13.4 Graded application of the Management System requirements

A graded approach is used for the implementation of the management system requirements, in accordance with the regulatory provisions which state that grading shall be reflected in:

a) the managerial level giving the approvals;
b) the extent of the managerial assessment;
c) the level of detailing and review of documents;
d) the extent and type of verifications;
e) the frequency and depth of audits;
f) the extent of surveillance;
g) the extent of requested corrective actions;
h) the extent of the records kept;
i) the type and content of personnel training / qualification requirements;
j) the extent of material traceability requirements;
k) establishing requirements for the records to be issued and for those to be kept for the entire lifetime of the nuclear installation;
l) the level of using independent verifications;
m) the degree of detailing of the process of identification, disposal and solving of non-conformances.

The regulations NMC-02 and NMC-13 contain detailed provisions for the establishment of quality classes for the graded application of the quality management system requirements, to ensure a consistent approach to grading for both the NPP and the suppliers of products and services.

In accordance with the regulatory provisions in force, nuclear safety significance (reflected in the safety class) is the first of the factors contributing to the assignment of the classes for graded application. Other factors taken into account include the complexity of the design and the difficulty in validating it; the complexity and difficulty of the execution process, the uniqueness or recentness of the product, service or process; the necessity of special processes, methods or equipment for verification or inspections; the difficulty of testing the functionality by inspections or testing after installation, necessity for personnel special training, economical considerations.

The graded approach is reflected in the procedures describing the different station processes. As an example, for the procurement processes a specific procedure is in place ("Graded Application of the Management System Requirements"), which describes the methodology for establishing the quality classes (four classes) for purchasing products and services. In accordance with the methodology given in the above mentioned procedure, for each product or activity a grade is assigned to each factor and a final score is then calculated, based on which the class is assigned. The contributing factors are of different weights, the nuclear safety significance being the most important.

Another example of grading is presented in the Corrective Action Process procedure, where the level of approval for closure is established based on the importance of the addressed issue. For example, if the addressed issue is a regulatory body concern, approval for closure is given by the Site Manager, while for an issue such as an improvement requirement the level of approval for closure can be limited to that of the direct superintendent/manager responsible.

## 13.5 Process Implementation

### 13.5.1 Transition to Management by Process

The transition from the old concept of managing activities to the new approach based on processes is being done gradually for Cernavoda NPP. As a general rule, all the activities needed for / associated with the achievement of a certain outcome are constituted in a process and are accordingly planned and assessed to ensure that the expected results are obtained.

The hierarchical structure of Management System documentation is shown in Fig. 13.1. As observed from the figure, the documents defining processes are considered second tier documents, presenting a general description of the principles and structure of the process.

The list of Cernavoda NPP processes, grouped into three main categories, is given in Fig. 13.2, for exemplification. It should be noted that the list of processes is not frozen, new processes being introduced as the need arises. Most processes identified have already been defined (i.e. documented), while some are still under development, with the documentation in different stages of completion.

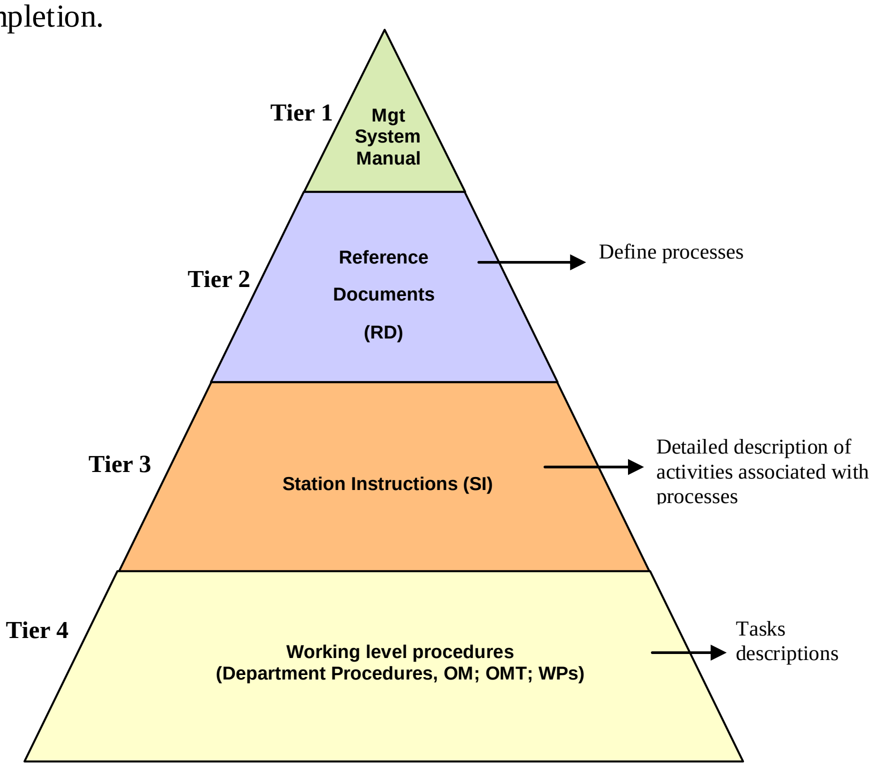



**Fig. 13.1 - Structure of Management System documentation for Cernavoda NPP**

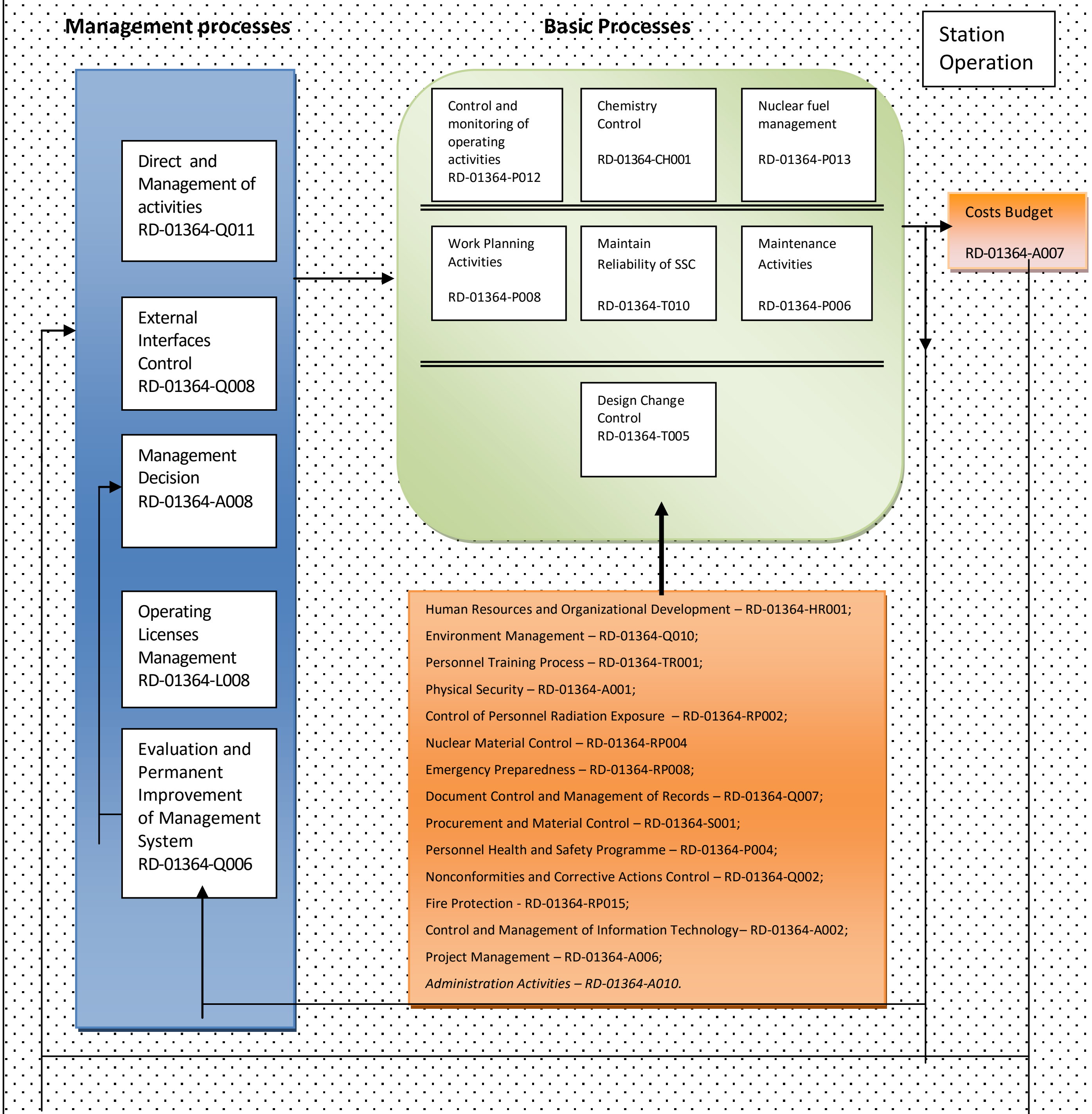



**Fig. 13.2 Processes Map for Cernavoda NPP**

### 13.5.2 Process ownership

For each process an individual is assigned as process owner, having the following responsibilities:

- establishing the process boundaries;
- developing the process diagram / flowchart;
- identifying the documentation that describes the activities within the process, evaluate it for completeness, ensure that it adequately reflects the process and maintain it up to date;
- identifying the interfaces with other processes;
- ensuring that the process meets all the applicable requirements and that it reflects the objectives of the station;
- establishing performance indicators for the process and for monitoring its efficiency;
- reporting on the performance of the process and promoting its improvement.

Clear procedures are established that define the individual responsibilities of those involved in the development, implementation and supervision of the activities and processes in such a manner that any conflict between responsibility and authority is avoided and that no undue delays in the performance of the work are introduced.

When outsourcing is used for activities within the station, the contractor personnel are working under the direct supervision and control of plant staff and the activities are performed using station procedures and respecting the rules established by these procedures.

The operating organisation retains overall responsibility when contracting any activity. Also specific training is provided for permanent contractors on site, similar with the training provided for plant personnel.

### 13.5.3 Generic Management System Processes

**Control of documents and records**

This process has been categorised as a support process and is defined in the procedure “Documents Control and Management of Records”. The procedure describes the main steps of the process including: necessity for documentation, categories of documents, responsibilities of persons involved in the preparation, review and approval, revision process, review for the applicability, distribution process, etc.

Each station procedure includes, in the section establishing the responsibilities of the involved personnel, also the requirements and specifications necessary to ensure an effective control of the various documents associated with the respective process or activity. Requirements and specifications regarding the records to be kept are also included as a distinct section in each station procedure.

**Communication**

Adequate means and interfaces are established for ensuring effective communication at all levels within the operating organisation and also with the external organisations. The general requirements and responsibilities for communication are specified in the IMM and further detailed in each procedure, as integral component of each process and activity.

## Purchasing

Prior selection of suppliers, the utility performs an initial evaluation for determining the capability of suppliers according to their management systems provisions. Suppliers are periodically audited to assess the level of proficiency in the area of interest. The frequency of the audits is determined by factors such as safety significance of the work and the performance records of the supplier.

The external audits/evaluation are performed:

- every 3 years in order to verify the capability of the supplier to provide goods and services according to the owner requirements;
- every time when significant changes of the management systems provisions of the suppliers are announced, such as reorganisation or major revisions of the procedures;
- Every time when a recurrent deficiency is identified in the products supplied by the subcontractors, etc.

At the beginning of each year, a plan for auditing the suppliers/contractors is elaborated by Cernavoda NPP, endorsed by SNN and submitted for approval to CNCAN. Personnel involved in the auditing of external organisations/contractors/suppliers are usually ISO certified.

The responsibilities for procurement activities are described in a set of appropriate procedures describing the procurement process, including identification of the need for purchasing, establishment of procurement requirements, selection of the supplier (including supplier evaluation), request for quotation, placing the purchase order, surveillance activities, verifications/inspections upon reception, etc.

Any activity dedicated to a safety related system, which is performed by contractors is based on Inspection and Test Plans approved by Station manager and Regulatory Body. Hold/Witness points are established and their surveillance is performed by the station personnel during work performance. E.g. The fuel bundles manufacturing process is periodically inspected, according to an agreed Inspection and Test Plan. In accordance with the Inspection and Test Plan, some bundles are inspected by the purchaser inspectors.

## Control of products

The products are the results of processes/activities. In some cases, in order to realise a product, input from different processes is considered. The quality of a product depends on the input data, on the knowledge and qualification of those using the input data in transforming them in output data, on the verification provided in order to ensure that the final results of an activity achieve the desired results, etc. Cernavoda NPP develops a comprehensive system to ensure that all the activities and resources involved in realising a certain result (product) are adequately managed. This includes the following aspects:

- processes, activities and tasks are well defined (documented in administrative and working level procedures);
- requirements for human resources are specified (type of qualification for persons involved, skills, communication, etc. are described in detail in the applicable procedures);
- material and financial resources are identified and provided (the evaluation process of each activity is documented, ensuring that all is started only after all facilities, tools,

spare parts, etc. have been provided);
- work performance risks associated is controlled and minimised (all activities are appropriately assessed and all work performing associated risks are identified, documented and adequate protection is provided e.g. protection equipment, isolating devices, pre-job briefing, fire protection measures, etc.);
- acceptance criteria for results is established (for each activity or task, the target and the measurable values of the target are specified in the applicable procedures);
- the verifications required are defined (as appropriate, the type of verification, the methods of verification and validation of the results are specified in the procedure describing the work);
- the responsibilities for carrying out the execution, control and supervision of the work are defined (where applicable through step by step working level procedures documenting all these responsibilities, including responsibilities at interface);
- testing requirements are specified, as appropriate, for the validation of the results (testing requirements are usually provided in working level procedures);
- the necessity for records is specified (the values of the results are usually recorded in order to be used for demonstrating that desired results were achieved or for further use, for comparison, when similar activities or tasks are performed).

Since 2008, CNE Cernavoda is part of two international organisations CANPAC (CANDU Procurement Audit Committee) and NUPIC (Nuclear Procurement Issues Committee) aiming to create and use a common data base of accepted CANDU reactor suppliers for the benefits of the members.

**Management of organisational change**

The management of organisational change is described in the plant procedure “Managing and Leading Change Initiatives”, which establishes the steps to be followed for the planning, control and implementation of the change initiatives, including the provisions for allocation of resources, communication and monitoring.

The scope of the procedure is to provide the framework for the management of change initiatives such as:
- those that would result in significant changes to the Station Programmes;
- those that would result in significant changes to Station Processes and would require major revisions to documents;
- those that would affect the Station Organisational Structure (impacting on more than one department), etc.

The responsibilities for review, assessment, approval, ownership of the implementation process, etc. are also stated in the procedure, as well as the criteria for determining the importance of the change. The procedure includes guidelines for preparing the justification for the proposed change, developing the implementation and communication plan, monitoring, reinforcement and review of effectiveness.

## 13.6 Measurement, Assessment and Improvement

Several mechanisms are used to review the effectiveness of the Management System established and implemented at Cernavoda NPP and its continuous improvement.

The Management System evaluation process is defined in the procedure “Evaluation processes within Cernavoda NPP”. In accordance with this procedure, three types of evaluation are used:
- Independent Assessments (audits, surveillance activities, external audits performed by different organizations e.g. SNN Audits, CNCAN audits, IAEA OSART Missions, WANO Peer Reviews, etc.);
- Self – Assessment;
- Management Reviews (Annual Management System Review, PSOC, etc.).

### 13.6.1 Monitoring and Measurement

For each programme/process, appropriate performance indicators are established, which are periodically reviewed (monthly, quarterly, biannually or annually) and their results and trends are reported to the management. A colour code is allocated to each indicator and qualitative interpretation of the performance can be made. For indicators which have recorded a low value (e.g. yellow or red colour), assessments are performed to identify the causes and corrective actions are established aimed at improving the performance of the respective activity.

### 13.6.2 Self - assessment

Cernavoda NPP has established and implemented a self-assessment process for continuously evaluating the performance of the systems and processes of the plant. The criteria used in evaluating the performance have been established for each area of activity, based on WANO and OSART guides and standards, as well as on the internal procedures of the station.

Self-assessments are periodically conducted to evaluate the activities and processes and identify opportunities for improvement and optimisation. The actions resulted from these evaluations are included in the Corrective Actions Database.

The means for evaluating the performance of a process in meeting the established objectives and criteria, the responsibilities of the personnel involved in the process, the requirements for reporting of the results from self-assessments and for initiating improvement or corrective actions are described in the procedure “Self-assessment process at Cernavoda NPP”.

### 13.6.3 Independent Assessment

According to the procedure “Evaluation processes within Cernavoda NPP”, the independent assessments are categorised as:
- internal audits;
- external audits;
- peer reviews;
- technical reviews;
- surveillance of activities.

The internal audits are performed based on a plan approved by the Site Manager, accepted by SNN and approved by CNCAN. The planning of the internal audit activities is done in accordance with the station procedure for internal audits and inspections of the management system. The personnel of the audit team is qualified in accordance with the applicable regulations and standards and is not involved in any of the activities being assessed. As appropriate, specialists from different areas are involved in the audit teams in order to increase the efficiency of the audit. Specialists included in the audit team do not have any responsibilities involvement in the work performed in the audited areas. The leaders of the audit team are certified auditors.

Examples of areas subject to internal audits:
- the performances of the safety related structures, systems, equipment, components and software;
- the performance of the maintenance activities;
- the condition of the safety related SSCs and the implementation of the programmes for testing and inspections;
- the development, review, use and updating of the management system documentation;
- the implementation of nuclear safety requirements and the safety culture;
- the activities related to personnel training;
- the implementation of the corrective actions and their efficiency.

The audits established through annual plans are supplemented, as necessary, for situations when there is a concern with regard to the quality of the results of a process/activity or to their efficiency, or when significant changes have been introduced in station processes.

A report is produced as a result of every internal audit and submitted for approval to plant management. The corrective and preventive actions or recommendations in the audit reports are introduced in the Corrective Actions Database and monitored through the Corrective Actions Process for the station. The internal audit reports are also made available to SNN and to CNCAN within two weeks from the completion of the audit.

The external audits are conducted at Cernavoda NPP by SNN Quality Management Department, by the regulatory authorities or by certification bodies. This category includes audits performed by CNCAN.

The peer reviews are conducted on specific areas by groups of internal or external experts, with the aim of identifying improvement opportunities and of promoting good practices. This category includes also the review missions by international organisations.

The technical reviews are independent assessments requested by the management. Their scope is to evaluate certain technical aspects of a process or activity, with focus on the identification of means for improvement. This type of reviews is described in the procedure “Information Reports”.

The surveillance of the activities is considered as the most suitable evaluation technique, being more flexible and requiring a lesser degree of formalism than the audits. It provides immediate feedback and detailed information on a specific activity or area of activities, being also used to monitor the implementation of observations/recommendations previously made.

### 13.6.4 Management System Review

A process for periodic review of the MS by management is established and implemented, in accordance with the approved procedure “Evaluation processes within Cernavoda NPP”. The review takes in consideration the results of the audits, self-assessments, etc., and is oriented to find opportunities for improvements of the system. As a rule, the review is performed annually, although supplementary reviews can be performed after new processes are introduced, or in case that the efficiency in the implementation of the management system requirements is below expectations, in order to identify causes and initiate timely corrective actions.

The review includes aspects related to:

- the adequacy of the management system documentation for each area of activity;
- the fulfilment of the tasks having impact on safety related SSCs;
- the conformity with the licence conditions and regulatory requirements;
- the fulfilment of the objectives and standards for training;
- the fulfilment of the objectives and standards for maintenance;
- the conformity with procurement standards for replacement of materials and components;
- the use of operating experience feedback;
- organisational issues such as levels of authority and responsibilities, internal and external interfaces, communication, etc.

For all the areas of activity, the review is focused on identifying results that fall short of the expectations and causes that contribute to and determine these results, and on establishing measures to correct deficiencies and improve performance.

The periodic review of management system efficiency does not substitute the normal processes for identifying and correcting deficiencies and is not intended to be used for performing detailed technical assessments or for the general evaluation of plant administration. Such processes are performed separately and provide input to the periodic review of the management system.

### 13.6.5 Non-conformances and corrective and preventive actions

The licensee has established and implemented a process for identification, reporting, analysis and control of materials, parts, or components which do not conform to requirements in order to prevent their inadvertent use or installation. This process include, as appropriate, procedures for identification, documentation, segregation, disposition, and notification. Nonconforming items are reviewed and accepted, rejected, repaired or reworked in accordance with documented procedures.

Corrective/preventive actions are established and implemented in order to ensure that the cause of the abnormal condition is determined and corrective action is taken to preclude repetition or to avoid the occurrence. The corrective/preventive actions are entered for tracking in the Action Tracking database.

For each corrective/preventive action there is a responsible assigned and a deadline for implementation. Clear responsibilities are established for the implementation, monitoring the progress of the work, documenting the respective activities and verifying the efficiency of the corrective/ preventive action to provide assurance that its objectives are met. A non-conformance is closed when the solution is implemented and associated actions closed.

Periodically, the status of open corrective/preventive actions is reported to station management.

### 13.6.6 Improvement

The results from all the evaluations performed, as described in the previous sections, are used to identify opportunities for improvement of the station processes and of the management system as a whole, and to follow up on their implementation. As necessary, specific programmes and projects are established when comprehensive improvement initiatives are undertaken, e.g. for Development of a Component Engineering Process, etc.

## 13.7 Regulatory Activities

According to the current licensing practice, each participant in a nuclear project has to demonstrate to the satisfaction of CNCAN the fulfilment of all the requirements of the applicable QMS regulations.

In the case of Cernavoda NPP, several review mechanisms are used by CNCAN to evaluate compliance with the legislative and regulatory requirements:
- assessment of the Integrated Management Manual and the conduct of comprehensive audits and inspections prior to granting the licence for the respective phase of the nuclear installation;
- review and approval of the Management Manuals and a range of documents referenced in Management System Manual;
- evaluation and licensing of the personnel with major responsibilities in the establishment and development the Management Systems;
- the review of the arrangements for the quality assurance included in Chapter 17 of the Safety Analysis Report (PSAR or FSAR, depending on the stage in the lifetime of the installation);
- periodic audits, supplemented by inspections, to verify compliance with the licensing conditions and the arrangements made to ensure the continuous improvement of the management system;
- audits and inspections for verifying licensee’s arrangements for the contracted work;
- audits and inspections at the various suppliers of products and services for the nuclear installation, and at their sub-contractors, to verify compliance with the conditions of their respective licences and with the provisions of the applicable regulations.

Regarding the Romanian practice of licensing contractors, there are currently over 100 companies that are licensed or authorised by CNCAN. If the items/services provided by a subcontractor are to be used for equipment / systems classified as safety-related, then the subcontractor shall be licensed/authorised by CNCAN. As appropriate, periodic audits are performed in order to check if the licensed/authorised suppliers and subcontractors maintain their capabilities and continue to meet the requirements of the applicable regulations. This approach should not be considered as having the potential for diminishing the licensee’s responsibility, as it only constitutes an additional mechanism to provide confidence that the specified requirements for all activities important to nuclear safety are satisfied. It should be noted that the QMS are licensed by CNCAN from the point of view of the arrangements for and impact on nuclear safety.

The QMS manuals describing the quality management systems implemented by suppliers and subcontractors have to be submitted to CNCAN for review and approval and a licence/authorisation from CNCAN is needed as a prerequisite for obtaining a contract for supplying products or services for the nuclear power plant. This however is not sufficient, as a supplier having a QMS licensed by CNCAN can still be rejected by the utility if the criteria used for the utility's own evaluation are not met.

Cernavoda NPP performs a comprehensive evaluation of the technical capabilities and of the QMS of any supplier, in accordance with the station procedure defining the procurement/purchasing process. Only the suppliers found acceptable are considered qualified to provide services for the utility. As appropriate, periodic audits are performed in order to check if the accepted suppliers and their subcontractors maintain their capabilities.

For each of the audits and inspections performed, at the NPP or at the various contractors, CNCAN staff produces detailed reports of the audit findings and forwards them to the licence holders of the involved organisations. When deficiencies are observed, the licence holders are notified and required to take corrective actions. Depending on the non-compliances identified, enforcement actions are also taken by CNCAN, in compliance with the provisions of the Law.

### 13.8 Significant developments for the last reporting period

The most important changes since the issuance of the last report are summarised as follows:

- 40% of the processes' procedures of the Cernavoda NPP Integrated Management Systems have been revised;
- Cernavoda NPP's position in NUPIC and CANPAC organisations has been consolidated;
- A new revision of the Integrated Management System Manual (rev.11) aligned to GS-R-3 has been issued by Cernavoda NPP and approved by CNCAN in 2015.
- In December 2014, CNCAN issued modifications / updates to the regulations on quality management system for nuclear installations and activities, to include provisions on the prevention of use of counterfeit, fraudulent and suspect items in systems, structures, components and equipment important for nuclear safety and for nuclear security.

## ARTICLE 14 - ASSESSMENT AND VERIFICATION OF SAFETY

*Each Contracting Party shall take the appropriate steps to ensure that:*

*(i) Comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;*

*(ii) Verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.*

### 14.1 Regulatory requirements on assessment and verification of safety

A general description of the Romanian licensing system for nuclear installations Romania is provided in Article 7, while the more detailed aspects of the licensing process, including safety assessments and verifications, for the different stages of the lifetime of a nuclear power plant are discussed under the Articles 17, 18 and 19.

The regulatory requirements on the assessment and verification of safety are established mainly by the following regulations:

- Nuclear Safety Requirements on Design and Construction of Nuclear Power Plants;
- Requirements on Containment Systems for CANDU NPPs;
- Requirements on Shutdown Systems for CANDU NPPs;
- Requirements on Emergency Core Cooling Systems for CANDU NPPs;
- Requirements on Probabilistic Safety Assessment for nuclear power plants;
- Requirements on Periodic Safety Review for nuclear power plants.

Relevant requirements for assessment and verification of safety, for the different phases of a nuclear installation project, are included also in the set of regulations on Quality Management Systems for nuclear installations (NMC series, presented under Article 13) which contain provisions related to the quality assurance and safety of operation, maintenance, in-service inspection, testing, modifications, etc. The other regulations mentioned under Article 7 also contain requirements for the assessment and verification of safety for specific areas (e.g. fire protection, radiation protection, etc.). As described under Article 7, regulatory requirements are also established based on applicable international standards, codes and guides.

The regulatory requirements also specify the criteria for quality and validation for both analysis and computer codes, in order to ensure adherence to current standards. Tools and methodologies used in the Safety Report have to be proven according to national and international practices, and validated against relevant test data and benchmark solutions. The list of codes used for safety analysis for all CANDU stations (the standard analysis tool set) is defined and maintained by the CANDU Owners Group and SNN, the licence holder for Cernavoda NPP, is a member of this group.

## 14.2 Safety assessments for Cernavoda NPP

### 14.2.1 Background

For the purpose of safety assessment all major systems in CANDU reactors are categorised as "special safety systems", "safety related systems" and "process systems". All special safety systems are independent from all process systems and from each other. The CANDU safety philosophy is based on the concept of single/dual failures. "Single failure" is a failure of any process system which is required for the normal operation of the plant and "dual failure" represents a combination of the single failure events and a simultaneous failure or impairment of one of the special safety systems.

The requirements that shaped the CANDU safety philosophy and design established that a plant shall be designed and operated such that the single failure events and the dual failure events do not exceed a frequency of one per three years and one per three thousand years respectively. The probability for any significant release of radioactivity shall be less than 1E-7/year (for any individual sequence of events). In order to meet these targets, the unavailability of the special safety systems must be 1E-3/year, or less. The existence of two independent fast shutdown systems in CANDU reactors, each with an unavailability of less than 1E-3/year, allows the assumption that at least one will operate when called upon by a process failure. The CANDU design basis safety philosophy does not consider a triple failure, i.e. a coincident process system failure and unavailability of two special safety systems, which has a probability of less than 1E-7/year.

Safety analyses are performed to demonstrate to the regulatory body that dose limits for postulated accidents do not exceed targets and to show that other credible sequences of events would not lead to unacceptable consequences. The safety analyses also set the requirements for the special safety systems (shutdown systems, emergency core cooling system and containment system). For the purpose of the accident analyses, only those events for which the intervention of one or more of the special safety systems is required to prevent fuel failure or the release of radioactive material into the environment are considered. These are referred as serious process failures. Typically, events were grouped according to the process system where single failure is postulated to occur. These include the primary circuit, the steam and feed water system and the fuelling machine.

Coincident failure analysis is a systematic assessment of postulated dual failures. Each postulated process failure is systematically coupled with a failure of one of the special safety systems. Loss of the shutdown systems is excluded from required dual failure sequences because the design includes two independent shutdown systems which are each capable of shutting down the reactor.

A distinguishing feature of dual failure assessment is that the analysis of CANDU 6 reactors must show that:

- coolable core geometry is retained, even if the ECCS were to be impaired;
- radioactive releases are adequately prevented, even if the containment system were to be impaired.

The deterministic approach uses several generic assumptions which are applied in assessing the consequences resulting from the postulated accidents. These include the following:

- Reactor trip occurs at the second trip signal on the less effective shutdown system.

- Intervention by the operator is not credited during the first 15 minutes following the clear and unambiguous indication that an initiating event has occurred and that operator action is required.
- Mitigating automatic action by process system response is not credited.
- Each special safety system is assumed to be in its minimum acceptable configuration.

As part of the compliance with more detailed regulatory guidelines, safety analysis must also prove reactor trip coverage, by demonstrating that there are two diverse trip parameters, wherever practicable, that are detected by the sensing and control logic of each shutdown system for each serious process failure.

The resulting radiation dose for both an individual at the site boundary and the surrounding population are derived for the events in the accidents analysis matrix. These must meet the guidelines which have been established by the regulatory body.

These analyses, together with the assumptions on which they are based, define the analysed state or condition of the plant. As such, they identify the envelope within which the plant must be operated in order to assure consistency with the supporting accident analysis. This can place specific performance requirement in terms of capability and availability on station system, components and instrumentation. In general, these special requirements are translated into operating practice by the Operating Policies and Principles (OP&P) Reference Document, as well as the operating manuals, including the Impairments manual.

Another analytical technique that has been used for CANDU reactors is the Safety Design Matrix, for dealing with matters of interdependency, post-accident operation and actions requiring operator intervention. The safety design matrix contained a combination of fault trees and event trees. In a Safety Design Matrix (SDM), event sequences are developed starting with an initiating event and concluding with a stable plant condition in which an adequate heat sink for fuel cooling exists, or to an acceptable low event frequency. The event frequency is generated from fault trees prepared to identify the frequency of occurrence of different failure modes of a system.

The event sequences address reactor shutdown, both by regulating and shutdown system action, and adequacy of fuel cooling for all post-accident time frames. The assumptions used in the SDMs are not as conservative as those used in deterministic analyses. They also identify operator action over a large time scale and factor in a reliability model for the operator based on the quality of information he receives and stress he is exposed to. As a result, SDMs are a more realistic representation than the deterministic analyses of the consequences to a similar initiating event.

The SDMs originally developed by AECL for Point Lepreau Nuclear Generating Station have been reviewed against Cernavoda NPP Unit 1 design and issued as supporting documents for FSAR Chapter 15. The SDM studies which were developed for Cernavoda NPP Unit 1 are:

1) Containment Operation;
2) Moderator as a Heat Sink;
3) Loss of Shutdown Cooling;
4) Moderator and Shield Cooling System as a Heat Sink;
5) Reactor Building Flooding;
6) Operation Following an Earthquake;

7) Flooding in Turbine and Service Building;
8) Total Loss of Service Water;
9) Inadvertent Addition of Positive Reactivity;
10) Loss of Electrical Power;
11) Small LOCA and ECC Operation;
12) Large LOCA and ECC Operation;
13) Loss of Instrument Air;
14) Loss of Steam Generator as a Heat Sink;
15) Dual Computer Failure.

In conjunction with SDMs, detailed reliability analyses for the most significant safety related systems have been developed. The selected systems are continuously monitored and the reliability analyses yearly updated consequently. The following reliability analyses have been performed:

1) Reliability Analysis for Emergency Core Cooling System;
2) Reliability Analysis for Shutdown System No. 1;
3) Reliability Analysis for Shutdown System No. 2;
4) Reliability Analysis for Containment System;
5) Reliability Analysis for Emergency Power Supply System;
6) Reliability Analysis for Emergency Water Supply;
7) Reliability Analysis for Auxiliary Feedwater System;
8) Reliability Analysis for Reactor Regulating System (Stepback on Neutronic Parameters);
9) Reliability Analysis for Shutdown Cooling System;
10) Reliability Analysis for Class III Standby Diesel Generators;
11) Reliability Analysis for RSW -Backup Cooling Water System.

In addition to the deterministic analyses, Safety Design Matrices and Reliability Studies, probabilistic analyses have also been developed. Following CNCAN requirements, a PSA level 1 for the design was prepared and reviewed by IAEA through an IPERS mission (1995) and subsequently after implementation of the mission recommendations. The results of the design PSA came up with the recommendation to improve the design through a series of design changes that were implemented during commissioning phase.

Information on the deterministic analyses performed for Cernavoda NPP Units 1 and 2 and on the current status of the Safety Analysis Strategic Programme and the PSA Programme is provided in the following sections.

### 14.2.2 Deterministic safety assessments

The deterministic analyses, including the description of initiating events, event sequences, acceptance criteria, methodology, results and interpretation are provided in Chapter 15 of the FSAR.

For Cernavoda NPP Unit 1, the process systems failures analysed include:

- loss of regulation - loss of reactivity control;
- LOCA events (large LOCA and small LOCA);
- single channel events (spontaneous pressure tube rupture, channel flow blockage, end-fitting failure, feeder stagnation break);
- fuelling machine events;

- pipe breaks in HT auxiliary systems;
- loss of off-site power (complete and partial loss of Class IV electrical power, single heat transport pump trip and seizure of a primary heat transport system main pump);
- loss of heat transport system pressure and inventory control (pressurisation events and depressurisation events);
- loss of secondary circuit pressure control (pressurisation and depressurisation events)
- feedwater events (feedwater line breaks outside or inside containment, loss of steam generator feedwater flow);
- steam main breaks outside or inside containment;
- steam generator tube failure
- multiple steam generator tubes failure.

The majority of the above mentioned process systems failures (initiating events) were analysed for the case in which the ECCS and the containment subsystems are available, and also in combination with various failures/impairments to either ECCS or containment subsystems. Feedwater events and steam main breaks were also analysed in combination with loss of Class IV power. Large LOCA and small LOCA events are analysed also in combination with loss of off-site power and with impairments to either ECCS or containment system functions.

In the 2013 revision of FSAR, new categories of initiating events were included: moderator system events, end shield cooling system events, common mode events (design basis earthquake), initiating events originating from shutdown state (loss of normal shutdown state heat sink – shutdown cooling system and design basis earthquake) and severe accident analysis. Also, combinations of steam and feedwater system events with loss of class IV power were supplementary added.

For Cernavoda NPP Unit 2, the analyses provided in the Chapter 15 of the FSAR were grouped in sections dedicated to:

- Heat transport system LOCA events
- Heat transport system non-LOCA
- Steam and feedwater circuit events
- Moderator events
- Shield cooling events

The heat transport system LOCA section consists of large and small break analysis both with and without Class IV electrical power (off-site power). Events that affect a single fuel channel resulting in a small break in the heat transport system are assessed separately. These events are: spontaneous pressure tube rupture, channel blockage leading to channel failure, complete failure of a channel end fitting leading to ejection of fuel from the channel, inlet feeder breaks.

Also included are single and multiple steam generator tube failures. Heat transport non-LOCA events analysed are: complete and partial loss of Class IV electrical power, seizure of a single heat transport pump, loss of reactivity control and loss of heat transport system pressure and inventory control. Steam and feedwater circuit events include steam line breaks inside and outside containment, feedwater line breaks, loss of steam generator feedwater flow and loss of secondary circuit pressure control. Moderator and shield cooling system events include loss of flow, loss of heat sink and loss of inventory.

The initiating events (failures of the process systems) are also analysed in combination with impairments to the emergency core cooling system or to the containment subsystems.

The following events are explicitly analysed with a subsequent loss of Class IV power: large LOCA, small LOCA, steam line breaks and feedwater system events. The analysis of loss of Class IV power for small LOCA is applicable to the analysis of single channel events, which include pressure tube rupture, channel flow blockage, end fitting failure and feeder breaks.

The safety analyses for Unit 2 were based on the guidelines provided in the document "Requirements for the Safety Analysis of CANDU Nuclear Power Plants (C-6, June 1980, issued by AECB). Examples of safety analysis requirements introduced by C-6 that differ from previous practices are given as follows:

- a requirement for a systematic review for the identification of postulated initiating events;
- five event classes, replacing the two categories of single and dual failures;
- correlation of event classes with probability of occurrence and allowable release limit;
- more explicit consideration of combinations of postulated initiating events with failures of mitigating systems (not just the classical dual failures).

A Safety Analysis Strategic Programme was developed by Cernavoda NPP Unit 1 and approved by CNCAN. The main objective of the Safety Analyses Strategic Programme is to get a better definition of the plant safe envelope. Also, the program intended to create and develop a group that will be able to perform and re-evaluate the safety analyses results. The program purpose was to update, based on plant specific models and state of the art computer codes, the entire set of accident analyses included in the Cernavoda Unit 1 Safety Analyses Report. This programme is also aimed at maintaining and developing site capabilities to deal with safety related operational issues and also generic safety issues.

The first step considered in the project was to develop plant specific models, to be used with the last version of the computer codes. As part of this stage, primary circuit and secondary side models have been developed. Specific models for single channel analyses have been developed. Specific models for containment and dose calculation were also developed. As part of this stage there were prepared, verified and approved a number of about 31 internal reports. Each report is focused on the description of the plant systems and components and of the models developed for each of these. The models have been tested with similar conditions and the results have been compared with available results.

After the preparation and approval of all these models, another set of reports have been prepared in order to present the methodology that will be used for safety analyses purposes. For each initiating event that has to be analysed in detail, based on plant specific models, a specific report has been prepared. Once the methodology was prepared and approved, for each of these initiating events, the analysis of the initiating events has been started. A total number of 37 information reports have been prepared, verified and approved.

### 14.2.3 Probabilistic safety assessments

Part of the Cernavoda NPP PSA Programme, the development of Cernavoda NPP Level 1 PSA was completed in June 2007, for Unit 1, respectively in March 2008, for Unit 2. The core damage frequency calculated as part of Level 1 PSA study for Cernavoda includes contributions from Internal Events, Internal Fires, Internal Floods and Seismic Events, for plant full power operation and shutdown states.

The PSA Programme developed for Cernavoda NPP covers the following objectives:

- To assess the level of plant safety and identify the most effective areas for improvements;
- To assess the level of safety and compare it with explicit and implicit standards;
- To assess the level of safety to assist day by day safe plant operation using the Risk Monitor.

The first stage of this programme was the development of Level 1 PSA study for Cernavoda NPP Unit 1, started in September 2000. In September 2003, after the successful completion of a limited scope Internal Events PSA for full power operation, the second stage of the programme started by addressing the impacts of Seismic Events, Internal Fire, Internal Flooding and High-Energy Line Breaks on Cernavoda Unit 1 core damage frequency. Together with the internal events analysed in the first stage of the project, these hazards are considered to be the relevant contributors to the NPP operational risk at full power operation. The second stage was finished in January 2005.

In the period 2000 - 2005, several IAEA IPSART Missions for Cernavoda PSA Project Stage I and Stage II confirmed the validity of methods used and the results obtained from classical state-of-the-art base PSA point of view and provided recommendations to refine some hypotheses in the frame of future use of the model for risk monitoring and other PSA applications.

During 2005 - 2007, the scope of Cernavoda Unit 1 Level 1 PSA was extended considering the events initiated during shutdown operating modes. The CNE Cernavoda Unit 1 PSA model resulted after this stage was used in two directions:

- To identify potentially significant contributors to plant risk from events that occur during shutdown operation;
- To extend the Risk Monitor EOOS of CNE Unit 1 to include shutdown states operation in order to be used for risk evaluation of planned outages.

The detailed study for Level 1 PSA for Cernavoda NPP Unit 2 has been started in 2006 and has been completed with Internal Events (including Fires & Floods) and Seismic Events for all plant operating states in 2008.

In order to support operational decisions with input from probabilistic assessment, Risk Monitor applications are developed based on the plant specific PSA models, providing on-line / off-line users with friendly interface. Cernavoda NPP Risk Monitor computer program for monitoring safety is Equipment Out of Service (EOOS) developed by EPRI, commonly used in nuclear power plants.

For Unit 1, the EOOS Risk Monitor application was developed and implemented in 2006 for full power operation, respectively in 2008 for low power and shutdown states. For Unit 2, the EOOS Risk Monitor application was developed and implemented in 2008 for full power operation, respectively in 2009 for low power and shutdown states.

The Level 2 PSA for Cernavoda NPP has been completed in 2014. In terms of initiating events and plant states required to be covered, the Level 2 PSA, started in 2012, is consistent with the scope of the Level 1 PSA. It covers Internal Events (including internal fires, high energy line breaks and internal floods) and Seismic Events. Full power, shutdown and transition states are covered at the same resolution level as already considered in the Level 1 PSA study.

Up to date, the Level 2 Internal Events, Fire, Flood and Seismic PSA study has been finalized. The large off-site release frequencies (LRF) calculated per calendar year (taking into account the period of time that the unit is in each operating state) fulfill the safety goal target as recommended by IAEA, International Nuclear Safety Advisory Group, INSAG-12, *"*Basic Safety Principles for Nuclear Power Plants*"* 1999.

External hazards screening has been performed and the applicable external events for Cernavoda NPP site are under evaluation to support External Events PSA development.

## 14.3 Continued Monitoring of the Nuclear Power Plant

### 14.3.1 Assessment and verification of plant modifications

The plant procedure "Design modifications policy" covers both permanent and temporary modifications. According to this procedure the number of simultaneous temporary modifications must be kept to a minimum. The procedure "Temporary Modifications" deals only with temporary modifications. The period of a temporary modification is limited. Sometimes temporary modifications are used as an intermediate stage before implementing a permanent modification. The status of temporary modifications which might have an impact on plant's safety is at all times known by operating personnel and reported to the management of the plant.

According to station specific procedures, modifications are classified in three classes: major (corresponding to modifications in categories 1 and 2 as provided in the IAEA NS-G-2.3), minor (corresponding to category 3 in the safety guide) and commercial modification (modifications with no safety impact). As a result of application of an evaluation screening process the type and safety significance of the modification are determined.

After the initial assessment performed to categorise the modification, a more comprehensive assessment is undertaken for major modifications. The graded approach is used in establishing the extent of the assessment. For major modifications, all the safety aspects are considered in the assessments and a demonstration that all the relevant safety requirements are met must be submitted to CNCAN. The non-routine operations or tests are treated in the same way as a major change or as a temporary modification that may affect the safety envelope. All major and safety relevant modifications (permanent, as well as temporary) are submitted for approval to CNCAN.

The Operating Licence Conditions state that excepting the cases for which CNCAN is granting written approval, there shall be no modification, not even temporary, which might diminish the nuclear safety margins resulted from the accident analyses included in the Final Safety Analysis Report, especially to the Shutdown Systems No. 1 and 2, the Containment Systems, the Emergency Core Cooling System and any support system for the above mentioned systems. This applies also for any other safety-related system, which are referred to in the plant Reference Document "List of safety related systems".

Cernavoda NPP Nuclear Safety Policy and OP&P documents state that safety review of procedures, analysis and design changes shall be completed before the work is started. To comply, a dedicated process for all work/activities or modifications other than routine operation and maintenance has been in place since the early commissioning phase and require the use of a

work plan for the implementation of each activity.
Examples of the plant internal procedures related to design changes are given below:

- RD “Design Change Policy”
- RD ”Management and control of modifications”
- RD “Document Control and Records”
- SI "Modification Proposal and Approval Process"
- SI “Temporary Modifications”
- SI “Commercial Modifications”
- SI "Design Modification Implementation"
- SI "Configuration Change Determination"
- SI "Modification Close-Out"
- SI "Management and Control of Drawings"
- SI "Technical Specifications"
- SI "Design Revision Package”
- SI "Technical Calculations/Analyses and Design Verification"
- SI "Use of Replacement Materials, Parts and Equipment"

The initiation of the process is done in accordance with the procedure “Configuration Change Determination”. As a result of application of an evaluation screening process the type and safety significance of the modification are determined.

The requirements for installation, inspection and testing are developed according to the procedure “Design Modification Implementation”.

All Deviations During Implementation (DDI) are subject for safety assessments and appropriate actions are taken considering the importance of the DDI:

- Major DDI that affects the conceptual solution of the design modification will require a revision of the conceptual solution (in compliance with the procedure “Modification Proposal and Approval Process”)
- Major DDI that has no effect on the conceptual solution of the design modification will require a revision of the detailed solution (in compliance with the procedure “Design Revision Package”)
- Minor DDI are accepted “as it is” (in compliance with the procedure “Design Revision Package”)

After the implementation steps are completed, the system is declared as “available for service” and modification is “closed out” (in compliance with the procedure “Modification Close-Out”). This means that the modification tests meet the safety and performance requirements and all affected documentation is updated and the personnel is trained.

### 14.3.2 Surveillance Programmes

The Operating Licence Conditions require having in place a programme for the continuous monitoring of the plant safety parameters. At Cernavoda NPP, the continued monitoring of the nuclear installation is carried out through the Surveillance Programme. The purpose of the programme is to verify that provisions made in the design for safe operation, which were verified during construction and commissioning phases, are maintained throughout the life of the plant. At the same time, the program verifies that the safety margins are adequate and provide a high tolerance for anticipated operational occurrences, errors and malfunctions, and detect in time any deterioration that could results in an unsafe condition.

Also, as per Operating Licence Conditions, the compliance with the following reference documents and station instructions, prepared by the utility and approved by CNCAN, is mandatory: “Operating Policies and Principles”, “Management of the Maintenance Activities”, “Maintaining Systems, Structures and Component Reliability”, “Periodic Inspection Program”, “Mandatory Testing Program”, “Preventive Maintenance and Routine Administration”, “Plant Life Management”, “Predictive Maintenance”, “Preventive Maintenance”.

All important input data and main assumptions used in deterministic/probabilistic analyses supporting the plant licence were included in a comprehensive document Safety Analysis Data List (SADL). The document also identifies the corresponding design data together with the applicable design references. SADL are submitted to CNCAN as part of the licensing basis documentation.

The purpose of the SADL is to demonstrate that the specific design of the plant is compatible with the safety analyses. This objective is achieved if the data and assumptions used in the accident analyses are confirmed against the design data documented in the final design manuals (when applicable). Where achievable, the design data were confirmed by specific commissioning tests. In case of inconsistencies between the results of the commissioning tests and the safety analysis data/assumptions, then more in-depth assessments are provided to confirm adequate safety margin.

These data constitute the main acceptance criteria for continuous operation of the plant. As surveillance results are obtained, the person conducting the surveillance activity, according with specific work procedures, compares them with the acceptance criteria. If the results fall outside of tolerances, corrective actions are initiated, in accordance with appropriate work procedures. The surveillance programme includes appropriate actions to be taken for postulated deviations from the acceptance criteria, based also on safety analyses.

Surveillance results are examined by appropriate qualified persons, to provide assurance that all results satisfy the acceptance criteria from safety analyses and also to analyse the result trends that may indicate equipment deterioration. Where the trends indicate an unsafe direction of safety performance and the corrective actions can solve the problem only for a short period of time, a modification of the configuration is the subject of a safety assessment. The surveillance results represent also the plant specific data that are used as input data for the periodic review of deterministic and probabilistic analyses.

The Surveillance Programme for Cernavoda NPP is divided into the following activities/programmes:

a) Monitoring of Plant Parameters and System Status

One of the basic management process implemented at Cernavoda NPP, developed using INPO guidelines, consists in the Equipment Reliability Process. The performance of the systems and components that were identified as critical, considering the nuclear safety or production impact, is monitored. The surveillance program results, documented in the System Monitoring Health Report (SMHR) and the Component Monitoring Health Report (CMHR), are used both for operational risk and for reliability evaluation, so playing an important role in work planning and in station decision making processes. Also, the safety related systems equipment performance monitoring are key inputs for the Plant Life Management Program (PLIM) and the major SSCs

Life Cycle Plan. Therefore, the surveillance program ensures that items important to safety continue to perform in accordance with the original design assumptions and intent.

b) Mandatory Testing Program

Mandatory tests are developed in accordance with the reliability claims made within the probabilistic analyses of the safety related systems. The test results offer an overview of the "actual-past" unavailability of the standby safety systems and allow immediate corrective measures in the case the test failed.

c) Checking and Calibrating of Instrumentation

A calibration verification test is intended to check whether a known input to the instrument or channel gives the required output. Also, it verifies that the response times are within the specified limits. This activity gives the confidence in instrumentation indications and its associated response time.

d) In-Service Inspection Programme

The document which establishes the framework for the Inaugural and Periodic Inspection Programme of NPP Cernavoda Unit 1 and Unit 2 is the Periodic Inspection Programme Document (PIPD) based on the Canadian standard CAN/CSA N285.4 – 94: Periodic Inspection of CANDU Nuclear Power Plant Components.

Industry and own operating experience was used to upgrade the Periodic Inspection Programme:

- Feeders inspection requirements changed to address possible damages observed in other CANDU stations;
- Steam Generators were modified to allow proper inspection;
- Piping inspection programme upgraded using “CHECKWORKS™” software.

Cernavoda NPP obtained the regulatory approval and will improve the Periodic Inspection Program, by implementing the 2009 edition requirements of the standard CAN/CSA N285.4.

e) Preventive and Predictive Maintenance Programme

The objective of preventive maintenance (PM) is to prevent equipment breakdown through a planned program of activities in order to ensure continued availability for service. The objective of the plant predictive maintenance program is to improve plant safety and reliability through early detection and diagnosis of equipment problems and degradation prior to equipment failure. This activity is based on monitoring the health of the system and associated equipment, measuring and analysing trends of critical performance parameters.

A strong and technically sound maintenance programme for critical equipment was fully implemented at Cernavoda NPP using EPRI (Electric Power Research Institute -USA) guidelines. Supporting predictive programmes (vibration measurements, oil analysis, ultrasound detection, thermography etc) were also developed. Systematic collection of equipment ‘as-found’ data, industry and station OPEX is used for continuous monitoring of programme’s performance.

Considering the WANO and AIEA recommendations, required actions has been put in place to prevent suspect, counterfeit or fraudulent items usage in Cernavoda nuclear facilities and activities, such as procurement quality surveillance, staff training and procedural barriers.

f) Ageing Management Programme

Cernavoda NPP Plant Life Management (PLiM) Programme integrates Preventive / Predictive Maintenance Programmes, Ageing Management Programme, Obsolescence Mitigation Programme, Environmental Qualification Programme and System Surveillance/Health Monitoring Programmes. In this way, the PLiM Programme integrates all aspects regarding ageing and degradation processes of the plant. The purpose of this program is to maintain the performance in acceptable limits of critical Systems Structures and Components (SSC), throughout the plant life, based on implementation of several long term technical programmes.

Cernavoda NPP joined the COG R&D programs in order to ensure strong technical basis for the station PLiM. Specific PLiM programmes have been developed, with AIEA support, and submitted to the regulator, and life assessment studies are conducted, for relevant components, that allow the actual condition evaluation from the perspective of plant life extension.

Using the experience gained and benchmark missions to other nuclear facilities, a full set of reference documents and station instructions were prepared to sustain the extension of PLiM Program to all major plant assets. Also, a strategic plan is in progress to develop dedicated Functional Groups and Duty areas within station organisation in order to ensure proper support to PLiM programmes.

g) Systematic assessment of Critical Spare Parts Programme

The critical spare parts inventory was revised based on the findings of equipment failure mechanisms analysis. Also, a shelf life programme for spare parts was implemented.

### 14.3.3 Implementation and use of Risk Monitor (EOOS)

A risk monitoring program has been developed based on the existing PSA model and Equipment Out of Service (EOOS) software developed by DS&S as an EPRI contractor.

The PSA model has been built as a master fault tree F/T that includes the failure logic for all the accident sequences ending in a Core Damage State. The logic model development fully exploits the advance techniques and features available in CAFTA environment. Mainly those techniques involve use of a limited number logic flags, inclusion of initiating events identifiers inside the system F/T top events to simulate the initiating event's impact on different equipment, trains or systems, restructure the input logic in order to allow the quantification engine to work faster while generating the minimal cut-sets for all initiating events in a single run.

The next step in building the risk monitor model was to replicate the failure logic existing in the base PSA and introduce configuration flags inside the master logic F/T in order to account for any unit operating state (full power, intermediate power levels or shutdown state) or active equipment can be at a particular moment in time (ON/AUTO/STBY/OFF).

Mapping the relevant conditions, logic flags and basic events modelled in PSA to the corresponding equipment and constructing the panel interface were subsequent steps required to translate the PSA specific language to the operator's and scheduler language.

The following specific features provided by the Risk Monitor developed for Cernavoda NPP have to be emphasised:

- Dynamic recalculation of some initiating events frequencies based on the IEs F/Ts re-evaluation.
- Ability to increase the frequency of LOOP and General Transient by a factor to simulate the most credible impact of some conditions (e.g. external events, weather related) which are not explicitly included in the PSA.
- Ability to check equipment misalignments based on F/T supporting logic.
- Ability to recalculate the failure probability of the most significant standby equipment based on equations that consider the time elapsed from the last test.
- Ability to identify and prioritize the operator actions to reduce the risk based on the importance measures (RRW for the equipment out of service show what equipment are worth to be returned in service and RIR for the in service equipment show what equipment are worth to be protected or their failure probability to be reduced).

The risk thresholds have been defined by splitting the CDF variation interval in four regions. Two reference values have been used: the base CDF (the PSA value while setting up maintenance unavailability to zero) and the maximum acceptable CDF value (average PSA value). Each risk region is represented by a colour consistent with those used in the Significance Determination Process colours:

- Green (Insignificant Risk Increase) – No actions required in respect with the risk management.
- White (Moderate Risk Increase) – Limit the duration. Evaluate the importance of OOS and I/S equipment and do not approve any work resulting in a higher action level. Inform Shift Supervisor.
- Yellow (Significant Risk Increase) – Same action as for White plus: Allocate all available resources to return in service the most risk significant equipment. Define and implement compensatory measures. Inform the Production and Safety Managers.
- Red (Unacceptable Risk Increase) – Same measures as for Yellow plus: Request for extra resources. Inform the Station Manager and initiate a Technical Operability Evaluation meeting.

As per EOOS results recorded from Cernavoda NPP two units cumulative operating experience of more than 18 years there were no instances to operate in Yellow or Red risk region.

An updating and configuration control process is in place to ensure that the following types of modifications are identified on a day by day plant operation review and their impact on risk is considered: permanent/temporary configuration changes, hardware changes, changes to the plant operating procedures or maintenance procedures, changes to the component unavailability data as a result of the plant specific reliability data collection program.

Internal department procedures have been developed in order to define how the risk monitor is to be used by three categories of users:

- Main Control Room – keep the risk monitor updated with all relevant plant operating configurations, use the risk colour thresholds to support mitigating actions;
- Planning Department – 13 weeks (E-13) schedules evaluation up to E-5 / E-2 / E-1 and E-0 execution week;
- Safety & Compliance Department – Safety Cases Evaluation (check list to be used by R&R

engineers), allowed configuration time (ACT) assessment and compensatory measures for risk reduction (based on cumulative risk increases thresholds), outage scheduling, CDF monitoring and reporting on the monthly safety performance indicators, quarterly Plant Safety Oversight Committee meetings and QTR reports, EOOS users training.

The feedback from the users is being used to refine and improve the PSA model and to optimise the process for providing meaningful insights in support of the day by day operational decision making. After several years of EOOS Risk Monitor usage the plant personnel become aware on how PSA applications can support their activities.

### 14.3.4 Periodic Safety Review

In the past, the Romanian licensing system required a safety review to be carried every two years by Cernavoda NPP Unit 1, in order to support the license renewal. The main safety issues addressed, with the current Safety Analysis Report as the main document under review, corresponded largely to the 14 safety factors proposed by IAEA's Safety Guide NS-G-2.10. The scope of the Periodic Safety Reviews in the general understanding being more comprehensive, the benefit of carrying such reviews was recognised and this has led to a change in the Romanian licensing approach.

In 2006, following a recommendation received from an IRRS Mission organised by IAEA and also as a result of the participation in the study "Harmonisation of Reactor Safety in WENRA Countries", CNCAN issued a regulation on Periodic Safety Review of Nuclear Power Plants, as a first step towards the changing of the licensing system. The regulation requires a PSR to be conducted every ten years. The Romanian regulation is based on the Safety Guide NS-G-2.10, having the 14 "safety factors" defined as "areas of review", for each of these having specified most of the "generic review elements" given in the Appendix to the IAEA guide.

In 2005, CNE Cernavoda started for Unit 1 the preparation phase of PSR using the IAEA Safety Guide, and also CNCAN regulations on PSR when they issued in 2006.

The main objectives of the Cernavoda Unit 1 PSR were the following:

- To undertake a systematic review of the current plant design and safety analysis against internationally accepted safety standards, codes and practices.
- To review ageing mechanisms and their management, in order to confirm that the plant is safe to operate for at least the next 10-year period, subject to continuing routine maintenance, testing, monitoring and inspection.
- To review the operating history of the plant, and plants of similar design, to identify and evaluate factors that could limit safe operation during the next 10-year period.
- To identify PSR Findings of safety significance, and determine those safety enhancements which are reasonably practicable, and that should be implemented as Corrective Actions to resolve the issues that have been identified.

The scope of the Cernavoda PSR was to cover all the 14 safety factors recommended by the IAEA and required by CNCAN.

As per national and international recommendations, the Cernavoda PSR project has been split into three phases:

**Phase 1 - Project Set-up and Planning**

The Phase 1 represents the initial set-up phase when the PSR scope, review criteria, program, quality arrangements, documentation plan, and project organisation requirements were identified.

PSR Phase 1 of Cernavoda NPP Unit 1 was completed in 2007, when CNCAN approved the scope and programme of the PSR for Cernavoda NPP Unit1, together with the Quality Assurance Plan.

**Phase 2 – Main PSR Activities**

The Phase 2 represents the main activity of the PSR, covering the review of the safety of all aspects of the plant. It was assessed the safety performance during the first ten years of operation, up to May 1, 2008.

This phase has been undertaken between May 1, 2008 and June 30, 2012. As a first step, a preliminary analysis has been done and documented in 6 Discipline Based Reports (DRs) and 39 Topic Reports (TRs) that constitute the primary low level documentation. The consolidated, systematic safety review has been further completed as the next step.

The PSR results were documented in 4 Information Reports, as follows:

- Main Chapter 1 – Summary of Periodic Safety Review
- Main Chapter 2 – Operational and Safety Performance
- Main Chapter 3 – Systems, Structures and Components
- Main Chapter 4 – Safety Analysis

**Phase 3 – Corrective Action Plan & Implementation**

The Phase 3 of PSR includes the analyses of identified safety issues and the development of the detailed proposals for the implementation of the corrective actions and/ or safety improvements to address the PSR Findings.

During the Phase 3, for each of the Findings identified in PSR and summarized in the Main Chapter 1, an analysis has been performed, that includes the final assessment of the safety impact of the finding. The final assessment considered what was done already between May 1, 2008 and June 30, 2012 and what had to be done to correct the problem. These analyses included also the final proposal of the corrective actions and were used as an intermediate steep for the development of the PSR Corrective Action Plan (CAP). A number of 37 corrective actions and improvements have been identified and included in the PSR Corrective Action Plan together with the proposed target dates for implementation.

In accordance with the national regulations, the results of Unit 1 PSR and the Corrective Actions Plan were submitted to CNCAN for approval. As a result of the review performed by CNCAN, 4 corrective actions have been added to the Corrective Actions Plan.

Up to date, 35 out of 41 of the total number of corrective actions resulted from the PSR have been implemented.

Further, Cernavoda NPP has performed an analysis of the applicability of Unit 1 PSR results on Unit 2, submitted to CNCAN as licensing support document.

The deficiencies identified through PSR, the corrective actions, the target dates proposed for implementation and the analysis of the impact of Unit 1 PSR results on Unit 2 were considered adequate by CNCAN.

After PSR completion, the main licensing document - Unit 1 Final Safety Analysis Report (FSAR) - has been updated and submitted to CNCAN, in order to support the Operating License Application.

Based on PSR results and on U1& U2 FSARs, in May 2013 CNCAN granted new licences: for Unit 1 for 10 years and for Unit 2 for 7 years.

As required by the PSR specific national regulation and by the U1&U2 licenses provisions, a strategy is currently developed for conducting the second PSR evaluation of the Unit 1 and the first PSR review for the Unit 2.

## 14.4 Description of the regulatory review process

Complex technical assessments/evaluations are performed by CNCAN staff when reviewing safety documentation (Safety Analysis Report and the supporting technical documentation) submitted in support of license applications. Technical evaluations are also performed for event analyses and when approving operation documentation. Other types of evaluation (inspections, audits, etc.) are described in the chapter corresponding to Article 7.

The main responsibilities of CNCAN staff performing safety assessment activities are:

- To determine whether the conceptual design is safe and meets applicable regulatory criteria;
- To determine whether the operating envelope is consistent with safety requirements, including regulatory requirements;
- Perform evaluations of the proposed plant modifications;
- Provide the basis for the decision of issuing licences and approvals.

Safety evaluations of the safety documentation include the review of deterministic analyses, probabilistic analyses and reliability analyses.

The review and assessment performed by CNCAN as part of the licensing process and as part of the continuous regulatory oversight focuses on:

- Operating licence renewal documents, including updates to the FSARs;
- New or updated safety analyses performed by the licensee;
- Resulting of periodic safety reviews (PSR or other more frequent routine reviews);
- Station safety performance;
- Significant events reported by the licensee;
- Temporary configuration changes;
- Plant modifications.

The review and assessment activities aim at verifying compliance with the following:

- Regulatory requirements, safety principles and design criteria;
- Defence in depth concept achievement;

- Systems separation philosophy;
- Special safety systems design requirements;
- Design codes, standards and safety guides.

The review and assessment activities are performed with the objectives of determining whether the applicable safety objectives and requirements for each aspect or topic have been met, whether the safety analyses cover both normal and fault conditions and whether the safety submissions provided are sufficiently complete, detailed and accurate.

## 14.5 Significant developments for the last reporting period

**Safety Reviews post-Fukushima:**

The safety reassessments conducted in response to the Fukushima accident included the "stress tests" review required by the European Council for all the European nuclear power plants, in compliance with the specifications and criteria issued by the European Commission, based on the work done by the European Nuclear Safety Regulators' Group (ENSREG) and the Western European Nuclear Regulators' Association (WENRA).

These safety reassessments include:
- review of the safety margins for extreme external events;
- analysis of loss of electrical power and loss of ultimate heat sink accident scenarios;
- severe accident analyses.

The results of these reassessments have been extensively presented in the National Report of Romania for the 2nd Extraordinary Meeting under the Convention on Nuclear Safety (May 2012) http://www.cncan.ro/assets/Informatii-Publice/06-Rapoarte/RO-National-Report-for-2nd-Extraordinary-Meeting-under-CNS-May2012-doc.pdf.

The regulatory reviews performed on the implementation of the “stress tests” have focused on verification of the completeness and validity of the reports submitted and claims made by the licensee. Numerous on-site inspections have been performed to assess the progress of improvement actions resulted from the stress tests. All the design changes associated with the improvements proposed (and outlined in Annex 2 of this report) have been subject to CNCAN review and approval.

**Implementation of corrective actions from the first periodic safety review:**

The implementation of the actions resulting from the PSR has progressed well. There are currently only 6 corrective actions that are still in progress, while the rest have been implemented.

**Completion of Level 2 PSA:**

The Level 2 PSA study for internal events, internal fire, internal flood events and seismic events for Cernavoda Units 1 and 2 has been finalized in 2014.

**Other reviews:**

A review of the latest studies on the chemical effects in the sump water pool during post LOCA conditions (i.e on the potential interaction between the chemical additives used for the control of pH in the sump following a LOCA for retaining organic iodine and the insulation materials that would be dislodged by such an accident) was performed by CNCAN and Cernavoda NPP, together with a verification of the insulation materials. These reviews and verifications confirmed the reliability of the long-term core cooling.

## ARTICLE 15 - RADIATION PROTECTION

*Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.*

### 15.1 Regulatory framework for radiation protection for Nuclear Power Plants

In accordance with the provisions of the Law, CNCAN is empowered to issue regulations for the detailed specification of the general requirements on the protection against ionising radiation and to control their implementation.

In this respect, CNCAN has issued a number of regulations regarding the radiological safety of nuclear and radiological installations, the following being the most important ones applicable to nuclear power plants:

- Fundamental Requirements on Radiological Safety;
- Requirements on Individual Dosimetry;
- Requirements for Limiting Radioactive Discharges into the Environment;
- Requirements for the Monitoring of Radioactive Emissions from Nuclear and Radiological Installations;
- Requirements for the Environmental Radioactivity Monitoring around Nuclear and Radiological Installations;
- Requirements for the Calculation of Dispersion of Radioactive Effluents, Discharged into the Environment by the Nuclear Installations;
- Requirements for the Meteorological and Hydrological Measurements at Nuclear Installations;
- Requirements on the Issuance of Practice Permits for Nuclear Activities and the Designation of Qualified Radioprotection Experts.

The other national authorities involved in the licensing process, with regard to aspects relevant to the radiological safety, are:

- The Ministry of Environment and Sustainable Development, which issues the environmental agreement (as a prerequisite for the siting licence issued by CNCAN) and the environmental authorisation (after CNCAN granting the operation licence).
- The Ministry of Public Health, which issues the sanitary approvals, in accordance with the regulations in force.

### 15.2 Implementation of legislative and regulatory requirements on radiation protection for Nuclear Power Plants

According to art. 37 of the Fundamental Requirements on Radiological Safety (NFSR), the licensee has the general obligation of taking all the necessary actions to reduce the radiation exposure of the workers to the most reasonable low level. The licensee is also responsible for the assessment and implementation of the measures regarding the radiation protection of occupationally exposed workers, as stipulated in the chapter VI of NFSR (radiological zoning, requirements for controlled areas and monitored areas, classification of occupationally exposed workers, information, training and authorisation of workers, radiological monitoring of the workplace, individual monitoring of radiation exposure of the occupationally exposed workers, monitoring of radiation exposure in case of accidental and emergency exposures, recording and reporting of the results of individual monitoring of radiation exposure, investigation and reporting of overexposures and abnormal exposures, general requirements for the medical surveillance, medical conditions and special medical surveillance of the occupationally exposed workers, etc.).

In this respect, the licensee has developed individual company policies, regulations and procedures, based on the national laws and regulations, latest ICRP/IAEA recommendations and operating experience of other nuclear power plants. The implementation of the Radiation Safety Policies and Principles is directed through a comprehensive process developed by the Health Physics Department and is detailed in radiation protection procedures covering all aspects of radiation safety. Furthermore, where necessary and appropriate, Operating and Maintenance procedures include radiation safety aspects.

Radiation Protection provisions are documented and approved by CNCAN, for the following:

- Personnel radiation protection training and qualification;
- Operational radiation protection of occupationally exposed workers;
- Personnel dosimetry;
- Public radiation protection;
- Radioactive waste management;
- Management of controlled radiation sources;
- Planning and preparedness for emergency response process.

As stipulated by art. 42 of NFSR, for each controlled and monitored area, the licensee must nominate in writing at least one responsible person for the radiological safety, who shall be in charge of the application of these Requirements and of the specific regulations in the respective area. The Radiological Safety Responsible must possess a Practice Permit issued by CNCAN, in the field and specialisation according with the practices carried on in the controlled/monitored area. In certain cases, CNCAN can request this position to be ensured by a special department, managed by a Qualified Expert in Radioprotection (a person having the necessary knowledge and training to carry out the physical, technical or radiochemical tests to evaluate the doses and/or for giving advice in order to ensure an effective protection of individuals and the correct use of protective equipments, and whose capacity to act as expert in this matter is recognized by CNCAN, by issuing a practice permit, in accordance with the specific regulations).

In this respect, the radiation protection function of the Cernavoda NPP organization is assigned to the Health Physics Department, which is led by a CNCAN Certified Expert in NPP Radiation Protection, designated as the NPP Radiological Safety Responsible. The NPP Health Physics Department is responsible for:

- implementing Radiation Safety Policies and Principles;
- issuing Radiation Safety Regulations, which define the specific application of these policies and principles;
- establishing, in consultation with the other NPP Departments, the Radiation Protection Process;
- continuously assessing the effectiveness of all aspects of the Radiation Protection Process and communicating the findings and recommendations to the station management.

The Health Physics Department is directly reporting to Cernavoda NPP Director, who is responsible to assure sufficient resources for the implementation of the radiation protection programmes.

The Health Physics Department includes a Radioprotection Technical Services, a Radiation Control Services, the Individual Dosimetry Laboratory and the Environmental Control Laboratory. As requested by CNCAN, the Technical Radioprotection Services Head has been designated as CNCAN Certified Expert in NPP Radiation Protection and the Chief of the Individual Dosimetry Laboratory has been designated as CNCAN Certified Expert in NPP Radiation Protection – limited to individual dosimetry activities.

Also, the CNCAN specific regulations stipulate that the capability of the laboratories which provide dosimetric services and perform radioactivity measurements on effluent samples and environmental samples must be recognised by CNCAN. In this respect, the Individual Dosimetric Laboratory and the Environmental Control Laboratory of the NPP Health Physics Department were designated by CNCAN to be able to perform the respective measurements, according to the Requirements on the Designation of Notified Bodies for the Nuclear Field.

### 15.2.1 Dose Limits

In Romania, the dose limits for the population, as stipulated in art. 25 of NFSR are:

- 1 mSv per year of effective dose; in special situations, CNCAN may authorise an annual superior limit of up to 5 mSv in a year, provided that the average of the effective dose on a period of 5 consecutive years does not exceed 1 mSv per year;
- 15 mSv per year, equivalent dose for the lens of the eye;
- 50 mSv per year, equivalent dose for the skin.

For the occupationally exposed workers, art. 22 of NFSR establish the following dose limits:

- 20 mSv per year, effective dose;
- 150 mSv per year, equivalent dose for the lens of the eye ;
- 500 mSv per year, equivalent dose for skin;
- 500 mSv per year, equivalent dose for the extremity of hands and legs.

In order to maintain doses as low as reasonably achievable, Cernavoda NPP has established an administrative limit for the occupationally exposed workers of 14 mSv/ year effective dose.

### 15.2.2 Occupational Exposure

As stipulated in art. 55 – 57 of NFSR, the licensee shall ensure the systematic individual monitoring of all category A workers (occupationally exposed workers for whom there is a significant probability of receiving an effective annual dose or an equivalent annual dose higher than three tenths of the legal limit of the respective dose); in those cases where these workers are likely to receive significant internal contamination, individual monitoring shall include also internal contamination monitoring. For the category B workers (those occupationally exposed workers not included in category A), the individual monitoring shall be at least sufficient to demonstrate that such workers are correctly assigned to this category.

In order to fulfil these requirements, Cernavoda NPP has established and implemented an Individual Dosimetry Programme, which is intended to provide a proper evaluation, measurement and recording of radiation doses received at Cernavoda NPP by occupationally exposed workers (both Cernavoda NPP employees and external workers - contractors). Radiation workers at Cernavoda NPP are classified both as category A and B occupationally exposed workers. All radiation types which are significant from the dosimetry point of view are monitored with appropriate frequency and monitoring devices for accurate determination of external and internal doses likely to be received.

The routine individual dosimetry programme consists of:

- Monthly evaluation of individual penetrating dose equivalent, $H_{p(10)}$, due to gamma radiation and individual superficial dose equivalent, $H_{s(0.07)}$, due to beta & gamma radiations, both measured with individual TLD's;
- Estimation of committed effective dose, $E_{50}$, due to tritiated heavy water intakes, by LSC beta-spectrometry analyses of urine samples, provided with a frequency depending on the tritium concentration on the last sample (28, 7 or 1 day);
- Estimation of committed effective dose, $E_{50}$, due to gamma-emitters intakes, by in vivo measurements with Whole Body Counter; the monitoring frequency is for each new person at the initialization in the DOSERECORDS database and monthly or quarterly (for Fuel Handling personnel), annually (for operation, maintenance and health physics departments) and once in 3 years (for the rest of the NPP personnel).

Special individual monitoring is provided in the following situations:

- Working in neutron fields: the external doses due to neutrons, $H_{p(10)}$ is assessed by integrating in time the neutron dose rate measured with portable neutron monitors in the most exposed area of the working place;
- Working in not homogenous radiation fields: the workers must wear several TLDs;
- Working in high, variable, no homogenous radiation fields: the worker must wear an electronic dosimeter with direct reading and acoustic alarms;
- For those activities which entail anticipated exposures to tritium significantly higher than the usual situation, the urine samples must be provided before and after the work; when there are known or suspected significantly high, unanticipated, exposures to tritium, all those persons which might be affected must provide supplementary urine samples for evaluation of the committed effective dose;
- For those activities which entail anticipated intakes of gamma-emitters significantly higher than the usual situation, the whole body monitoring must be performed before and after the work; when there are known or suspected significantly high, not anticipated intakes of gamma-emitters, all those persons which might be affected must perform supplementary whole body monitoring;
- For those activities which entail anticipated beta-gamma dose rates at contact with extremities 10 times higher than those registered at the thorax level, the worker must wear TLDs for extremities.

The management of the estimated doses is done trough dedicated software and database (DOSERECORDS), which also issue routine reports. The dose registrations are reported as follows:

- Daily and monthly reports regarding the systematic individual monitoring;
- Quarterly reports to the NPP management;
- Half-yearly reports to CNCAN;
- Annually and at the end of working for NPP to the employee (own and outside workers);
- At request, to external organisations.

The dosimetric services are provided for the NPP by the Individual Dosimetry Laboratory. Since 2001 this laboratory participates on international intercomparison exercises, as a member of PROCORAD Association from France, for H-3, C-14, whole body counting and gamma-spectrometry analyses in urine. The results for each category of analyses met the acceptance criteria since 2001 to 2015. The laboratory is being designated as "reference laboratory" for C-14 in urine in 2001, 2004, 2006 2007, 2008, 2009, 2010, 2011, 2012 and 2103 and for H-3 in urine in 2004, 2006 and 2007. Also the laboratory regularly participates in COG intercomparison exercises for external dosimetry since 2007, meeting acceptance criteria.

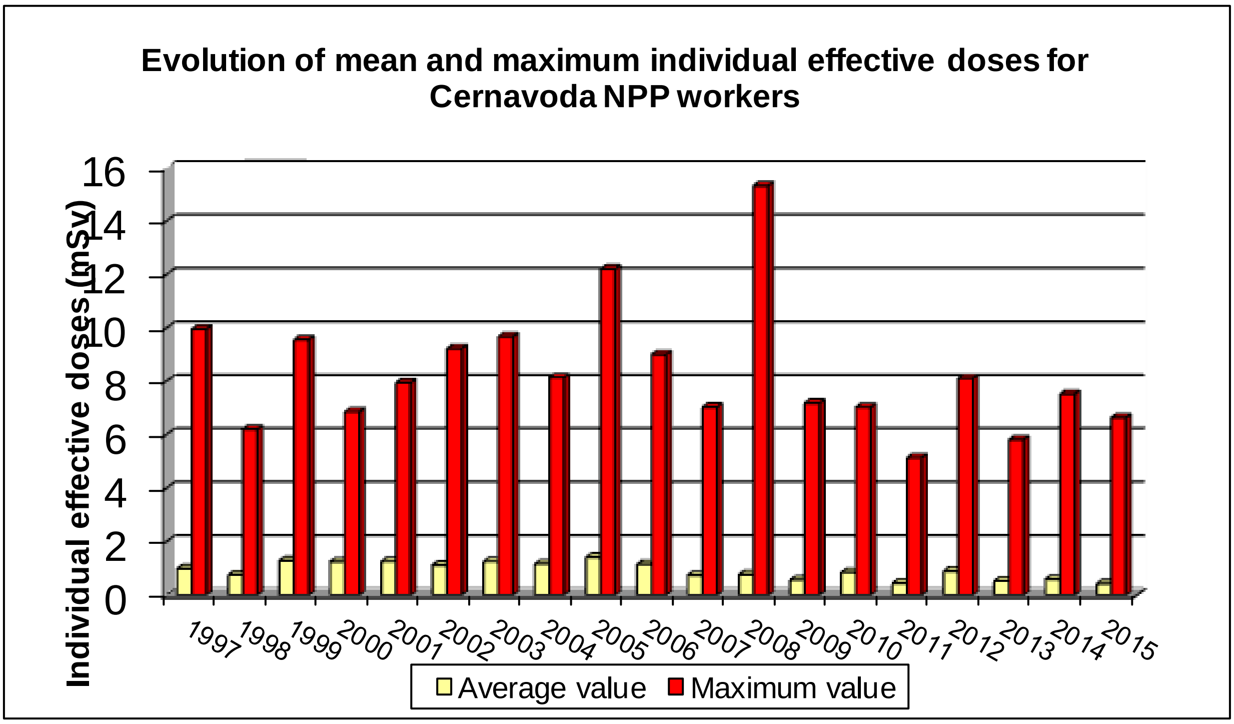



**Fig. 15.1**

The average effective dose for a Cernavoda NPP worker in 2015 was 0.43 mSv with a maximum of 6.63 mSv. The evolution of mean and maximum individual effective doses for Cernavoda NPP workers is shown in Fig. 15.1.

The Individual Dosimetry Programme is supplemented by a Monitoring Programme of Working Places, established and implemented in order to evaluate the radiological conditions in the NPP controlled areas, assuring by this a decisional support in those matters regarding the warning, access control, approval of works and individual monitoring, as well as a valuable back-up for estimation of the individual doses. The routine monitoring programme includes:

- Measurements of gamma and neutron dose rates, tritium in air concentrations, aerosols (alpha, beta, gamma), iodine in air, (alpha, beta, gamma) surface contamination levels; the scope and frequency of measurements inside the NPP are established taking into consideration the anticipated hazards and are modified, as the case may be, based on the accumulated experience.
- Contamination monitoring of the personnel: the contamination of all employees walking from zone 1 (a controlled area containing systems and equipments which can be significant sources of contamination and/or dose rates higher than 10 μSv/h) to zone 2 (a controlled area without radioactive systems and sources, excepting those approved sources, usually without contamination, but which can be contaminated and where the dose rates are less than 10 μSv/h) and zone 3 (a controlled area without radioactive sources, excepting those approved sources, with very low probability of contamination

spread from adjacent areas and where the dose rates are less than 0.5 μSv/h) is monitored. From zone 1 to zone 2 it is necessary to monitor the beta-gamma contamination of hands and foot, from zone 2 to zone 3, the beta-gamma contamination of whole body.

- Contamination monitoring of materials and equipment: all the materials and equipments moving from zone 1 to zone 2 are monitored for beta-gamma contamination and, for radioactive materials (solid waste and transport equipments), the gamma dose rate.
- Surveillance of radiation fields for routine activities: these checks are specified in the Radiation Work Permit and they must be performed by the employees before starting the work.
- In the last 2 years, alpha emitting radionuclides monitoring and control in Cernavoda NPP have been significantly improved by introducing best industry practices. Plant areas and systems have been characterized and classified according to the abundance of loose alpha contamination relative to the presence of loose beta-gamma contamination. Alpha monitoring equipment is available providing the capability for workplace and personnel monitoring to determine the alpha hazard and protect workers.

The communication and registration of the results of the monitoring programme of NPP working places are made trough warning panels placed in field, monitoring sheets and Hazard Info database electronic system.

During 2014 the implementation of Radiation Monitoring System (RMS) at Cernavoda U1 was started. This project was finalized in 2015.

The purpose of this improvement is to connect the on-line radiation monitoring equipment to a computerized interface system that allows remote monitoring, limited remote control capability and maintaining integrated short and long-term database.

Radiation Monitoring System integrates all fixed radiation monitoring equipment, uses a local area network (LAN) and dedicated components and software to control the field equipment, store and display the measured or processed data, trends. RMS interfaces with the following systems: Fixed Gamma Area Monitoring, Fixed Contamination Monitoring, Portable Radiation Monitors, Fixed Tritium in Air Monitoring, Liquid Effluent Monitor, Gaseous Effluent Monitor and Post Accident Air Sampling and Monitoring.

Thus the collective dose of the operating personnel decreased (by avoiding the entrance in high radiation hazard areas) and a better radiation hazard control was improved for the normal operation of the plant (due to real time radiation hazard information).

Further implementation of radiation protection systems modification leading to personnel and public exposure optimization represents a top priority for the plant management and health physics department staff.

Since Unit #2 fuel load and first criticality in 2007 efforts have been made for the integration of both units radiation protection programs and systems related to personnel dosimetric surveillance (i.e. Personal Alarm Dosimeters databases and computers serving Liquid Scintillator Counters for tritium analysis in urine samples, in Unit 1 and Unit 2, were connected with the unique DOSERECORDS system). Also DOSERECORDS (a package consisting of a database and a number of specific programs) was adapted to support and work with dose information from both units. This unique dosimetric surveillance system ensures that individual dose limits are not exceeded no matter an employee works in Unit #1, Unit #2 or both units.

Since the dose is a measure of the potential detriment on the health of an individual following the exposure of the human body to ionizing radiation, as a conservative decision from the radiation workers protection point of view, at the beginning of 2008 it has been decided to lower the recording levels for deep individual dose equivalent Hp(10), shallow individual dose equivalent Hp(0.07) and effective internal dose E50, from 0.17 mSv per month to 0.1 mSv per month.

### 15.2.3. Public Exposure

As requested in art.109 of NFSR, the release into the environment of liquid or gaseous radioactive effluents can be made only in compliance with the DELs approved by CNCAN.
Also, the Radioprotection Regulation of Cernavoda NPP stipulates that the radioactive emissions levels shall be maintained below the DELs approved by CNCAN, in order to optimise the public radiation protection.

According to the CNCAN monitoring requirements, the NPP shall ensure the adequate monitoring of all radioactive discharges, at the source as well as in the receiving media, in all operational phases (from preoperational to decommissioning) and conditions (normal operation and radiation emergency situations). In this respect, the radioactive effluents of Cernavoda NPP are monitored in the discharge points, through the Gaseous and Liquid Radioactive Emissions Monitoring Programme and in the environment, through the Environmental Radioactivity Programme.

#### 15.2.3.1 Radioactive Releases

According to the Gaseous and Liquid Radioactive Emissions Monitoring Programme, the radioactivity emissions are continuously monitored by the Gaseous Effluent Monitoring System (GEM) and Liquid Effluent Monitoring System (LEM), installed in both units and continuously sampled for further periodic laboratory analyses.

The potentially contaminated air inside NPP comes from:

- Central Contaminated Exhaust System: the air from this system is filtered through a High Efficiency Particulate Air (HEPA) filter;
- Reactor Building Exhaust System: the air from the Reactor Building is passed through a pre-filter, a HEPA filter, an activated charcoal filter (to retain radioiodine) and a final HEPA filter;
- Spent Fuel Bay Exhaust System: filtration of this air is similar to that of the Reactor Building;
- $D_2O$ Enrichment Tower Exhaust System: this air is not filtered, because it contains only tritium
- In those areas of the station where heavy water systems exist, the Closed Cycle Vapour Recovery System recovers much of the tritium.

After filtering, all potentially contaminated exhaust air is routed to the exhaust stack, which disperses it to the environment. Representative samples of the air flow in the stack are continuously extracted and routed to the GEM, by an isokinetic sampling system.
The GEM is designed to:

- monitor the total activities of particulate, radioiodine and noble gases;

- alarm (locally and in MCR) when predefined release setpoints are exceeded;
- collect samples on adequate sampling media, for further laboratory analyses to determine the particulate, radioiodine, total tritium and total C-14 content of gaseous effluents.

The particulate filters are changed and measured daily, by gamma-spectrometry and gross-beta analyses. The charcoal filters for radioiodine are changed and measured daily, by gamma-spectrometry analyses. In case of High Activity Release Alarm provided by GEM, the filters are immediately changed and measured in the Chemical Laboratory. In routine situations, the filters are measured in the Individual Dosimetry Laboratory, which also analyses the H-3 and C-14 concentration in effluent samples. Tritiated water vapours are trapped in molecular sieve at Unit 1 and both forms of tritium, tritiated water and gas tritium, are trapped in demi water at Unit 2. After extraction from sampling media, tritium content is measured by LSC, daily in both Units. Both anorganic and organic forms of C-14 are extracted from NaOH solution and measured by LSC, daily in both Units. These laboratory analyses results represent the data of the NPP gaseous discharges that are officially reported to the management and to the relevant authorities.

Radioactive liquid wastes resulted from the operation of Cernavoda NPP are collected in five liquid effluent hold-up tanks (approx. $50m^3$ each) at each Unit. Before the discharge, the content of a tank is recirculated in order to assure a good homogeneity and a representative sample is taken, which will be analysed in the Chemical Laboratory for gross-gamma activity and tritium concentration. Based on these laboratory analyses, the Shift Supervisor will approve the discharge if the radioactive level is below the established limits. In order to limit the radioactive concentration, during the discharge it must be assured a minimum dilution factor. If radioactive aqueous liquid waste doesn’t meet the requirements to be discharged as liquid effluents, it must be decontaminated or temporarily stored.

Each liquid discharge from the NPP is monitored by the LEM, which is designed to:
- continuously monitor the gross-gamma activity discharged;
- collect a representative integrated sample, for further laboratory analyses;
- automatically stop the discharge and provide an alarm (locally and in MCR) if a preset count rate set point is exceeded, or if any malfunction occurs on LEM.

The samples collected by LEM are measured in the Individual Dosimetry Laboratory, by gamma-spectrometry analyses, LSC for H-3 concentration, LSC on weekly composite samples for C-14 concentration, gross-beta analyses on weekly composite samples. These laboratory analyses results represent the data of the NPP liquid discharges that are officially reported to the management and to the relevant authorities.

Supplementary, the Individual Dosimetry Laboratory measures, weekly, an integrated sample (continuously collected) from CCW, by gamma-spectrometry and gross-beta analyses and LSC for H-3 determination. These samples are analysed only for verification purposes.

As requested by the CNCAN Requirements for the Monitoring of Radioactive Emissions from Nuclear and Radiological Installations, the capability of the laboratory performing the radioactivity measurements on effluents samples must be recognised by CNCAN. In this respect, the Individual Dosimetry Laboratory which provides the official data on radioactive discharges, beside dosimetric services for Cernavoda NPP, was designated by CNCAN as a “notified body” not only for dosimetric services, but also for radioactive effluents monitoring.

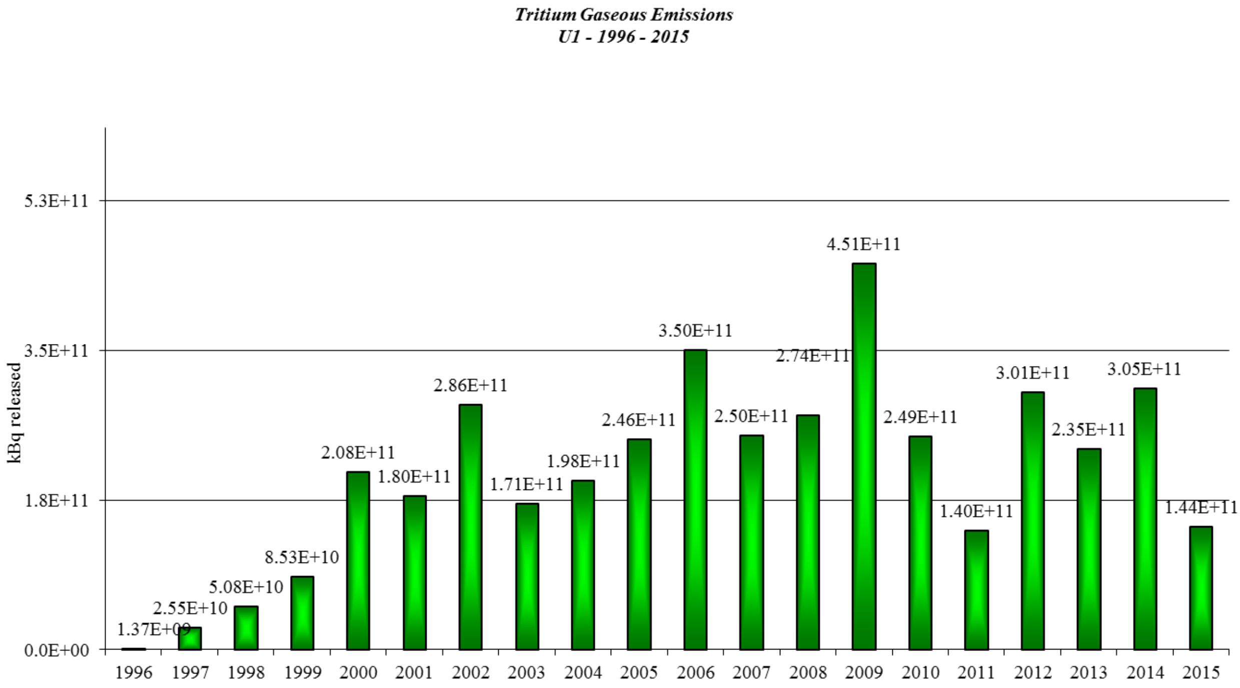
A summary of the gaseous and liquid emissions data are reported quarterly to CNCAN, the fourth report representing the annual one. The results of the Gaseous and Liquid Radioactive Emissions Monitoring Programme are also included in the annual report on environmental monitoring programme. Also, any gaseous emission exceeding the limits is immediately notified to CNCAN.

Since the beginning of the commercial operation of Cernavoda NPP, all the radioactive emissions were far below the Derived Emission Limits. Fig. 15.2 a, b and c show the evolution of gaseous emissions from Cernavoda NPP Unit 1 and Fig 15.2.d, e and f for Unit 2. Fig. 15.3 a shows the evolution of tritium liquid emissions from Cernavoda NPP Unit 1 and Fig 15.3 b from Unit 2.

The %ADEL (% Annual Derived Emissions Limits) graphs start with 2008, the time when new Derived Emissions Limits have been implemented in accordance with CNCAN requirements. As shown in trends of tritium levels in airborne emissions, for the same period of operation (8 years) Unit 2 levels are consistently lower than those observed at Unit 1. This behaviour can be explained by considering the benefits that come from:

- using a dedicated unit for drying the R/B inlet flow air (this lead to an increased efficiency of Water Vapour Recovery System);
- continuous improvement of on-line monitoring by using a state-of-the-art Tritium in Air Monitoring System;

The effective doses for Critical group members have been calculated using new DEL's model and parameters values.


Tritium Gaseous Emissions
U1 - 1996 - 2015
kBq released
5.3E+11
3.5E+11
1.8E+11
0.0E+00
1.37E+09
2.55E+10
5.08E+10
8.53E+10
2.08E+11
1.80E+11
2.86E+11
1.71E+11
1.98E+11
2.46E+11
3.50E+11
2.50E+11
2.74E+11
4.51E+11
2.49E+11
1.40E+11
3.01E+11
2.35E+11
3.05E+11
1.44E+11
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

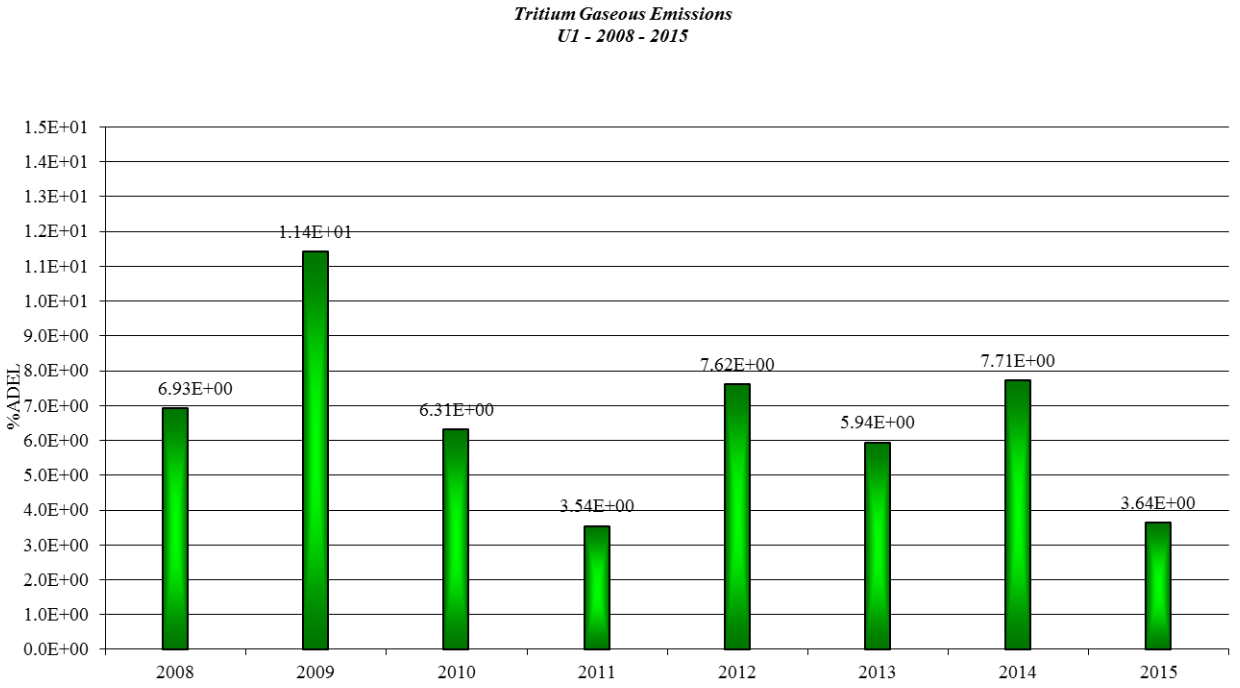
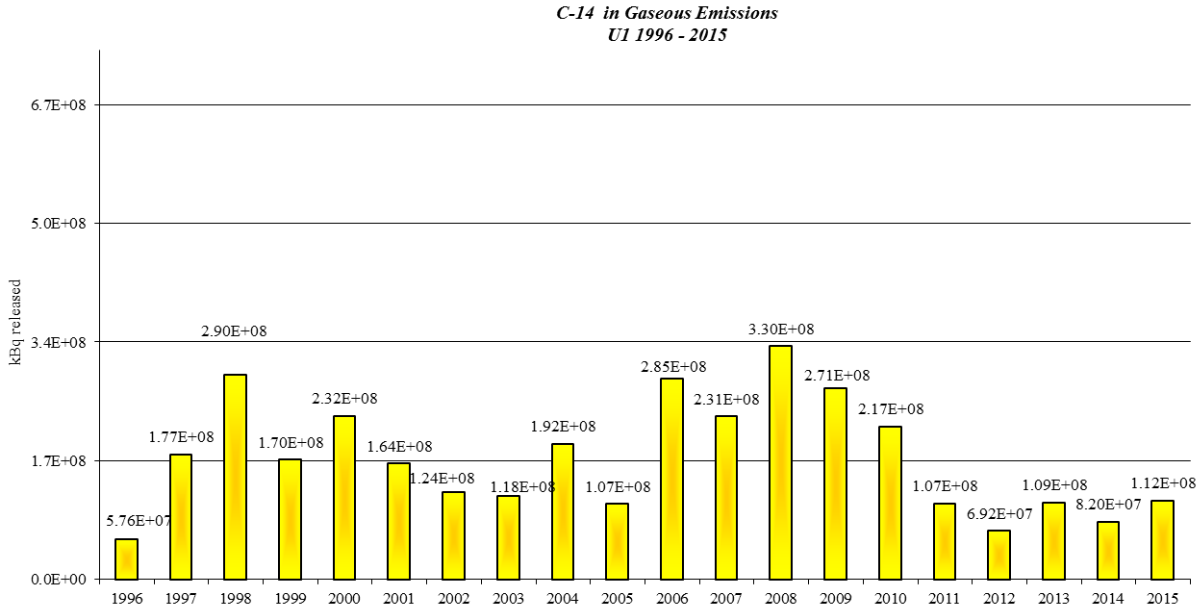

Tritium Gaseous Emissions
U1 - 2008 - 2015
%ADEL
1.5E+01
1.4E+01
1.3E+01
1.2E+01
1.1E+01
1.0E+01
9.0E+00
8.0E+00
7.0E+00
6.0E+00
5.0E+00
4.0E+00
3.0E+00
2.0E+00
1.0E+00
0.0E+00
6.93E+00
1.14E+01
6.31E+00
3.54E+00
7.62E+00
5.94E+00
7.71E+00
3.64E+00
2008
2009
2010
2011
2012
2013
2014
2015

**Fig. 15.2.a**


C-14 in Gaseous Emissions
U1 1996 - 2015
kBq released
6.7E+08
5.0E+08
3.4E+08
1.7E+08
0.0E+00
5.76E+07
1.77E+08
2.90E+08
1.70E+08
2.32E+08
1.64E+08
1.24E+08
1.18E+08
1.92E+08
1.07E+08
2.85E+08
2.31E+08
3.30E+08
2.71E+08
2.17E+08
1.07E+08
6.92E+07
1.09E+08
8.20E+07
1.12E+08
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

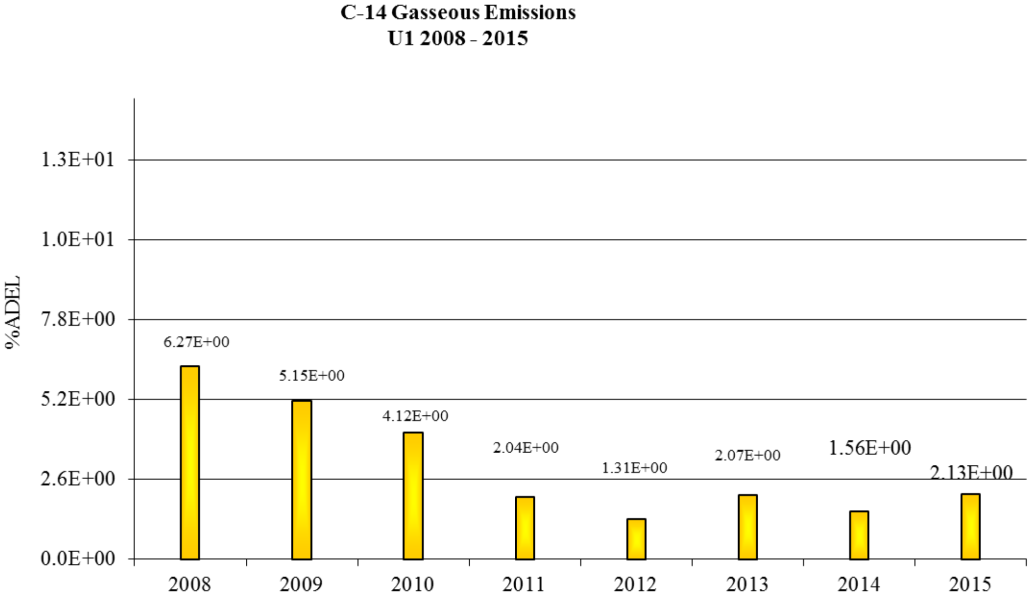
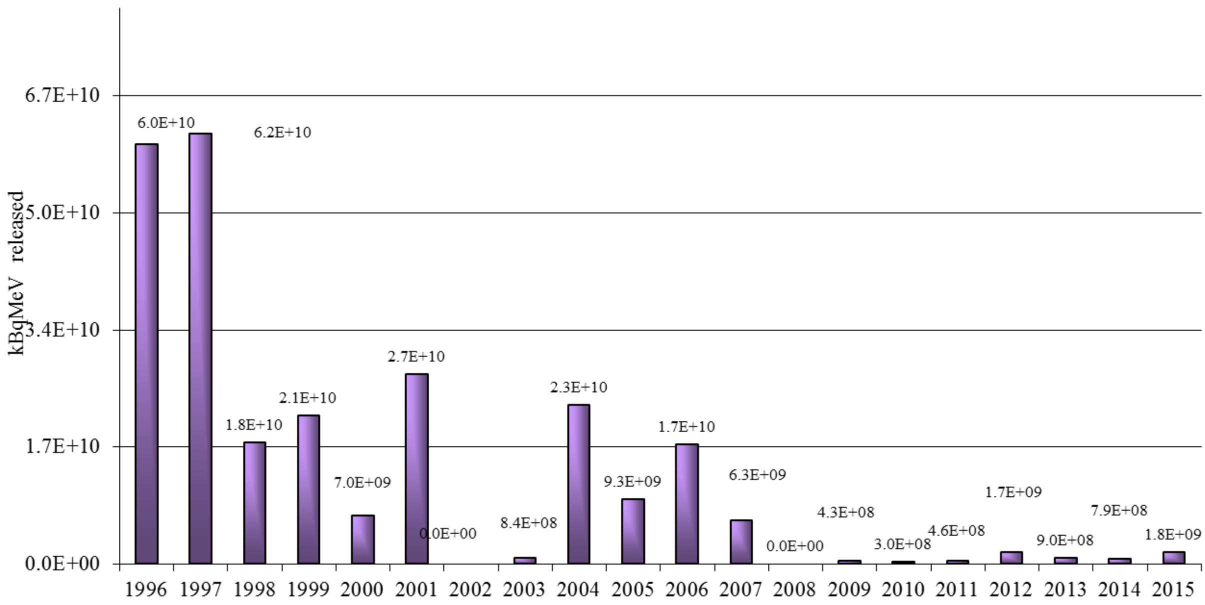

C-14 Gasseous Emissions
U1 2008 - 2015
%ADEL
1.3E+01
1.0E+01
7.8E+00
5.2E+00
2.6E+00
0.0E+00
6.27E+00
5.15E+00
4.12E+00
2.04E+00
1.31E+00
2.07E+00
1.56E+00
2.13E+00
2008
2009
2010
2011
2012
2013
2014
2015

**Fig. 15.2.b**

*Noble Gases Emissions*
*U1 - 1996 - 2015*




**Noble Gasses Emissions**
**U1 2008 - 2015**

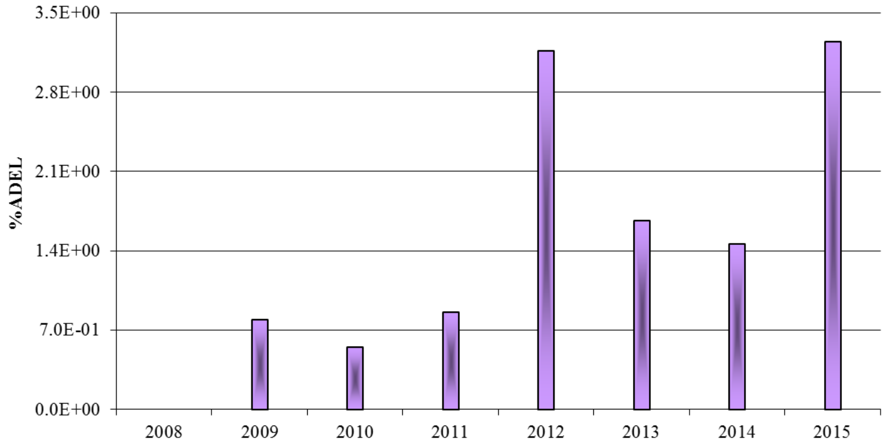
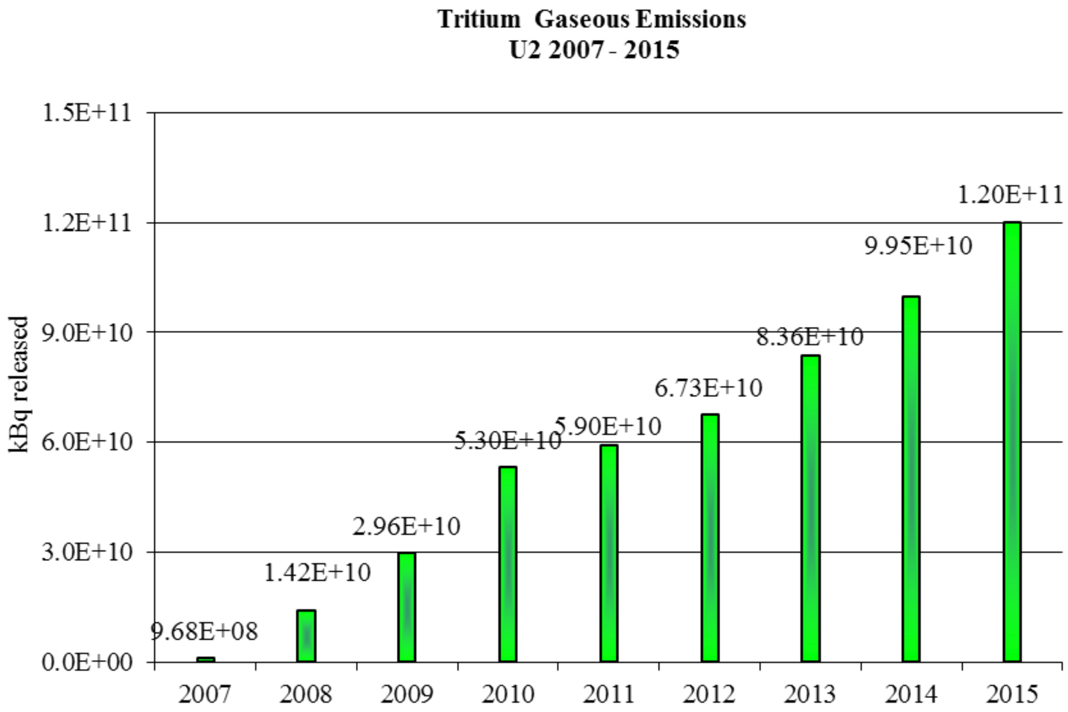



**Fig. 15.2.c**


Tritium Gaseous Emissions
U2 2007 - 2015
kBq released
1.5E+11
1.2E+11
9.0E+10
6.0E+10
3.0E+10
0.0E+00
9.68E+08
1.42E+10
2.96E+10
5.30E+10
5.90E+10
6.73E+10
8.36E+10
9.95E+10
1.20E+11
2007
2008
2009
2010
2011
2012
2013
2014
2015

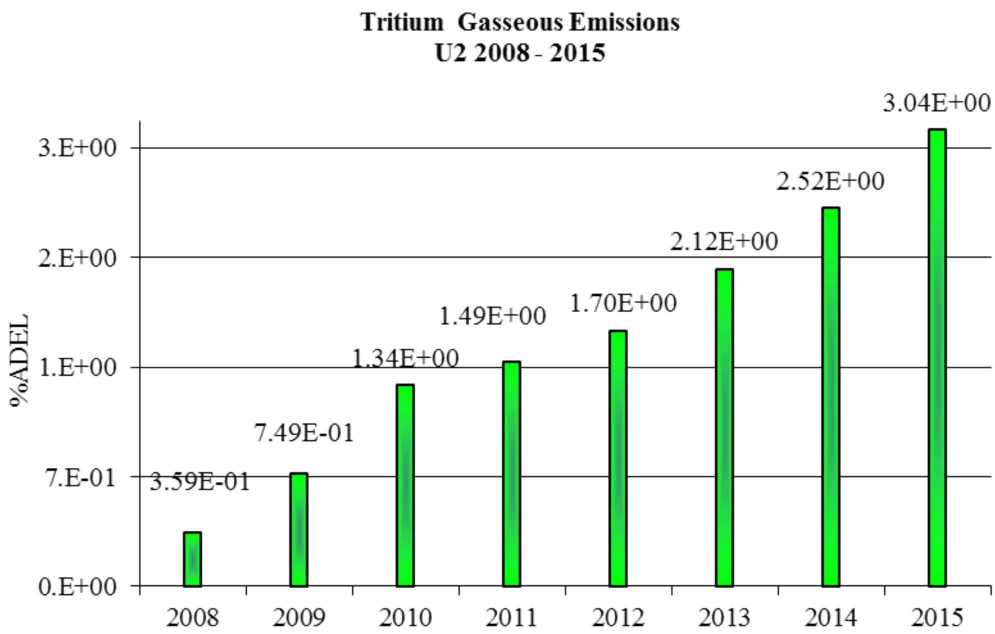
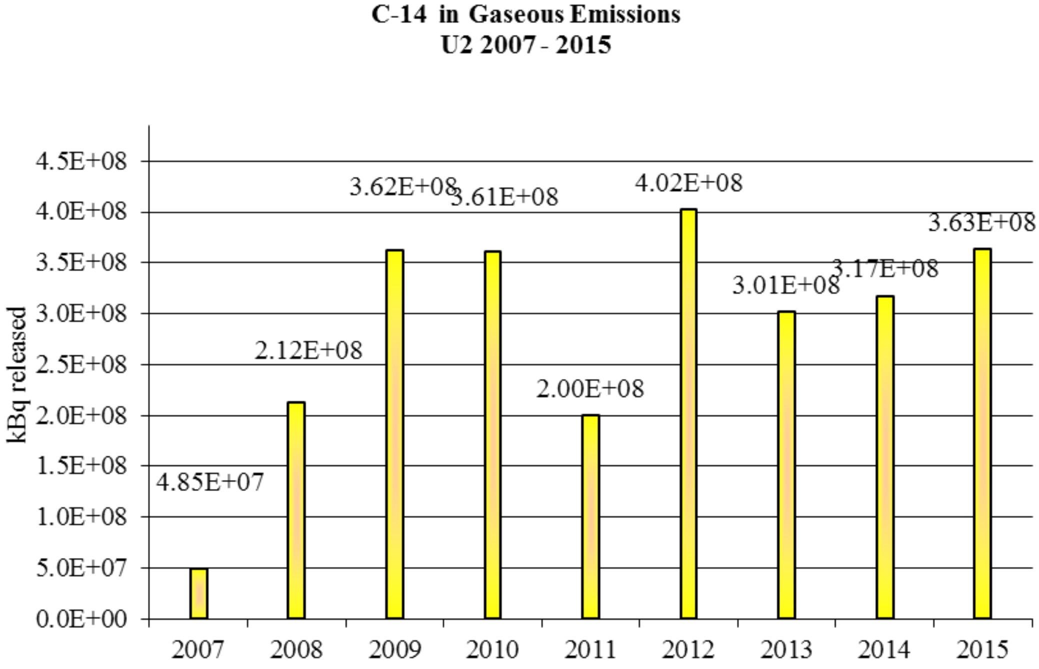

Tritium Gasseous Emissions
U2 2008 - 2015
%ADEL
3.E+00
2.E+00
1.E+00
7.E-01
0.E+00
3.59E-01
7.49E-01
1.34E+00
1.49E+00
1.70E+00
2.12E+00
2.52E+00
3.04E+00
2008
2009
2010
2011
2012
2013
2014
2015

**Fig. 15.2.d**


C-14 in Gaseous Emissions
U2 2007 - 2015
kBq released
4.5E+08
4.0E+08
3.5E+08
3.0E+08
2.5E+08
2.0E+08
1.5E+08
1.0E+08
5.0E+07
0.0E+00
4.85E+07
2.12E+08
3.62E+08
3.61E+08
2.00E+08
4.02E+08
3.01E+08
3.17E+08
3.63E+08
2007
2008
2009
2010
2011
2012
2013
2014
2015

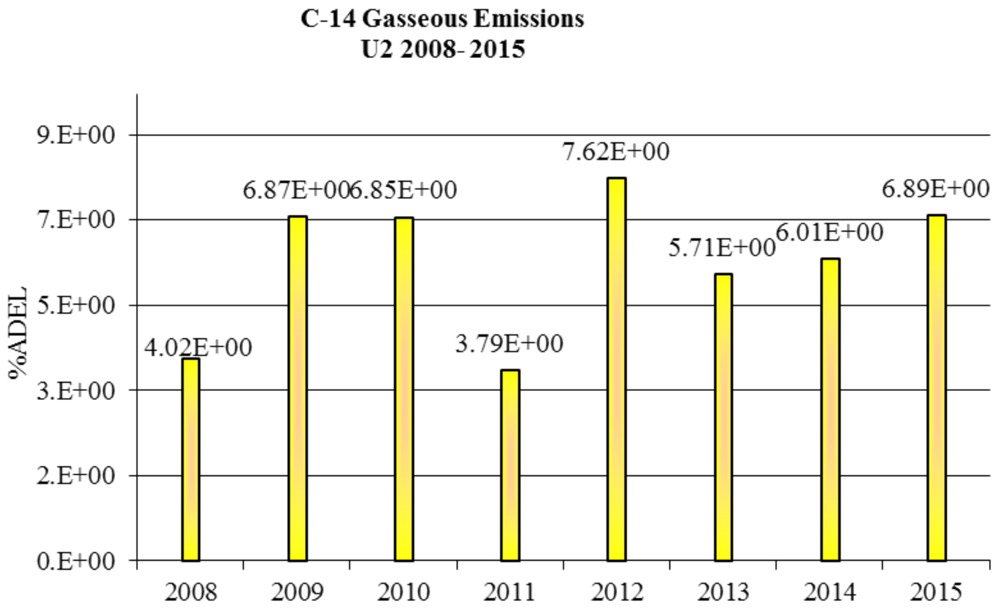

C-14 Gasseous Emissions
U2 2008- 2015
%ADEL
9.E+00
7.E+00
5.E+00
3.E+00
2.E+00
0.E+00
4.02E+00
6.87E+00
6.85E+00
3.79E+00
7.62E+00
5.71E+00
6.01E+00
6.89E+00
2008
2009
2010
2011
2012
2013
2014
2015

**Fig. 15.2.e**

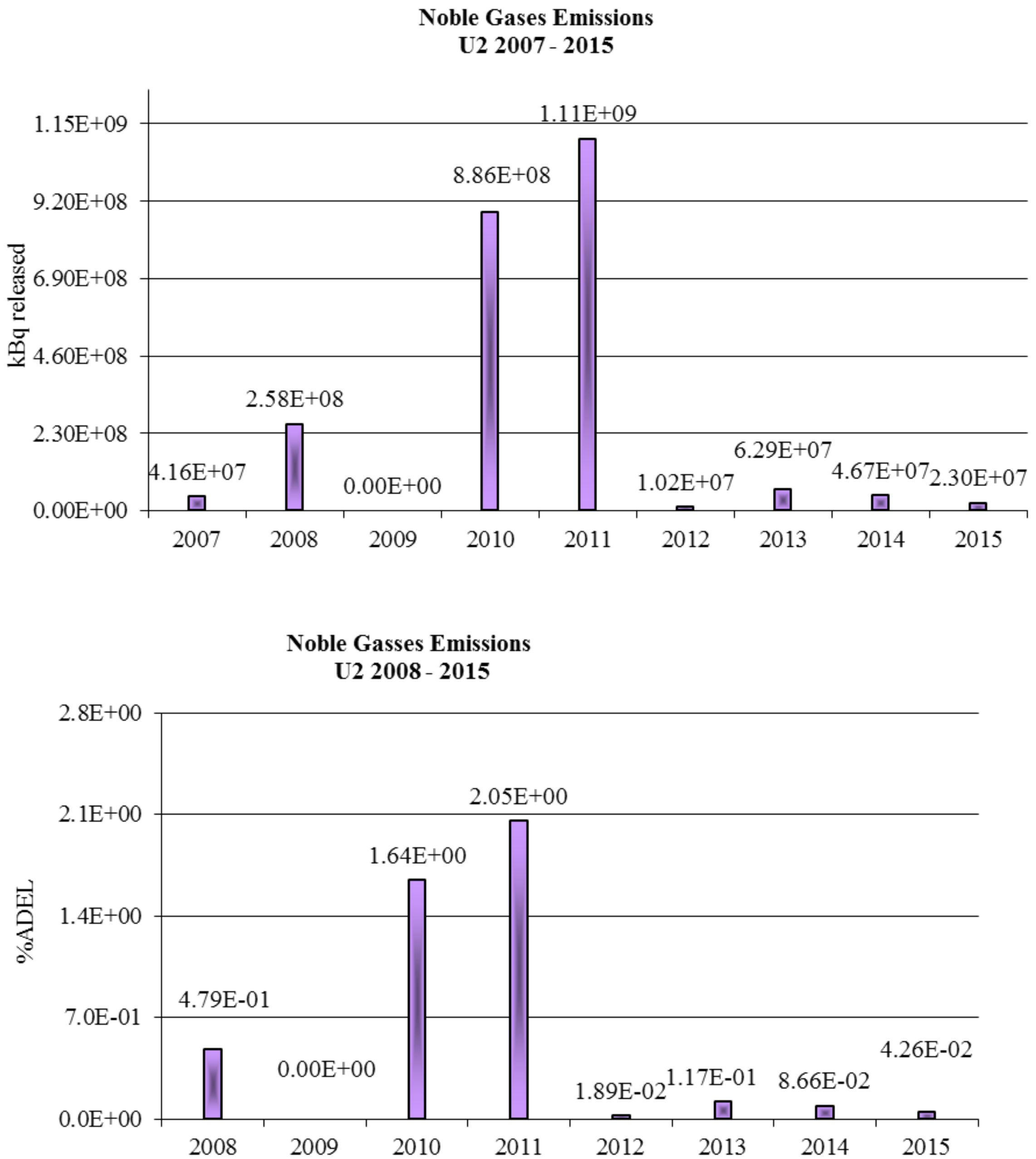
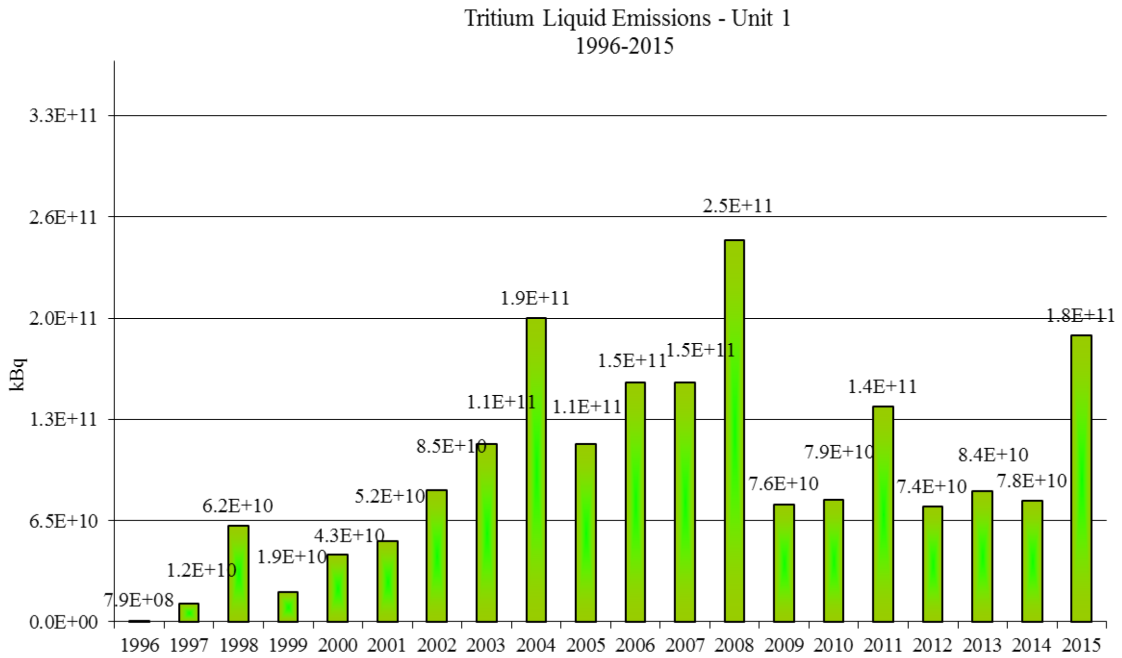

Noble Gases Emissions
U2 2007 - 2015
kBq released
1.15E+09
9.20E+08
6.90E+08
4.60E+08
2.30E+08
0.00E+00
4.16E+07
2.58E+08
0.00E+00
8.86E+08
1.11E+09
1.02E+07
6.29E+07
4.67E+07
2.30E+07
2007
2008
2009
2010
2011
2012
2013
2014
2015
Noble Gasses Emissions
U2 2008 - 2015
%ADEL
2.8E+00
2.1E+00
1.4E+00
7.0E-01
0.0E+00
4.79E-01
0.00E+00
1.64E+00
2.05E+00
1.89E-02
1.17E-01
8.66E-02
4.26E-02
2008
2009
2010
2011
2012
2013
2014
2015

**Fig. 15.2.f**


Tritium Liquid Emissions - Unit 1
1996-2015
kBq
3.3E+11
2.6E+11
2.0E+11
1.3E+11
6.5E+10
0.0E+00
7.9E+08
1.2E+10
6.2E+10
1.9E+10
4.3E+10
5.2E+10
8.5E+10
1.1E+11
1.9E+11
1.1E+11
1.5E+11
1.5E+11
2.5E+11
7.6E+10
7.9E+10
1.4E+11
7.4E+10
8.4E+10
7.8E+10
1.8E+11
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

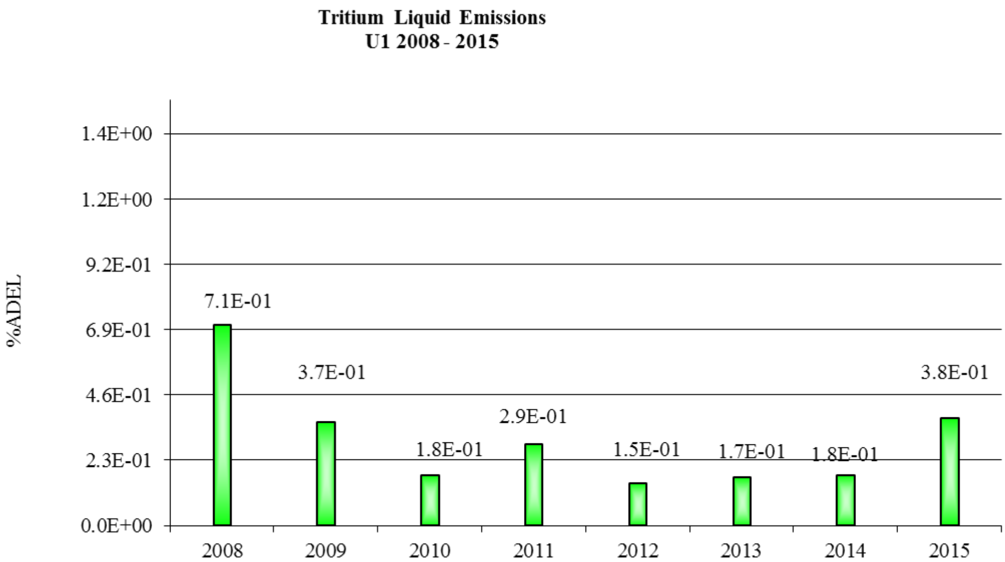
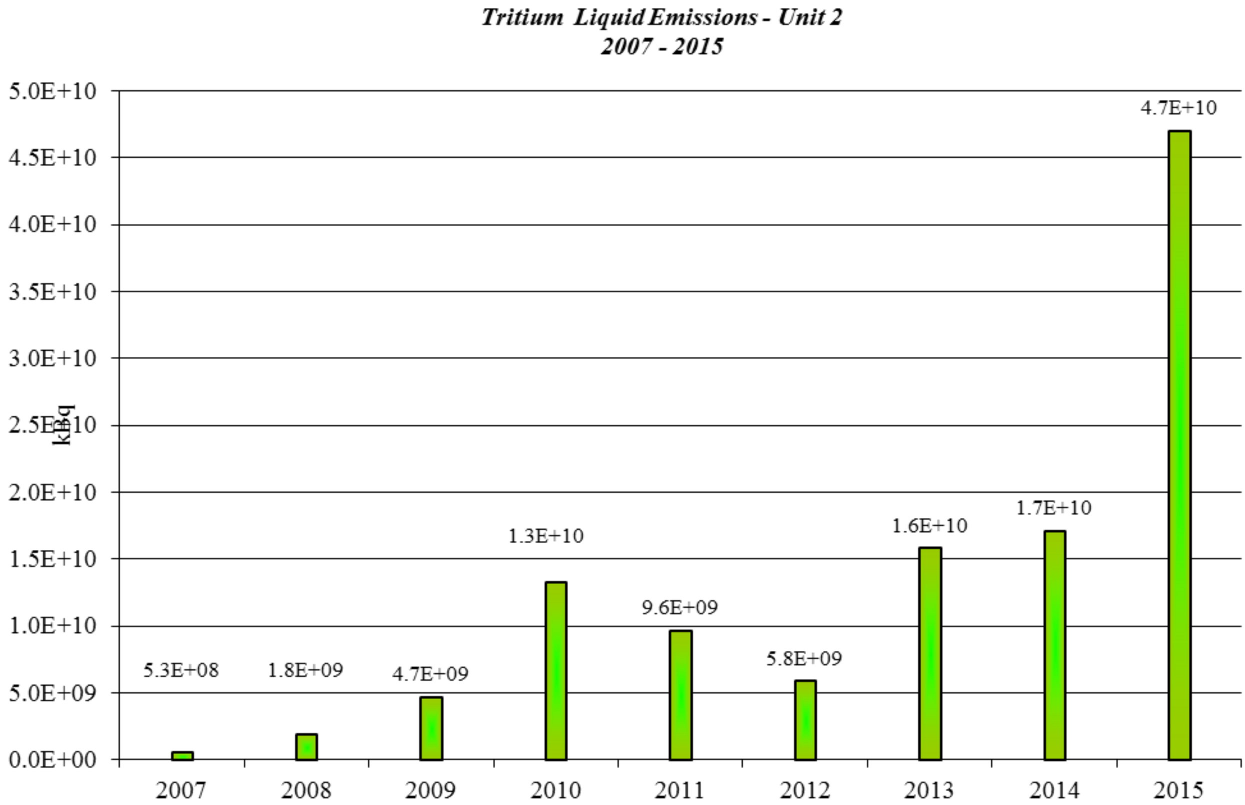

Tritium Liquid Emissions
U1 2008 - 2015
%ADEL
1.4E+00
1.2E+00
9.2E-01
6.9E-01
4.6E-01
2.3E-01
0.0E+00
7.1E-01
3.7E-01
1.8E-01
2.9E-01
1.5E-01
1.7E-01
1.8E-01
3.8E-01
2008 2009 2010 2011 2012 2013 2014 2015

**Fig. 15.3.a**


Tritium Liquid Emissions - Unit 2
2007 - 2015
kBq
5.0E+10
4.5E+10
4.0E+10
3.5E+10
3.0E+10
2.5E+10
2.0E+10
1.5E+10
1.0E+10
5.0E+09
0.0E+00
5.3E+08
1.8E+09
4.7E+09
1.3E+10
9.6E+09
5.8E+09
1.6E+10
1.7E+10
4.7E+10
2007
2008
2009
2010
2011
2012
2013
2014
2015

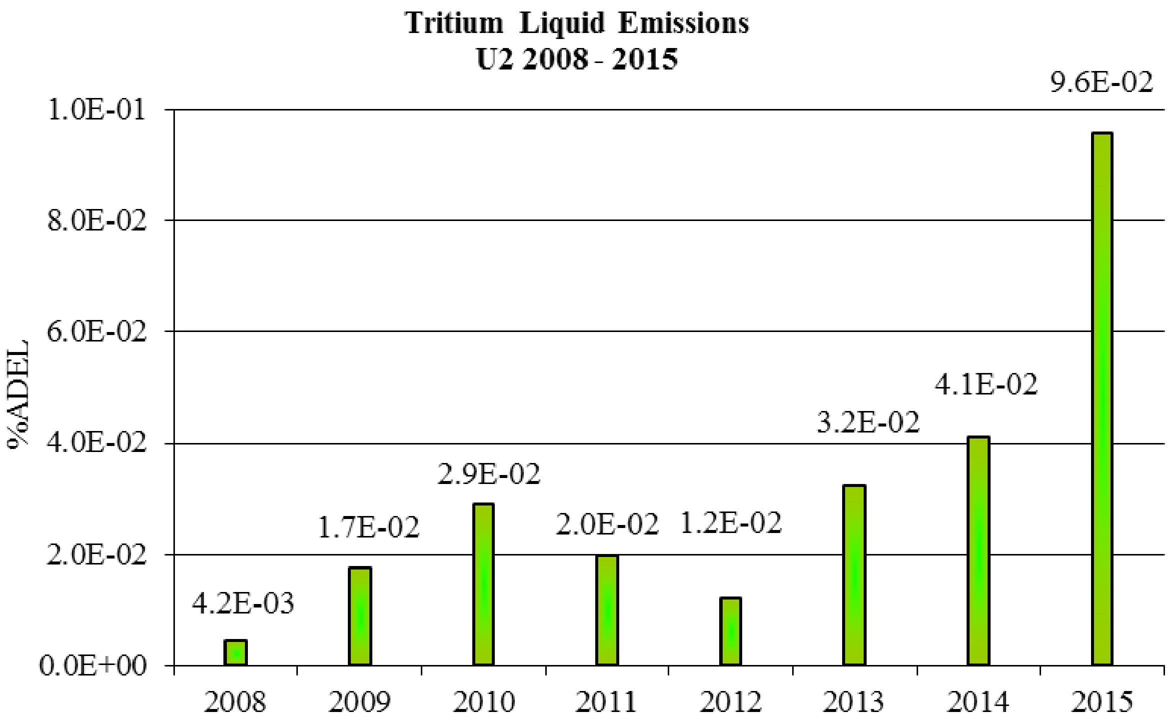

Tritium Liquid Emissions
U2 2008 - 2015
%ADEL
1.0E-01
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
4.2E-03
1.7E-02
2.9E-02
2.0E-02
1.2E-02
3.2E-02
4.1E-02
9.6E-02
2008
2009
2010
2011
2012
2013
2014
2015

**Fig. 15.3.b**

### 15.2.3.2 Environmental Radioactivity Monitoring

The Environmental Radioactivity Monitoring Programme of Cernavoda NPP was designed to assure a correct evaluation of the doses for a member of the critical group, by determining the increases of the radioactive levels in the specific environmental media, due to the NPP operation, a correct assessment of the effluents control and monitoring, based on environmental measurements and an estimation of the doses to population in case of significant radioactive releases.

The environmental radioactivity monitoring in Cernavoda area was started in 1984, based on a preoperational monitoring programme. The operational programme was established and approved in 1995 and implemented in March 1996.

Table 15.1 shows the sample types, sampling frequencies, as well as analytical methods and frequencies established by the environmental monitoring programme of the station. All the samples were analysed in the Environmental Control Laboratory, located at 2 km from Cernavoda NPP Unit 1. Starting with 2002, the laboratory participated on international intercomparison exercises, organized by PROCORAD Association from France, for H-3, C-14 and gamma-spectrometry analyses in urine and water. The results obtained for each category of analyses met the acceptance criteria, the laboratory being designated as “reference laboratory” for C-14 analyses in 2004, 2006, 2007 and 2011 and for H-3 analyses in 2007.

**Table 15.1: Environmental samples type, sampling frequencies, analytical methods and analytical frequencies**

| Environmental media | | Sampling frequency | Analysis Frequency |
|---|---|---|---|
| Airborne particulate | | Monthly (Integrated sample) | Monthly |
| Airborne Radioiodine | | Quarterly (Integrated sample) | Quarterly |
| Airborne Tritium | | Monthly (Integrated sample) | Monthly |
| Ambient gamma (TLD's) | | Quarterly (Integrated sample) | Quarterly |
| Water (surface water from Danube) | | Weekly | Monthly (composite sample) |
| Water ( CCW duct) | | Weekly (Integrated sample) | Weekly |
| Water (underground water from infiltration) | | Monthly | Monthly |
| Water (deep underground water) | | Monthly | Monthly |
| Water (potable water) | | Monthly | Monthly |
| Soil | | Twice a year | Twice a year |
| Sediment | | Twice a year | Twice a year |
| Milk | | Weekly | Weekly (gamma spectrometry and H-3)<br>Monthly (Gross Beta and C-14 on composite sample) |
| Deposition | | Monthly (Integrated sample) | Monthly |
| Fish | | Twice a year | Twice a year |
| Meat | | Annual | Annual |
| Vegetables | | Annual | Annual |
| Leafy vegetables | | Twice a year | Twice a year |
| Fruits | | Annual | Annual |
| Cereals | wheat | Annual | Annual |
| | maize | Twice a year | Twice a year |
| Wild vegetation | | Monthly (May - October) | Monthly (May - October) |

The maps showing the monitoring and environmental sampling points around Cernavoda NPP have been included in the 4th National Report under the Convention on Nuclear Safety.

The environmental radioactivity measurements show the presence of tritium in the majority of environmental samples, the obtained values being comparable with the detection limits.

The distribution of the tritium in air concentration measured in 2015 for the most relevant sampling points and sample types, in comparison with the past years, is presented in the next figure.

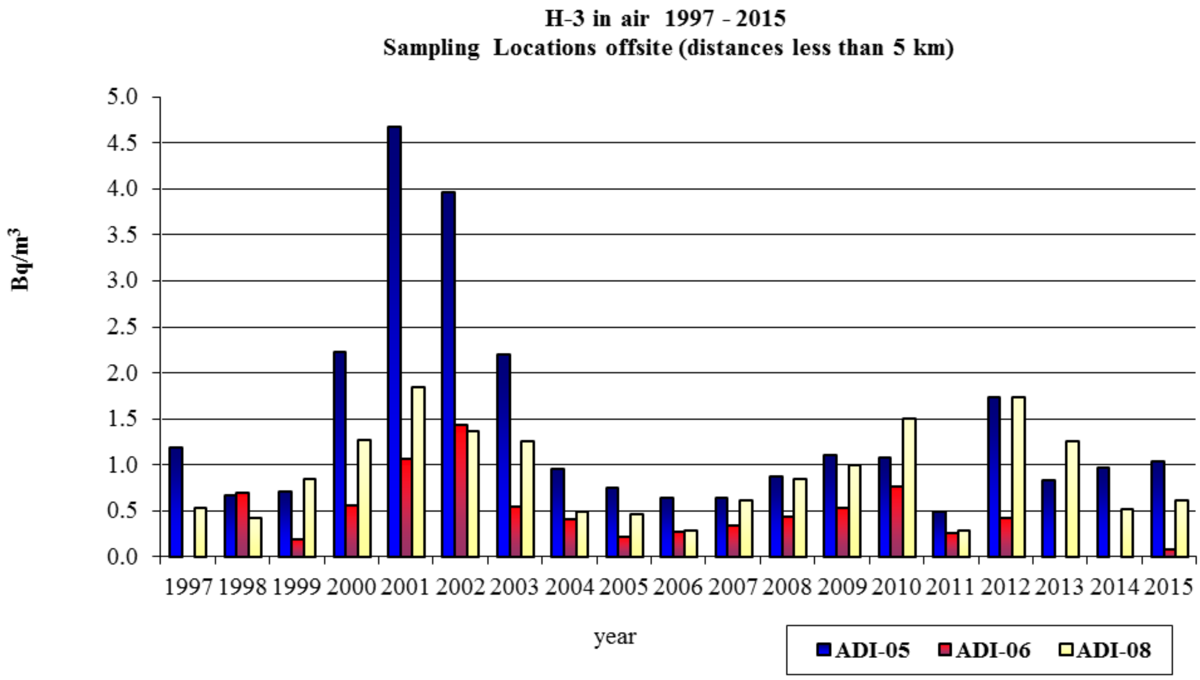



**Fig. 15.4**

The natural concentration of H-3 in air, determined between 1994 and 1996 as part of the preoperational monitoring programme varies between 0.032 Bq/m$^3$ and 0.186 Bq/m$^3$.

Fig. 15.4 shows the evolution of H-3 in air for 3 sampling stations located in the close vicinity of the plant (distances less than 5km).

Fig. 15.5 shows the evolution of H-3 in air for 3 sampling stations located at a distance between 5 and 10 km from the station.

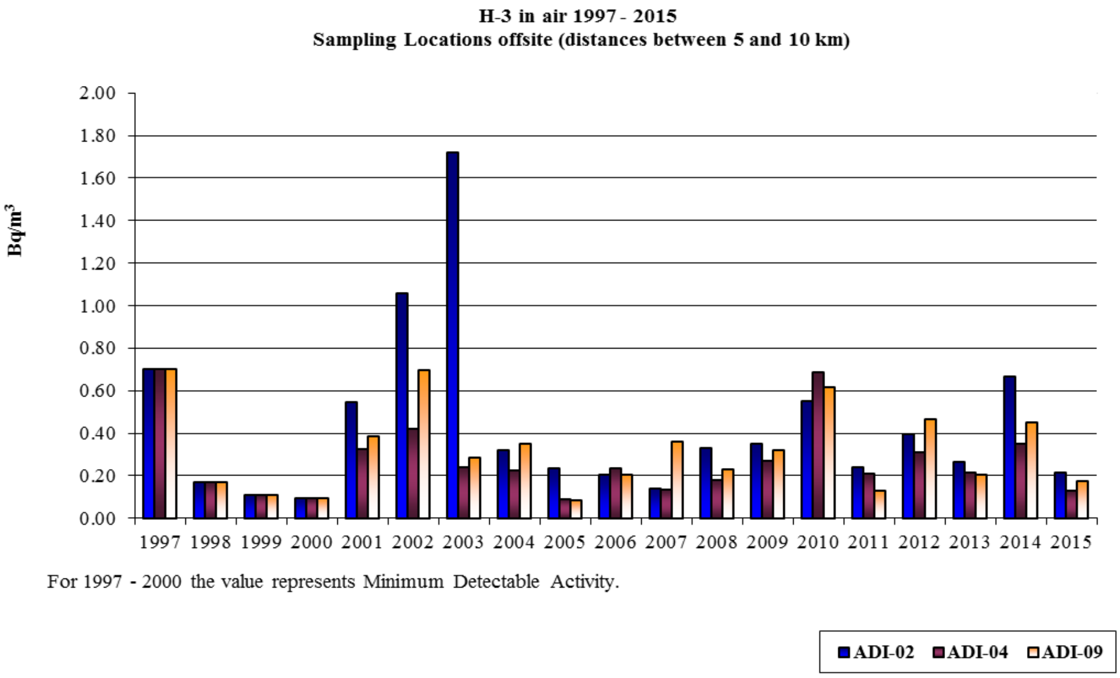



**Fig. 15.5**

As it will be shown in the next paragraph, these levels of tritium in air concentration will lead to very low values of dose to the public, far below the dose constraints approved by regulatory.

The tritium concentration measured in different environmental samples are used to calculate the doses received by the population. Figure 15.6 shows the evolution of the doses to Cernavoda population due to the presence of tritium into the environment.

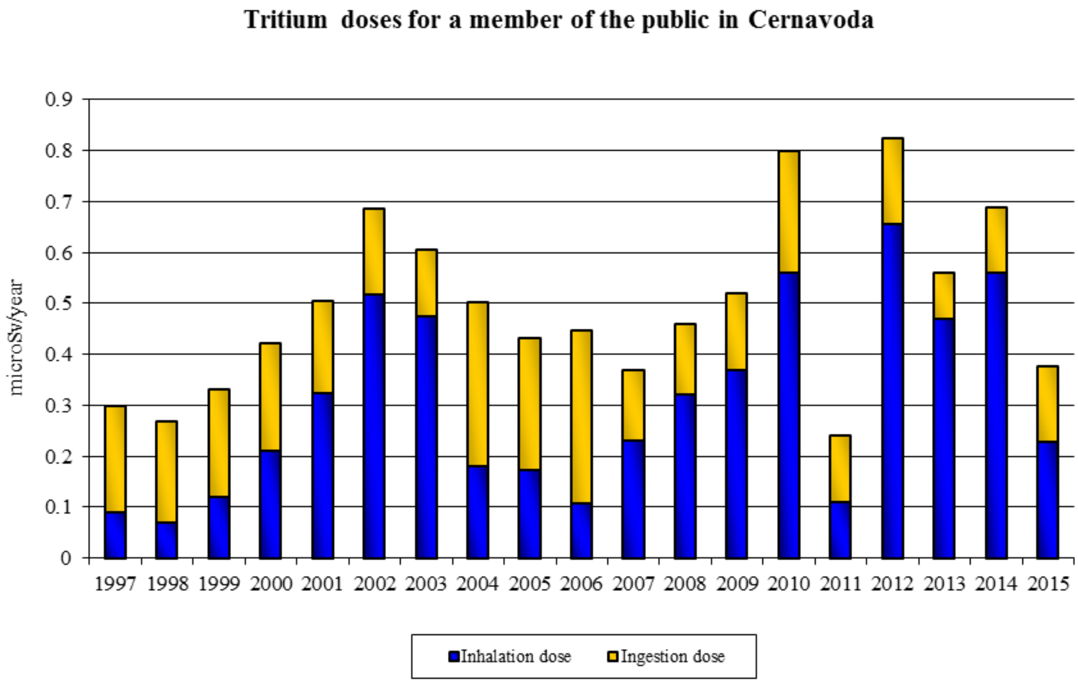



**Fig. 15.6**

According to art. 88 of the Requirements for the Monitoring of Radioactive Emissions from Nuclear and Radiological Installations, the licensee shall monitor the radioactive effluents at the source, as well as in the receiving media, as requested by the applicable CNCAN regulations and shall present the results of both the associated monitoring programmes, in such a form to demonstrate the conformity with the dose constraint established by CNCAN. Furthermore, as stipulated in art.16 of the above mentioned Requirements, the licensee shall assure the validity of the dose calculations based on the radioactive emissions using the results of the environmental radioactivity monitoring programme.

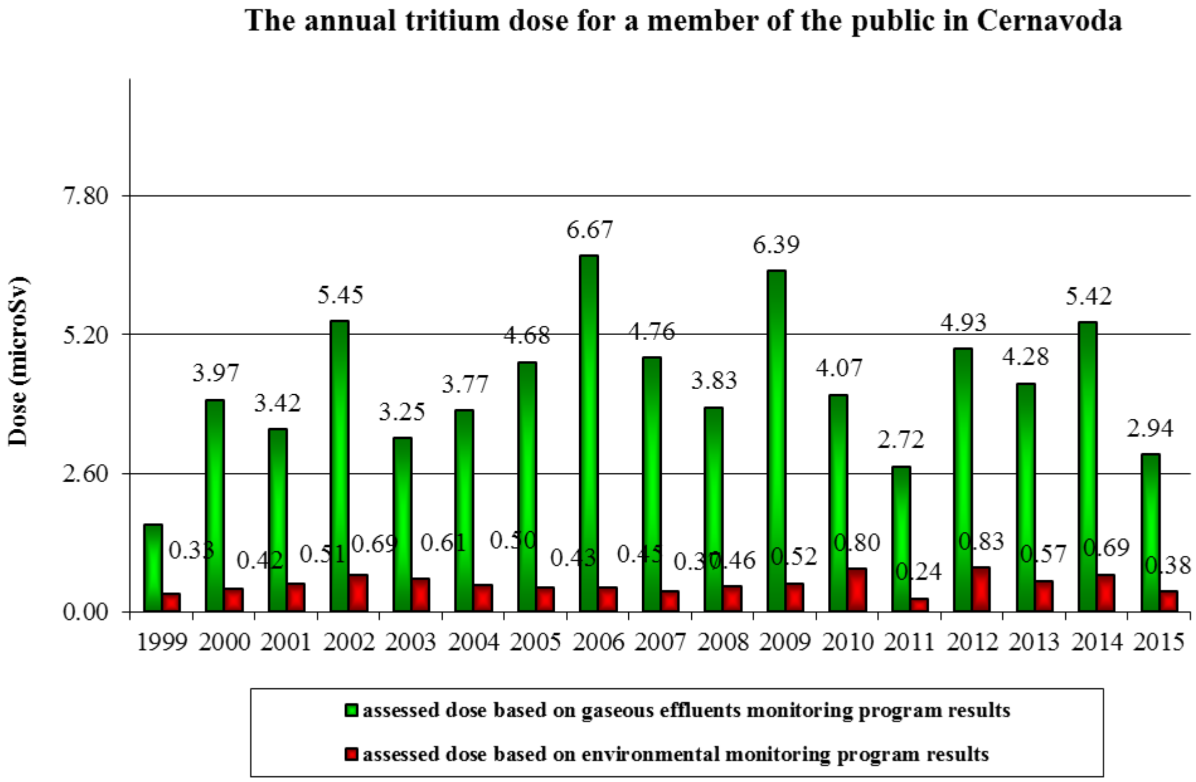



**Fig. 15.7**

Fig. 15.7 shows the evolution of the doses received by the population of Cernavoda, due to the presence of tritium in the surrounding environment, calculated with the results of both programmes (effluents monitoring and environmental monitoring programme). As can be seen, the doses calculated based on the tritium emissions data are with one order of magnitude higher than those calculated based on the tritium concentrations measured in the environmental samples. This demonstrates not only the doses to population are below the dose constraint for Cernavoda NPP (with one to two orders of magnitude), but also the models used for calculating the Derived Emission Limits are conservative.

The results of the monitoring programmes deployed by Cernavoda NPP are verified for their validity, by the different responsible Romanian authorities. According to the legislative framework in Romania, the main ministries and organizations having responsibilities in the field of environmental radioactivity monitoring (including the surveillance of food stuffs) are:

- Ministry of Environment and Climate Change, which organises the Environmental Radioactivity Monitoring Network on the Romanian territory;
- Ministry of Health, which organises the epidemiological monitoring system of the

health condition of the occupationally exposed personnel and of the hygiene conditions in nuclear installations, follows up the influence of nuclear activities on the population health;
- National Commission for Nuclear Activities Control (CNCAN);

According to the Law on the safe deployment, regulation, licensing and control of nuclear activities, CNCAN is empowered to control the licensee, in order to verify the compliance with the national legal requirements and licensing conditions. In addition, the art.111 of the Requirements for the monitoring of radioactive emissions from nuclear or radiological facilities stipulates that in the case of nuclear installations that may have a significant environmental impact, CNCAN may deploy its own environmental radioactivity monitoring programme in the vicinity of the nuclear installation, in order to check the results supplied by the licensee and to confirm that public exposure to radiations is maintained below the dose constraints imposed by CNCAN.

#### 15.2.3.2 Impact of Cernavoda NPP operation on biota

The concept of sustainable development confers the environmental protection the same status with that of the human protection, based on the idea that we first need to protect the environment in order to protect the man (Protection of the environment from the effects of ionizing radiation, IAEA-TECDOC-1091, International Atomic Energy Agency, Vienna). In this context, a study was conducted on the impact the operation of the two units may have on living organisms in the area of Cernavoda NPP in 2009-2011.

The study focused on the assessment of the chemical and radiological impact on flora, fauna and the environment (water, air, soil, sediment), based on over 80 types of complex analysis (X-ray fluorescence, GCMS, LSC, HPLC, genetic analysis).

During next years the decision to extend the monitoring regarding the impact nuclear power production has on the environment, by including plants and animals, was made based on the new approach regarding environmental protection, in which other critical aspects except man are taken into consideration.

As consequence, Cernavoda NPP implemented a continuous project of monitoring the impact on aquatic and terrestrial biota, conducted by certified laboratories, which proves that Cernavoda NPP Operation has not any significant hazardous effect on environment.

### 15.2.4 Optimisation of Radiation Protection

#### 15.2.4.1 Radiation Workers

As requested by art.16 of NFSR, the licensee shall take all the necessary actions to optimise the radioprotection, by ensuring that all exposures to ionising radiation, including the potential ones, are maintained at the lowest reasonably achievable level (ALARA principle).

In order to keep the radiation exposures as low as reasonably achievable, the NPP has applied various measures, including design measures, procedural control of activity performance, planning for unusual situations, personnel training and qualification in radiation protection, specific procedures, such as:
- ALARA process

- Radiation Work Permit process

In order to implement the ALARA process, two committees have been established at Cernavoda NPP:

- Technical ALARA committee, which analyses and approves the action plans to reduce the exposures at the departments level, proposes the ALARA objectives and targets at NPP level, periodically approves the ALARA results and recommends programmes to improve the ALARA process; this committee is lead by the Station Health Physicist and it is composed by the Plant ALARA Coordinator and ALARA Coordinators of the main departments of the plant: Operations, Maintenance, Fuel Handling, Health Physics, Chemical Laboratory, Non Destructive Examinations Laboratory);
- ALARA NPP committee, which approves the ALARA objectives and targets at NPP level, analyses the evolution of ALARA indicators and proposes actions for correcting and changing those objectives, analyses the opportunity to implement specific ALARA actions; this committee is lead by the Plant Manager and is composed by the Technical Manager, Production Manager, Station Health Physicist, Operations, Maintenance and Planning Superintendents, Plant ALARA Coordinator.

A significant improvement of ALARA policy was done at NPP Cernavoda by implementing an effective ALARA process. Senior managers are directly involved in ALARA process as members of the ALARA committee. This committee is responsible for approving and reviewing the station ALARA long term plan. It meets periodically to review the performance of the facility in relation to radiation protection, to approve performance indicators and, periodically analyse plant performances, to evaluate suggestions for reducing doses and to review high collective dose jobs.

Also, a long term reduction dose plan was approved by ALARA Committee as a tool of ALARA policy; this plan integrates CNE Cernavoda radiation protection projects in order to optimize occupational exposures and reduce environment impact. This plan includes the main actions for keeping doses ALARA based on the newest radiation protection search results and, the best industry good practices.

Another practical measure to control the radiation exposures is the Radiation Work Permits process, through which the activities deployed in radiological risk areas are identified, so that the radiological conditions are assessed, in order to establish and implement the adequate radioprotection measures. If the estimated collective dose for a certain work exceeds certain established levels, supplementary analyses and approvals are needed to deploy the respective work. For example, if the estimated collective dose is higher than 5 man*mSv, the ALARA coordinator of the compartment must issue an ALARA action plan, which must include all the supplementary radioprotection measures, the progress of the work, the preliminary requirements and the techniques for controlling the exposure. During the progress of the work, the collective dose is monitored against the estimated one, so that the necessary measures for optimizing the exposures could be taken in due time. After completion of the work, an analysis of the estimated against received values must be done, in order to identify the efficiency of the dose reduction and special working techniques, the problems occurred and the lessons learned, the probable causes for significant discrepancies between received and estimated collective doses, if there is the case.

Fig.15.8 shows the evolution of the annual collective total and internal doses registered at Cernavoda NPP. The maximum value (918 man·mSv) was registered in 2012 and it was caused by the extended 38 days outage at Unit #1, two unplanned outages at Unit #1 and three radiological events that had a significant impact on individual and collective doses.

The increasing number of employees under dosimetric surveillance did not cause a proportional increase of the collective doses and of the number of exposed workers with doses above recording level. It should be noted that the 388 man mSv for the year 2015 and 918 man mSv for 2012 represent the collective doses for both Unit 1 and Unit 2, with extended planned outages in Unit 2 (2015) and Unit 1 (2012). The actual levels of total effective doses due to internal and external exposures reveal the effectiveness of implementation of the Radiation Safety Policies and Principles, based on the ALARA principles.

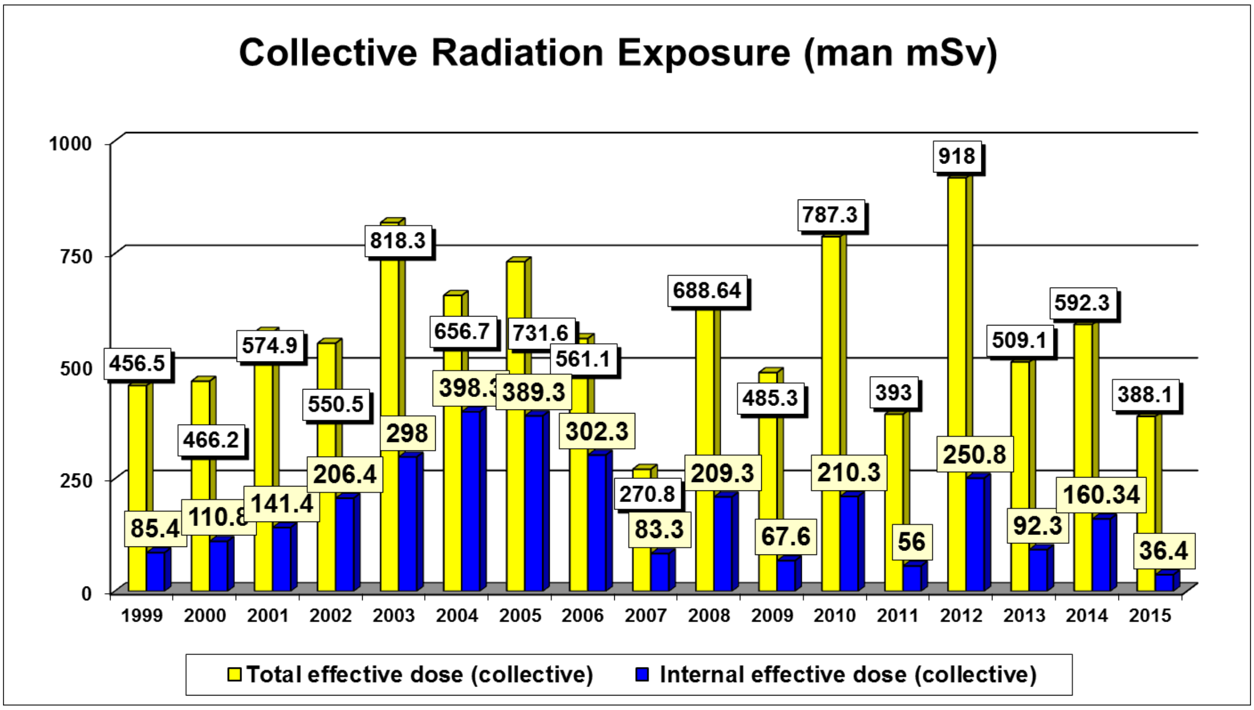



**Fig.15.8**

### 15.2.4.2. Public

According to art.18 of NFSR, the dose constraints for the public, established by CNCAN, shall be used as superior margin in the radioprotection optimisation process. This must be done by using the dose constraint into the calculations of Derived Emission Limits (DEL), as stipulated by the new CNCAN Requirements for Limiting Radioactive Discharges into the Environment (issued in 2005).

For this reason, the NPP reviewed in 2007 its DELs, which have been fully implemented by the 1st January, 2008, the major changing being the use of the dose constraints established by CNCAN for Cernavoda NPP (0.1 mSv/year for each unit and 0.05 mSv/year for Spent Fuel Intermediate Dry Storage facility) instead of the legal dose limit for population (1 mSv/year) in the calculation of DELs.

As a consequence of recalculation of DELs, and in order to accomplish the requirements of the new CNCAN Requirements for the Monitoring of Radioactive Emissions from Nuclear and Radiological Installations and the Requirements for the Environmental Radioactivity

Monitoring around Nuclear and Radiological Installations, the NPP also revised in 2007 the Radioactive Release Monitoring Programme and, respectively, the Environmental Radioactivity Monitoring Programme. Both programs are fully implemented since 2008.

### 15.2.4.3 Detritiation project

The design features of a CANDU reactor for ensuring the control of tritium can be considered as conceptual barriers which prevent and minimise the occupational exposures to tritium and the tritium emissions into the environment.

The fundamental method to mitigate both the occupational and the public exposure to tritium consists in reducing the tritium concentrations into the heavy water by „detritiation", in this way the consequences of heavy water leaks being reduced at their source. The efficiency of the following barriers is decreasing in this order: tightening of leaks, vapours recovery, confinement, purging.

In this respect, Cernavoda NPP initiated a project for a detritiation facility for Unit 1 and Unit 2, and eventually, with extension possibilities for Unit 3 and Unit 4.

The main objectives of the project are:

- to reduce and maintain the tritium concentration in moderator heavy water at about 10 Ci/kg;
- to reach the above mentioned target in 3 – 4 years of operation;
- upgrading heavy water to about 99.95%.

The conceptual design is complete and the licensing basis are already agreed with the Regulatory Body for this project. The next step of the project is to obtain the approvals for the project implementation which will consist of obtaining the licences and contracting the detailed design, construction and commissioning.

## 15.3 Significant developments for the last reporting period

Cernavoda NPP reduced the effective dose administrative limit for the occupationally exposed workers from 18 mSv/year of 14 mSv/ year to maintain occupational exposure ALARA.

Cernavoda NPP dosimetry programme was improved in order to introduce individual monitoring of occupationally exposed workers for alpha emitting nuclides internal contamination.

## ARTICLE 16 - EMERGENCY PREPAREDNESS

*1. Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.*
*2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.*
*3. Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.*

### 16.1 Description of the legislative and regulatory framework for on-site and off-site emergency planning and preparedness

Emergency preparedness and response in Romania is organised in accordance with the Law 15/2005 for the approval of the Governmental Ordinance no. 21/2004, regarding the National System for the Management of Emergencies. Other applicable regulations (Governmental Decisions) are mentioned as follows:

- GD no. 94/2014 regarding the organisation, functioning and componence of the National Committee for Special Emergency Situations (CNSSU)
- GD no. 1491/2004 for the approval of the frame Regulation on the structure, attributions, functioning and endowment of the committees and operative centres for emergencies;
- GD no. 1492/2004 on the organisational and functioning principles and attributions of the professional emergency services;
- GD no. 557/2016 regarding the management of various types of risk; this GD outlines the main support functions which the ministries, state authorities and non-governmental organisations have to perform in order to prevent and manage emergency situations.

The national emergency response scheme, as established by this legislation, is described in section 16.2.2.

The Law on the safe deployment, regulation, licensing and control of nuclear activities stipulates, as one of the licensing conditions, the obligation of the applicant to institute and maintain his own approved system for the intervention in case of nuclear accidents. Also, the licensee has the obligation and responsibility to take all necessary measures in order to ensure and maintain his own emergency plan in case of nuclear accident, and the development of his own system of requirements, regulations, and instructions ensuring the deployment of licensed activities without unacceptable risks of any kind. The responsibility for nuclear damage caused during or as a result of an accident that might occur by deployment of the activities under the license or of other activities resulting in the death, damage to the corporal integrity or health of a person, destruction, degradation, or temporary impossibility of using some goods rests entirely upon the licensee, under the terms established by law and by international commitments Romania is a party to.

The co-ordination of the intervention preparations in case of nuclear accident shall be ensured by the National Committee for Special Emergency Situations (CNSSU) within the Ministry of Internal Affairs (MAI), in co-operation with all specialised bodies of the central and local public administration with powers in these matters. The intervention plan in case of nuclear accident for the site of nuclear installations shall be developed by the licensee, together with all the responsible central and local public authorities and specialised organisations; the on-site intervention plans shall be approved by CNCAN, which has also the responsibility to evaluate periodically and control the applicability of the plan.

The intervention plans in case of radiological emergencies, caused by nuclear accidents in NPPs located on the territory of other states that may affect the Romanian territory, by transboundary effects, as well as the general off-site intervention plans for nuclear plants on the Romanian territory are prepared by the General Inspectorate for Emergency Situations (IGSU) within MAI. These general intervention plans are submitted for approval to CNSSU and their applicability has to be periodically assessed and controlled by IGSU. The central and local public authorities with powers in the field of preparedness and practical response to a nuclear accident are responsible for developing their own plans correlated with the general intervention plan. These plans must be approved by the respective authorities, with the advice of IGSU, and their applicability has to be periodically assessed and controlled by IGSU.

According to art. 5 of the Law, CNCAN is empowered to issue regulations for the detailed specification of the general requirements on intervention in case of nuclear accidents. In this respect, specific requirements are provided in the following regulations:

- Fundamental Requirements on Radiological Safety (NFSR);
- Specific Requirements for the Quality Management Systems applied to the Operation of Nuclear Installations (NMC-10);
- Nuclear Safety Requirements on Emergency Plans, Preparedness and Intervention for Nuclear Accidents and Radiological Emergencies (approved by Ministerial Order No. 242/1993);
- Nuclear Safety Regulations on Preparedness for Response to Transients, Accidents and Emergencies at Nuclear Power Plants (approved by CNCAN Order No. 3/2014);
- Regulations and Requirements on Planning and Preparedness for Intervention to Nuclear or Radiological Emergency (approved by CNCAN Order No. 69/2014).

Chapter X of NFSR includes specific requirements regarding the radiation protection in interventions, stipulating that, for obtaining a licence from CNCAN, for any nuclear activity, the applicant shall take into consideration all types of radiological emergencies which could arise from the practice, assesses the spatial and temporary distribution of radioactive substances dispersed in case of radiological emergencies and, consequently the corresponding potential exposures. Based on these evaluations, the applicant shall elaborate an adequate intervention plan, at all necessary levels, commensurate with the extent of all possible types of radiological emergencies.

The licensee is responsible to ensure that intervention plans are tested to an appropriate extent at regular intervals. Also, the licensee is responsible to notify immediately any radiological emergency occurring on site and to take all the necessary measures to reduce the consequences of the radiological emergency. For the adequate accomplishment of its own tasks concerning the intervention, the licensee has to perform an initial provisional assessment of the circumstances and the consequences of the radiological emergency and to communicate it immediately to the competent authorities. As a general principle, the intervention has to be focused on the source, to reduce or stop the direct radiation and radioactive emissions, to reduce the transfer of radioactive substances to the environment and to the individuals, to reduce exposure and organise the treatment of victims.

According to art. 182 of NMC-10, the analysis, approval and revision of the on-site emergency intervention plan shall be controlled and the responsible public authorities shall have the possibility to analyse each revision of the plan, to ensure the coordinated reaction to any emergency situation and at any moment. The on-site emergency intervention plan shall include the following elements:

a) classification of events that generate emergencies and the response to emergency situations;
b) notification and action of the emergency organisation, including the normal and alternative communication means, both on site as well as with the external emergency organisations;
c) necessary actions to meet the objectives of the emergency plan;
d) competence and responsibilities of the emergency organisation;
e) technical assessment of the emergency situation and the implications, including the conditions in the installation, the radiological protection and the damage of the reactor core;
f) actions to protect the personnel in the installation or on site, including the census of the personnel and the evacuation;
g) recommendation of all off-site protective actions outside the installation for the external emergency organisations;
h) ensuring the timely and accurate information of the responsible public authorities, including mass-media communication;
i) agreements with the external organisations supporting the emergency plan and the applicable procedures;
j) organisation, authority and responsibilities for the coordination of the re-entering the installation and recovery actions;
k) identification of emergency planning zones, equipment and resources;
l) detailed references to the emergency operation procedures and emergency response actions for rescue, operation of the security systems and of the communication ways.

Nuclear Safety Requirements on Emergency Plans, Preparedness and Intervention for Nuclear Accidents and Radiological Emergencies, approved by Ministerial Order No. 242/1993 (this regulation will be further referred to as MO 242/1993) established the specific actions to be taken by the operator, competent authorities and other responsible public authorities for planning, preparedness and intervention in the following cases:

- nuclear accidents at nuclear installations;
- radiological emergencies resulted from licensed practices;
- radiological emergencies resulted from transboundary effects.

According to these requirements, any operator of a nuclear installation has to make preparations, in conjunction with national, regional and local public authorities and support organisations, for coping with nuclear accidents. Also, a General Emergency Plan has to be prepared for any nuclear risk area in the country, which may be threatened by a radiation emergency. This Plan shall cover all activities planned to be carried out by all responsible authorities and organisations involved in case of an emergency situation leading to, or likely to lead to, a significant release of radioactivity beyond the site boundary of the nuclear facility.

Art. 8 of MO 242/1993 stipulates that the initial fuel loading of a nuclear reactor is only permitted provided that the licensees and the public authorities have established the emergency intervention plans and have proved, by means of an exercise, that they are prepared for emergency situations. In other words, the organisation of this exercise constitutes a prerequisite for obtaining CNCAN approval for the Fuel Loading milestone of the commissioning phase of a NPP. Furthermore, as stipulated in art. 186 of NMC-10, the operator shall establish a plan to perform the exercises and verifications for the testing of all emergency plan elements and shall perform a detailed annual analysis of the emergency response, in order to establish corrective actions to ensure the maintenance of the necessary capability to respond to emergency situations.

The MO 242/1993 is still in process of being revised and completed by other specific requirements, as part of the process of harmonisation of the national legislation with the latest international standards and recommendations.

## 16.2 Implementation of Emergency Preparedness Measures, Including the roles of the Regulatory Authority and of the other organisations

### 16.2.1 Classification of emergency situations

In the On-site Emergency Plan of Cernavoda NPP, the emergencies are classified as follows:

- Alert;
- Facility Emergency;
- Site Area Emergency;
- General Emergency.

As stipulated in the On-site Emergency Plan of Cernavoda NPP, in case of radiation emergencies the response actions should begin without any delay and be coordinated from the start. To facilitate this, an event classification system was established, in order to predefine the response actions for each emergency class. The events are classified on the basis of the actual or potential consequences of an incident for the public, environment, station personnel and property.

The classification criteria at Cernavoda NPP are the following:

- station / systems / personnel status;
- radiation hazards.

In order to classify the events, the radiation hazards criteria are applied in those cases when the dose rates increases are associated with the station / systems / personnel status impairment.

Based on the station / systems / personnel status, the events are grouped in:

a) Events in operating at power or zero-power hot mode. The classification of the events in operating at power or zero-power hot mode is given in Appendix 16.1 and includes radiation events at nuclear systems, grouped upon the safety function impairment:
   – loss of reactivity control;
   – inadequate fuel cooling;
   – containment isolation system impairment.

b) Events in zero power cold or HTS drained to the header level. The classification of the events in zero power cold or HTS drained to the header level is given in Appendix 16.2 and includes radiation events at nuclear systems, grouped in order of loss fission product barriers.

c) Events free of the reactor state. The classification of the events free of the reactor state is given in Appendix 16.3 and includes:
   – radiation events at Spent Fuel Bay, Shielded Work Station or Intermediate Dry Spent Fuel Storage;
   – security events;
   – external events;
   – other events, such as: Main Control Room unavailability events, fires, chemical incidents, medical incidents, etc.

Based on the radiation hazards, the events are classified taking into account:

- the radiation levels expressed in terms of external dose rates, determined on the base of the surveys and sampling performed by the on-site and off-site survey teams and On-site/Off-site Gamma Monitoring System readings;
- the total activity released to stack, determined on the base of laboratory analyses of Gaseous Effluent Monitors filters and Gaseous Effluent Noble Gases Monitor readings;
- the activity in the containment, determined on the base of results provided by the Post Accident Sampling System;
- tritium dose rates in normally occupied areas of the station.

The classification of the events based on the radiation hazards is given in Appendix 16.4.

**Appendix 16.1 – Emergency classification in operating at power or zero-power hot mode**

| For the following plant conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| **LOSS OF REACTIVITY CONTROL** | | | | |
| Early Loss of Core Structural Integrity<br>*Any event at full power that leads to an imbalance between power generated and power removed by the coolant. All the control and shutdown systems are assumed to fail. This includes the failure of RRS with both the setback and stepback functions, the failure of SDS#1 and the failure of SDS#2. The shutdown of the reactor is caused by moderator displacement as a result of steam discharged from the failed fuel channels. The discharge of superheated steam from many ruptured channels can damage calandria vessel and pressurize containment to failure.* | • Fast reactivity increase (severe power excursion) caused by LOCA<br>• Loss of reactivity control<br>• Decreased coolant flow (loss of HTS pumps) + failure to shutdown the reactor. | | | |
| **INADEQUATE FUEL COOLING** | | | | |
| Late loss of core structural integrity at high HTS pressure<br>*Any event, which will lead to loss of all heat sinks with the reactor at decay power. HTS is initially intact with decay heat being removed for a period of time by the boiling of the steam generators inventory (steaming through the MSSV) and by boiling the HTS coolant inventory (steaming through the LRV). The HTS* | • Loss of feedwater (main and auxiliary) + loss of SDCS + loss of EWS + loss of ECCS + loss of moderator.<br>• Loss of feedwater (main and auxiliary) + loss of EWS + loss of service water (RCW+ RSW). | • Loss of class IV + loss of class III (DGs) + EPS reduced to a single source | | |

| For the following plant conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| *pressure remains near the LRV setpoint through the boil-off period (10 MPa). Some high elevation channels void sufficiently to superheat to 600$^o$C.* | • Loss of class IV + loss of class III (DG's) + loss of EPS | | | |
| *The pressure tube wall attempts to strain radially into contact with its calandria tube but fails because a coolant stratification-induced temperature gradient combined with high internal pressure cause a highly localized thinning of the pressure tube. This lead to channel failure and the residual HTS coolant being discharged into calandria vessel. Calandria vessel integrity will be maintained until moderator inventory and shield tank inventory will be boil-off. After these inventories are depleted the calandria vessel disassembly will begin.* | | | | |
| Late loss of core structural integrity at low HTS pressure<br>*This scenario is similar with the one presented above until the fuel channels are melted and drops on the bottom of the calandria vessel. Starting from this point forward accident progression within calandria vessel can be terminated by successful initiation of high and medium pressure injection stages of ECCS into the core, prior to the calandria vessel failure. Molten corium is present but is confined to the bottom of the calandria vessel. This* | • Loss of feedwater (main and auxiliary) + loss of SDCS + loss of EWS + loss of moderator + loss of ECCS heat exchanger as a heat sink (ECCS provide make-up but the ECCS heat exchanger is unavailable as a heat sink due to loss of service water – RCW and RSW).<br><br>• LOCA + loss of ECCS + | | | |

| For the following plant conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| *scenario does not have the potential for the generation of non-condensable and flammable gases due to the molten–corium -concrete interactions.* | loss of moderator. | | | |
| Loss of core cooling requiring the moderator as a heat sink within 500 seconds<br>*This type of scenario is caused by any LOCA which requires automatic initiation of ECCS combined with failure of ECCS but with the moderator available as a heat sink. For this scenario, some pressure tubes may strain and contact their associated calandria tubes, in which case the moderator provides a heat sink. Extensive fuel sheaths failures and zirconium – steam reaction is expected in the broken loop. Fuel melting does not take place.* | • Any LOCA which requires automatic initiation of ECCS + loss of ECCS and failure of containment isolation but with the moderator available and required as a heat sink within 500 seconds following reactor trip | • Any LOCA which requires automatic initiation of ECCS + loss of ECCS but with the moderator available and required as a heat sink within 500 seconds following reactor trip | | |
| Loss of core cooling requiring the moderator as a heat sink after 500 seconds<br>*This type of scenario is caused by any LOCA accident, which requires manual initiation of ECCS combined with failure of ECCS but with the moderator available as a heat sink.* | • Any LOCA which requires manual initiation of ECCS + loss of ECCS and failure of containment isolation but with the moderator available as a heat sink and required as a heat sink after 500 seconds following reactor trip. | • Any LOCA which requires manual initiation of ECCS + loss of ECCS but with the moderator available as a heat sink and required as a heat sink after 500 seconds following reactor trip. | | |
| Loss of cooling/Inadequate cooling in one or more core passes following a large | | | • Large LOCA | |

| For the following plant conditions*:* | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| LOCA with successful initiation of ECCS<br>*This type of scenario is caused by Large LOCA* | | | | |
| Single channel LOCA with containment pressurization<br>*This type of scenario is caused by out-of-core events with fuel ejection from one channel on the reactor building floor* | | | • End Fitting Failure.<br>• F/M-induced LOCA with fuel ejection into containment.<br>• F/M-induced LOCA due to F/M-induced end fitting failure. | |
| Single channel LOCA with no containment pressurization<br>*This type of scenario is caused by in-core events with the fuel ejected from one channel into the moderator.* | | | • Severe channel flow blockage.<br>• Pressure tube rupture and fuel ejection,<br>• Inlet feeder break. | |
| Loss of cooling to the Fuelling Machine<br>*This type of scenario is caused by loss of cooling to Fuelling Machine, which transfers maximum eight fuel bundles.* | | | • F/M-induced LOCA with no fuel ejection.<br>• Fuelling Machine while "OFF" reactor.<br>• F/M D2O system failures. | |
| Loss of HTS integrity/Small LOCA with successful initiation of ECCS<br>*This type of scenario is caused by a break in the HTS that results in operation of ECCS but that does not cause fuel damages is nevertheless considered to have potential for significant economic* | | | • Any small LOCA which requires automatic initiation of ECCS with successful initiation of ECCS | |

| For the following plant conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| *consequences. Such an event results in the release of radionuclides (tritium, noble gases, radioiodines) from the coolant.* | | | | |
| Small LOCA without automatic initiation of ECCS<br>*This type of scenario is caused by a break in the HTS that not results in operation of ECCS.* | | | | • Small LOCA without automatic initiation of ECCS |
| Steam Generator Tube Failure (SGTF) | | • SGTF + failed fuel + one way open to discharge in the atmosphere (MSSV / ASDV) | • SGTF + failed fuel | • SGTF |
| Deuterium deflagration in cover gas and/or release of moderator into containment (fuel cooling is maintained)<br>*This type of scenario is caused by events that may result in a release of moderator fluid into containment with associated release of tritium.* | | | • Draining of moderator into containment with $D_2$>4% in cover gas and presence of ignition source. | |
| **FAILURES OF CONTAINMENT ISOLATION SYSTEM** | | | | |
| Any incident, which requires automatic containment isolation, combined with failures of containment isolation system. | • Large LOCA + failure to isolate containment<br>• End Fitting Failure + failure to isolate containment | | | |

## Appendix 16.2 – Emergency classification in zero power cold or HTS drained to the header level

| For the following entry conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| Impaired decay heat removal in cold plant conditions | Core damage is likely or has already occurred and containment impaired | Inability to provide alternative cooling to the core (no SDC, no boilers, no low pressure ECC, and unable to operate HTS pumps) | Single forced cooling method unavailable | Decay heat removal reduced to a single system |
| Fuelling Machine Induced LOCA (cold plant conditions) | | | F/M-induced LOCA with no fuel ejection. | |

## Appendix 16.3 –Classification of the events free of the reactor state

| For the following entry conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| **SPENT FUEL HANDLING EVENTS** | | | | |
| Loss of control of fuel or radioactive waste during movements | Airplane crash on the Intermediate Dry Storage Facility | • Fall of the transfer flask loaded with a basket on the storage platform (the basket leaves without biological protection).<br>• Fall of a basket during storage cylinder loading.<br>• Fall of the transfer flask loaded with a fuel storage basket (60 fuel bundle) during the transfer to Intermediate Dry Spent Fuel Storage | • Fall of a fuel storage basket (60 fuel bundle) in Spent Fuel Bay or Intermediate Dry Spent Fuel Storage. | • Fall of a fuel bundle / a fuel tray (24 fuel bundle) in Spent Fuel Bay. |
| **SECURITY EVENTS** | | | | |
| Security events may have consequences for the population, environment, site personnel and material goods | Security event resulting in loss of the ability to monitor and control safety functions needed to protect the core or containment | Security event resulting in damage prevention of the normal, abnormal or emergency operation of the plant | Security event potentially affecting safe system operation | Uncertain security condition |
| **EXTERNAL EVENTS** | | | | |

| For the following entry conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| Natural disaster or other major event such as:<br>• Severe weather phenomena (winds, lightning, tornadoes, extreme temperatures)<br>• Earthquake<br>• Floods<br>• Fires from natural sources<br>• External events caused by human activities (industrial plants, road, rail or water vehicles loaded with explosives, military activities) | | Natural disaster or other major event resulting in damage to safety systems or access to safety systems or affecting long term operation | Natural disaster or other major event resulting in events beyond the design basis of the plant | Natural disaster or other major event resulting in actual or potential loss of access to the site / potential loss of communication with the site for an extensive period of time |
| **OTHER EVENTS** | | | | |
| | Fires with potential damage of any safety system simultaneously with failures of containment isolation system | Fires with potential damage of any safety system simultaneously with failures of ECC | • Fires with potential damage of any process system<br>• Main Control Room Unavaibility Events | • Fires without potential damage of process systems<br>• Chemical spill<br>• Medical incidents<br>• Minor incidents with radiation consequences for the station personnel (ex.: small loss of $D_2O$ HTS or moderator, incidents involving radioactive sources).<br>• Incidents during the radioactive waste transfer to Intermediate Solid Radioactive Waste Storage |

## Appendix 16.4 – Emergency classification based on the radiation hazards

| For the following entry conditions: | Declare a General Emergency if: | Declare a Site Area Emergency if: | Declare a Facility Emergency if: | Declare an Alert if: |
|---|---|---|---|---|
| External dose rate ($\dot{H}_{ext}$) in normally occupied areas of the station*: | $\dot{H}_{ext}$ > 10 mSv/h | 1 mSv/h < $\dot{H}_{ext}$ <10 mSv/h (potentially lasting several hours) | 0.1 mSv/h < $\dot{H}_{ext}$ < 1 mSv/h (potentially lasting several hours) | ___ |
| External dose rate ($\dot{H}_{ext}$) at off-site / beyond the site boundary: | $\dot{H}_{ext}$ > 1 mSv/h | 0.1 mSv/h < $\dot{H}_{ext}$ < <1 mSv/h | 0.01 mSv/h < $\dot{H}_{ext}$ <0.1 mSv/h | ___ |
| Total activity released to stack (confirmed release), averaged on 15 minutes, which lead in 1 hour the off-site doses: | H > 1 mSv | H > 0.1 mSv | ___ | ___ |
| Total activity in the containment, based on the results from Post-Accident Sampling System: | $\Lambda_{GN}$ > 9E12 Bq | 4.5E11Bq < $\Lambda_{GN}$ < 9E12Bq | 7E6 Bq < $\Lambda_{GN}$ < 4.5E11 Bq | ___ |
| | $\Lambda_{I}$ > E11 Bq | 6E9 Bq < $\Lambda_{I}$ < E12 Bq | 32E4 Bq < $\Lambda_{I}$ < 6E9 Bq | ___ |
| Tritium dose rate ($\dot{H}_T$) in normally occupied areas of the station*: | ___ | ___ | $\dot{H}_T$ > 1mSv/h (which remains a significant period of time - hours) | 0.05 mSv/h < $\dot{H}_T$ < 1 mSv/h (which remains a significant period of time - hours) |

*Note: Areas (from Radiological Areas 2 and 3) where in normal conditions the dose rates are lower than 10 µSv/h.

### 16.2.2. Overall national emergency preparedness structure

The National System for the Management of Emergencies is composed of three types of structures:

- the decisional structure – the committees for emergencies;
- the executive structure – the inspectorates for emergencies;
- the operational structure – the operative centres for emergencies.

All the decisional, executive and operational structures are established on three levels: national, county and local.

As a decision structure, at national level is organised the National Committee for Special Emergency Situations (CNSSU). The CNSSU is set-up under the co-ordination of the Prime Minister and managed by the Minister of Internal Affairs (MAI). All the ministerial, county and local committees are subordinated to CNSSU. The County/Local Committees for Emergencies are directed by the county Prefect / local mayor.

As an executive structure, at national level is established the General Inspectorate for Emergency Situations (IGSU), a specialised organisation of MAI. IGSU has the responsibility of permanent co-ordination of the prevention and management of emergency situations, at national level. At county level, there are established County Inspectorates for Emergencies, acting as public professional emergency services.

Inside each Inspectorate for Emergency Situations is set-up an Operative Centre for Emergencies, with permanent activity, ready to activate the emergency organisation in case of an accidental event. These Operative Centres for Emergencies are receiving notifications for all types of emergencies, including radiation events.

Also, the responsible organisations at national level are operating such Operative Centres for Emergencies, in accordance with the legal provisions in their field of activity. As an operational structure, at national level is functioning the National Operative Centre of IGSU.

In order to fulfil the legal responsibilities in case of a nuclear accident or radiological emergency, CNCAN has established its own Emergency Response Centre (ERC), as part of the National System for the Management of Emergencies.

CNCAN – ERC acts as a support centre performing technical analysis and prognosis of the emergency situations with focus on the nuclear safety, radiation protection and radiological consequences, in nuclear and radiological emergency situations:

- independent analysis,
- technical recommendations in the nuclear safety field,
- technical recommendations in the radiation protection field,
- environmental radioactivity measurements (field and laboratory measurements).

CNCAN – ERC is the national contact point in relation to any type of radiation emergency. As part of the National System, CNCAN-ERC is communicating with IGSU Operative Centre and with other operative centres of public authorities.

In accordance with the legislation, the Ministry of Internal Affairs (MAI) is responsible for the management of nuclear and radiological emergencies, IGSU and CNCAN being the national competent authorities in case of nuclear accident or radiological emergency. At local level, the intervention is coordinated by the local committees for emergencies and performed by the local response forces. When the emergency situation cannot be solved by the local authorities, the national level is activated, in order to support the local intervention. Written agreements and protocols are in place between the responsible organizations, at local and central level, for common activities and exchange of information in emergency situations.

In accordance with the provisions of Law 15/2005, CNCAN, as national competent authority in the nuclear field, has the following specific functions in the National System for the Management of Emergencies:

- Monitoring of specific dangers and risks, together with their associated negative consequences, and
- Informing, notifying and alerting.

CNCAN has, in the field of radiation emergency preparedness and response, the following responsibilities:

- to notify an emergency to national & international responsible organisations;
- to create, update and disseminate information inside the country and outside (through IAEA and through bilateral agreements with other states) on the overall view of the safety status of the nuclear installation / radiological facility and on the radiological situation;
- to perform technical assessments and to advise the CNSSU representatives (the decision makers at national level) on the safety status of the nuclear installation / radiological facility;
- to give technical advice to and supervise the public authorities and the licensees on nuclear/ radiological safety issues;
- provide advice to licensees, as necessary, on additional steps to be taken to mitigate the consequences of the accident and avoid harm to the public and the environment;
- recommend to CNSSU representatives the protective actions for the population in case of an emergency;
- assess and advise CNSSU representatives on the appropriate information which are to be distributed to the media and the general public for accurate, timely and comprehensive information regarding the emergency;
- assess and advise CNSSU representatives on the appropriate long term post-emergency protective actions;
- advice for protective measures for industry, trade, traffic and customs.

The response organisations have the following responsibilities:

- to elaborate and revise to date an adequate emergency plan;
- to assure by means of laws, Governmental Ordinance, decrees, the legal basis for protection of the population, environment and property, medical care, financial compensations, etc. in emergency situations;
- to establish and maintain a proper structure of the intervention sources able to: advise on nuclear safety and radioprotection, sample and analyse samples, keep in contact with police, army and fire fighting forces, keep contact and receive advice from water management bodies, agriculture produce control bodies, medical services, meteorological forecast facilities.
- to organise and maintain an emergency co-ordination centre equipped with technical means for the expertise of the emergency and sufficient communication means;

- to organise exercises and drills, to maintain the level of personnel training and equipment availability for emergency situations;
- to establish levels for the triggering of the emergency in case of transboundary emergencies.

### 16.2.3. On-Site and Off-Site Emergency Intervention Plans

The objective of the On-site Radiation Emergency Plan along with its supporting documents is to ensure effective emergency preparedness and response to emergency situations at the nuclear installation. The purpose of the On-site Radiation Emergency Plan is to identify the essential elements of a response to a radiation emergency and to describe in general terms the measures required to control and mitigate the radiological accident consequences within the site and to minimise the off-site effects.

The On-site Radiation Emergency Plan emphasises the immediate on-site response actions. Also, it does cover the off-site emergency for the first few hours of the radiation incident having an impact on the public and the environment. The plan includes the classification of radiation incidents, the evaluation of on-site incidents and the response actions. It identifies also the material and human resources necessary to implement these actions, and defines the organisation and the responsibilities for the personnel involved for every phase of an incident. The On-site Radiation Emergency Plan is implemented through the On-site Radiation Emergency Procedures.

In the last three years many components of the Emergency Preparedness and Response Process were upgraded. Among them we can mention the followings: revision of the On-site Emergency Plan, set-up the Work Control Area in case of Severe Accident (2 km away from the plant), set-up the Off-site Emergency Control Centre in Constanta (50 km away from the plant), installation of the satellite phones in primary and secondary control rooms of Units 1 and 2.

The on-site emergency organisation ensures a complete on-site response to emergency situation as well as covering the off-site emergency responsibilities of Cernavoda NPP. The size of the on-site emergency organisation depends on the type of the emergency event and its evolution in time.

At the first indications of an event, the Station Shift Supervisor has the responsibility to identify the causes and effects of the emergency situation and anticipates its evolution. The transients without radiation consequences are not taken into account by the on-site emergency plan, being handled by the application of specific Abnormal Plant Operation Procedures (APOP).

The class of the event is established by the Shift Supervisor after assessing the station / systems / personnel status or the radiation hazards. The site personnel warning (through the Public Address System and through the site siren, depending on the incident class) will initiate the emergency response.

In case of emergencies which do not need the OSECC (On-Site Emergency Control Centre) to be activated (alerts) the response activities are directed and coordinated from the Main Control Room and they are performed by the Response Team formed by shift personnel.

In case of emergencies which do need the activation of OSECC, the Shift Supervisor will notify the emergency management and support personnel and he will accomplish the Emergency Manager duties till the authorised person will take over. Taking over the Emergency Manager responsibilities will occur in the same time with the OSECC activation, meaning at the moment when the Command Unit (Emergency Manager, Emergency Technical Officer, Emergency Health Physicist and Emergency Administrative Officer) will be present in the OSECC. The necessary time to set-up the OSECC is of 15 minutes during normal working hours, and of 2 hours, after normal working hours.

The purpose of the emergency operation activities is to bring back the station in a safe state, to ensure an adequate fuel cooling and to stop the radioactive releases from the station. These are realised by applying the adequate emergency operating procedures.

In order to prevent an escalation of the threat and to mitigate the consequences of any actual radioactive release or radiation exposures, the Technical Support Group will provide technical advice in a timely manner to the Emergency Manager and to the Shift Supervisor.

In case of radiation emergencies with off-site effects, Cernavoda NPP is responsible for initiating protective actions for the public, by notifying the public authorities and making recommendations on protective measures for the population. The responsibility to decide and implement these recommendations belongs to public authorities involved in the off-site intervention.

In all phases of an emergency, notification forms are sent by fax to the public authorities involved in the intervention off-site, as follows:

- the “Radiation Emergency Notification” form, sent as soon as possible after the declaration of the incident;
- the “Source Term Description” form is used only if the containment is boxed-up; the form is sent when enough data are available and, after this, each hour or when situation changes;
- the “Radiological Information” form is sent when a radiological release from the containment is in progress and data from the stack and/or from the On-site/Off-site Monitoring Team are available; after that, it is sent each hour or when the situation changes;
- the “Radiation Emergency Termination” form is sent when the Emergency Manager declare the termination of the emergency.

In order to provide to decision makers information to establish the protective actions which should be implemented, Generic Intervention Criteria (GIC) have been developed based on projected doses. GIC corresponding to protective actions are shown in Appendix 16.5.

The projected doses are calculated:

- during the planning process, in case of emergencies followed by an immediate radioactive release from the containment. The projected doses are calculated for a zone being at 10 km radius around the plant (Urgent protective action planning zone), in the most unfavourable meteorological conditions for dispersion (F stability class). The protective actions are established comparing the calculated projected doses with GIL. These protective actions will be recommended to public authorities immediately after the assessment and classification of the incident;

- during the emergencies, taking into account the current radiological conditions in the containment and the meteorological conditions affecting the dilution of the release; the protective actions established by comparing the calculated projected doses with GILs are used to be recommended to public authorities or to prepare the containment depressurisation strategy.

In case of radiation emergencies with off-site effects, Cernavoda NPP is also responsible to determine the amount of radioactivity released. In this respect, the Off-site Monitoring Teams of the plant will perform off-site survey and sampling activities. The off-site survey and sampling results are used:

- to update the emergency class and refine the strategy for response, if necessary;
- to establish the protective actions comparing the measured dose rates with the Operation Intervention Levels (OILs) calculated during the emergency planning process based on GIC.

The connection between OILs and protective actions are presented in Appendix 16.6.

The protective actions for the on-site personnel are established based on the incident classification and the results of in-station and on-site surveys, performed by the In-station/On-site/Off-site Monitoring Teams.

Under emergency situations, all possible efforts are made to keep the emergency exposures of the intervention personnel below the legal dose limit of 20 mSv/y. It is permitted to exceed the legal dose limit for dedicated tasks with the following dose limits:

- Type 1 (250 mSv):
  - Lifesaving actions;
  - Prevention of core damage or given core damage to prevention of a large release.
- Type 2 (100 mSv):
  - Prevent serious injury;
  - Avert a large collective dose;
  - Prevent the development of catastrophic conditions;
  - Recovery of reactor safety systems;
  - Off-site ambient dose rate monitoring (gamma dose rate).
- Type 3 (50 mSv):
  - Short term recovery operations;
  - Implement urgent protective actions;
  - Environmental sampling.

For these situations, the Emergency Manager approves the dose exceeding. All reasonable efforts will be made to keep doses below 100 mSv, except for life saving actions, in which the dose limit is 250 mSv. Workers who undertake actions in which the dose may exceed the maximum single year dose limit shall be volunteers, clearly and comprehensively informed in advance about the associated health risk and as much as possible, trained in the actions that might be required.

After termination of the emergency, the Station Manager has to establish a Recovery Organisation. If significant in-plant radiological hazards exist (beyond those experienced during normal operation), the following activities have to be considered:

- performing extensive surveys of affected plant areas (radiation, contamination and airborne levels);
- radioactive waste processing, using supplementary portable equipment (if abnormal quantities of radioactive waste are present).

**Appendix 16.5 – Protective actions based on the projected doses**

| Generic Intervention Criteria – GIC | | Actions |
|---|---|---|
| Physical bulk | Value | |
| Effective dose to the population and the nonessential site personnel | 100 mSv in 7 days | If the projected dose exceeds GIC:<br>• evacuation is implemented preceded by sheltering of the population and the nonessential site personnel;<br>• food restrictions are implemented (water, milk, contaminated vegetables) to the population;<br>• traffic control is implemented to the population. |
| Thyroid dose to the population and the site personnel | 50 mSv in 7 days | If the projected dose exceeds GIC:<br>• iodine prophylaxis is implemented to the population and the site personnel. |

## Appendix 16.6 – Protective actions based on based on a measured physical bulks

<table>
<tr><th colspan="2">Operational Intervention Level - OIL</th><th rowspan="2">Actions</th></tr>
<tr><th>Physical bulk</th><th>Calculated value during the emergency planning process</th></tr>
<tr><td>Gamma dose rate outside of the affected unit</td><td>NOI1 – 1 mSv/h</td><td>• evacuation is implemented preceded by sheltering of the population and the nonessential site personnel;<br>• food restrictions are implemented (water, milk, contaminated vegetables) to the population;<br>• traffic control is implemented to the population;<br>• personal contamination monitoring is implemented.</td></tr>
<tr><td>Ground deposition gamma dose rate</td><td>NOI2 – 500 μSv/h</td><td></td></tr>
<tr><td>Gamma dose rate to 10 cm away from the skin</td><td>NOI3 – 1 μSv/h</td><td rowspan="2">• personal contamination monitoring is implemented immediatelly.</td></tr>
<tr><td>Skin contamination</td><td>NOI4 – 1000 cps</td></tr>
<tr><td>Gamma dose rate in the normally occupied areas of the affected unit</td><td>NOI5 – 1 mSv/h</td><td>• relocation of the nonessential personnel from the affected unit is implemented.</td></tr>
<tr><td>Activity of I-131 in air</td><td>NOI6 - 35 $kBq/m^3$</td><td>• iodine prophylaxis is implemented to the population and the site personnel.</td></tr>
<tr><td>Gamma dose rate in the normally occupied areas of the affected unit</td><td>NOI7 – 50 mSv/h</td><td>• Evacuation of the all site personnel is implemented and relocation of the essential personnel to areas which allow to fulfill specific responsibilities of emergency functions or allow periodically return on the plant to carry out the necessary activities to ensure the safety functions in order to minimize the consequences of the accident.</td></tr>
</table>

In order to ensure an effective response to a radiological event, a good coordination between Cernavoda NPP actions and public authorities' actions is necessary. In this respect, periodic meetings are organised between Cernavoda NPP representatives and public authorities' representatives, in order to establish their specific responsibilities, the notification means, the content and format of the information to be exchanged during an emergency, the necessary agreements for the support which might be required by the plant, the organisation of the periodic general emergency exercises.

During an emergency with off-site effects, the Cernavoda NPP Management Representatives will go to Cernavoda Town Hall and Constanta County Emergency Inspectorate, in order to ensure the interface between the OSECC and the public authorities coordination centres (Local Emergency Operation Centre and, respectively, County Emergency Operation Centre). Their main responsibility is to provide to off-site responders accurate and reliable technical information, in a timely manner.

The on-site emergency plan covers all the activities performed on the Cernavoda NPP site in case of an emergency in order to protect the station personnel. It also covers the initial actions that must be performed to protect the population in the first hours of an emergency, which may have an off-site impact. The responsibility for off-site emergency planning lies with the public authorities. NPP shares some of the off-site emergency responsibilities with the Public Authority, especially in the initial stage of an emergency with off-site implications.

The on-site and off-site emergency plans, included in the general intervention plan, describes in general terms the measures required to control and mitigate the accident and to protect the site personnel and the public in case of an emergency. The actions to be followed by responsible personnel (personnel designated to respond to specific emergency situations) in order to meet the objectives of the emergency plan, are described in details in the on-site and the off-site emergency procedures.

In Romania, besides the Cernavoda NPP influence area, there are another three nuclear risk areas (emergency planning zones):

- the influence area of Kozloduy NPP (the Bulgarian NPP situated at few km distance from the Romanian – Bulgarian border, in the southern part of Romania);
- the influence area of TRIGA Research Reactor in Pitesti – Mioveni.

For each nuclear risk area, there are county plans for intervention in case of nuclear accidents. County emergency plans for radiological accidents have been elaborated and have been approved by IGSU. A National Intervention Plan for Nuclear Emergencies is in place and is periodically updated.

Two General Radiation Emergency Plans are in place for Cernavoda NPP and for Kozloduy NPP influence area. The plans describe the external organisations and their responsibilities during an incident at nuclear facilities, which may have an off-site impact. The plans also contain the description of the essential steps for off-site emergency response activation, the protective action levels, and the protective measures. The protective actions, and the organisation in charge to implement these actions, are identified for each emergency planning zone. Also, the plans describe the recovery activities, the international assistance, the periodic exercises, and the updating and revision of plans. Emergency procedures are in place, at all levels, in order to perform the response functions declared in the intervention plans.

The county emergency plans for radiological accidents are considering different types of accidents involving radioactive sources and materials used in medical, industrial, research or education facilities which can occur in a county (radioactive materials transport accidents, as well as finding, misplacing or losing radioactive sources). These plans specify the way to obtain expertise and services in radiation protection field, at local level, in a timely manner. When the situation requires, CNCAN experts are dispatched to the place of the accident for radiological investigations. Arrangements are in place between CNCAN and IGSU, CNCAN and specialised Police Teams for intervention in case of an accidental event involving radioactive materials.

Arrangements have been made in the last years for general practitioners and emergency staff to be made aware of the medical symptoms of radiation exposure and of the appropriate notification procedures if a nuclear or radiological emergency are suspected.

The Polyclinic of Cernavoda and County Hospital in Constanta have been prepared to treat injured people, for the eventuality of a radiation event at Cernavoda NPP. At national level, there is established a place for initial treatment of overexposed people at the Emergency Hospital from Bucharest.

### 16.2.4. Public information

The On-site Radiation Emergency Plan of the operator and the Off-site Radiation Emergency Plans of the public authorities establish the responsibilities, the resources and the interfaces required for informing the public in case of a nuclear emergency. Joint information centres, staffed by representatives of the nuclear facility and of the public authorities, are established at the local and national levels.

As stipulated by the On-site Emergency Plan of Cernavoda NPP, those emergencies with off-site effects are to be notified to the response organisations (Cernavoda Town Hall, Constanta County Emergency Situations Inspectorate, IGSU, CNCAN), including critical information about the plant status and protective action recommendations for the public.

Also, during an emergency, the link between the plant personnel and the public authorities is ensured through the Cernavoda NPP representatives at Local / County Emergency Situation Committees, as member of these committees. In this respect, Cernavoda NPP Public Relations Officers will go to Cernavoda Town Hall / Constanta County Emergency Inspectorate, to ensure accurate and reliable technical information, in a timely manner, for the mass-media, by means of:

- informing the press agencies of emergency conditions and emergency response activities;
- developing methods to monitor broadcasts, bulletins and reports for misinformation; to respond quickly to public and media inquiries; and to rapidly respond to rumours or misinformation;
- providing in advance and ongoing information to the media and public on subjects that would be discussed during an emergency, such as radiation, nuclear plant operation and the on-site emergency plan.

CNSSU, at national level, and the County Committees for Emergencies, at local level, are responsible to give instructions and information to the public. The local and national TV and mass-media are used to keep the public informed about the accidental / radiological event.

CNCAN, and also the operator, have the responsibility to support the public authorities in informing the public with accurate, timely and comprehensive information regarding the emergency, trough their representatives at national level, in CNSSU, and at local level, in the County Committees for Emergencies.

At national level, the information includes aspects regarding the status of the nuclear / radiological facility and the status of planning / implementing the protective actions for population. At local level, the information includes also instructions and warnings for the population in the affected area.

Arrangements are in place in all nuclear risk areas in the country for prompt warning and instruction of population in the emergency planning zones, in case of an accidental event. The public in the vicinity of Cernavoda NPP and Kozloduy NPP has received printed information about the threat and how to behave in the case of an emergency. At local / county level, a Public Information Group is established in case of emergency in order to provide information to mass-media and population.

### 16.3. Training and Exercises

According to the regulations, all the response organisations must organise exercises, train the personnel and maintain an adequate level of training and all the necessary resources for an efficient response. The response authorities must have sufficient personnel, adequately qualified and trained for performing the actions provided by the intervention plan. At all levels of planning, the intervention plans must establish the types, frequencies and evaluation methods of exercises and drills, as well as the training necessity of the response personnel.

Furthermore, the licensee shall ensure the adequate initial and periodical training for the personnel authorised to declare emergency situations and to manage the intervention, personnel responsible for the evaluations necessary to be performed in emergency situations, teams assigned for radiological monitoring and decontamination, control room and field operators, fire fighting teams, repair teams and those assignees for evaluation of damages, rescue and first-aid teams. The personnel assigned for emergency response shall be regularly trained, at least every three months.

The licensee has to maintain and verify the training of its own personnel by organising annual exercises. The exercise shall be planned such that they cover all the seasons and all meteorological conditions. All the exercises shall be followed by a critical evaluation in which will participate also representatives of the competent authorities. Also, the licensee has to participate in all the exercises organised by the public authorities, for the verification of the general intervention plan.

In this respect, Cernavoda NPP has implemented a “Training, qualification and requalification programme in emergency response for Cernavoda NPP personnel”. Also, a systematic programme of exercises is established. The exercises carried out at Cernavoda NPP are of the following types:

- Quarterly Emergency Drills, dedicated to train one or more components of the On-site Emergency Organisation, are organised quarterly with each operation shift crew and annually with each emergency management and support shift crew;
- Annual Emergency Exercises, dedicated to test almost all areas of the Cernavoda NPP emergency plan, are organised during the normal work programme, with each operation shift crew and emergency management and support shift crew, through rotation; these exercises are witnessed by CNCAN and the other public authorities involved in the off-site intervention;
- General Emergency Exercises simulate an emergency which results in radioactive releases outside the station and which requires the intervention of county and / or national public authorities; they are organised in collaboration with the public authorities, involving the neighbouring population, besides station personnel and public authorities personnel, at least once in three/four years and they have various scenarios in order to verify and test different parts of the emergency plan; they start at different hours of day and night, under various meteorological conditions and are scheduled to involve each operation shift crew / emergency management and support shift crew, through rotation, as much as practical;
- Exercises with external resources, carried out to ensure the harmonisation of the site personnel response with the external resources which are taken into account in the emergency plan; because the On-site Emergency Plan establishes the firefighters support in the fire intervention actions, annually is organised a fire drill involving the firefighters, with the general objectives of familiarising firefighters with the plant layout and of testing the cooperation between the Private Firefighters Services of the plant and the Professional Firefighters Units.

The objectives of these drills/exercises are planned for every 3 years and are established so that the On-site Emergency Organisation personnel, in a 3-year period, is trained for all type of emergencies.

The exercises end with an analysis and a balance of activities in order to evaluate the ability of the various components / organisations involved. The deficiencies noted during the exercises that indicate a lack of skills or knowledge will be corrected with appropriate training.

As regarding the number of Cernavoda NPP personnel involved in emergency response, in case of alerts, the response activities are directed and coordinated from the Main Control Room (MCR) – Intervention Support Centre and they are performed by the shift personnel. There is a sufficient number of qualified personnel in each shift, able to perform response activities until the emergency organisation is augmented, if necessary. The minimum shift complement ensures the number of trained personnel who are necessary for initial response actions. This complement will be augmented by shift civil fire fighters, shift security personnel, shift personnel in training, day personnel.

In case of emergencies which do need the OSECC to be set up, the Shift Supervisor will notify the emergency management and support personnel and will accomplish the Emergency Manager’s duties, till the authorised person will take over them. At least 5 persons from day personnel are appointed and trained for every emergency management and support position of the On-site emergency organisation. In order to ensure the continuity of the human resources in case of emergency, the appointed persons are scheduled, both during normal working hours and after normal working hours (on-call).

Also, in this respect, arrangements are in place for the selection and training of personnel in all the organisations of the CNSSU. Important training courses and exercises, both national and international were conducted in the last years in the field of radiation emergency preparedness and response. The effectiveness of the response is tested and enhanced through carrying out periodical radiation emergency exercises for all areas and facilities. Once in a few years, all the responsible organisations participate in the national large scale exercises organised by IGSU. The frequency of the training and exercises became constant in the last 3 – 4 years, with at least one major international exercise and one major national exercise being organised by CNCAN in partnership with national and international institutions. The exercises are followed by an evaluation report, in order to assess the capability of the various response organisations to fulfil their attributions and to recommend measures for improving the response.

### 16.4. International Arrangements

According to art. 35 of the Law, one of the main attributions of CNCAN is to control the implementation of the provisions of international treaties and bilateral agreements on the intervention in case of nuclear accident, such as:

- IAEA Convention on Early Notification of a Nuclear Accident;
- IAEA Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency;
- Convention Regarding the Liability for Nuclear Damages;
- Bilateral Agreements on Early Notification of Nuclear Accidents and Exchange of Information on Nuclear Installations with Bulgaria, Greece, Hungary, Slovakia, Russian Federation and Ukraine.

In this respect, CNCAN is the national contact point as per IAEA Conventions for Early Notification and Assistance (according to IAEA letter EPR/CP(0100) from 16/11/2000), with the following functions (as defined in ENATOM, 2000):

- National Warning Point;
- National Competent Authority for Domestic Accidents;
- National Competent Authority for Accidents Abroad.

### 16.5. Summary of significant developments for the last reporting period

- Revision of the On-site Emergency Plan, in order to include how to ensure the availability of equipment, systems and facilities important to emergency response; to update the criteria used for protection of the population; to include how to ensure continuity of human and material resources in case of natural disasters combined with a severe nuclear accident at Cernavoda NPP; to add the security events in the list of events; to include the Emergency Physical Protection Officer in the members of the Command Unit; to introduce the 15 minutes rule for certain emergency response activities.

- The project to set-up the Alternative Emergency Control Centre (ECC) of the Cernavoda NPP in Constanta (town situated 50 km away from the plant) was finished. The alternative ECC was declared operational in December 2015.

- Set-up the Work Control Area in case of Severe Accident, located in the Cernavoda NPP Campus (situated 2 km away from the plant) was finished in September 2015. The purpose of this facility is to accommodate the intervention personnel, when time spent on the site should be limited only to carry out the necessary activities to ensure the safety functions in order to minimize the consequences of the severe accident.
- The project for setting up an Intervention Support Centre at Simulator, similar with those existing in each MCR from Units 1 and 2 is underway. The main purpose of this project is to move the exercises from MCRs in the Simulator and to connect the Simulator with the On-site and Off-site ECC, this allowing for the possibility to carry on the simulator training along with the emergency drills/exercises.
- The emergency exercises carried out in the last three years at Cernavoda NPP include two annual exercises in 2013 and 2014 and a general exercise (large scale exercise) in 2015.
- Improvement measures have been implemented for increasing the reliability of the communication systems (satellite phones have been installed in primary and secondary control rooms of Units 1 and 2).
- Cernavoda NPP has acquisitioned in 2013 a new stock of KI pills (20.000 doses).
- All Cernavoda NPP site assembly areas (outside radiological area) have been equipped with portable gamma dose rate monitors and Personal Alarming Dosimeters (one of each in each assembly area).
- CNCAN has organised meetings with the representatives of the licensee and the representatives of IGSU and of other national organisations with roles in emergency response and has contributed to the review of national (off-site) emergency response strategy with an assessment of the lessons learned from the Fukushima accident.
- Planning is on-going for a major emergency response exercise called Valahia 2016, to be organized in Romania in October 2016, in the framework of the "Regional Excellence Project on Regulatory Capacity Building in Nuclear and Radiological Safety, Emergency Preparedness and Response in Romania".
- CNCAN has improved its emergency response capabilities using the support obtained through the above mentioned excellence project. The improvements consisted in:
    - New radiation monitoring devices, personal protective equipment, IT, communication means, etc. and procedures / operational manuals for using the purchased equipment;
    - Technical solutions for using weather prediction data for atmospheric dispersion calculations including trained staff;
    - Emergency response procedures for severe accident situations at CANDU reactors, including results of nuclear safety assessments from IAEA guidelines and dose calculations in different meteorological conditions;
    - Training modules developed for the emergency response organization of a nuclear regulatory authority.

## ARTICLE 17 – SITING

*Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:*
*(i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;*
*(ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;*
*(iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;*
*(iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.*

### 17.1 Regulatory requirements and licensing process for the siting phase

The general aspects regarding the regulatory framework and the licensing process have been provided under Article 7. This section gives details specific to the licensing process for the siting phase.

The licensing process and the general criteria for siting have been set, until the end of 2010, by the provisions of the Romanian regulation Nuclear Safety Requirements (NSR) - Nuclear Reactors and Nuclear Power Plants, which was in force since 1975 and which was based on the regulatory requirements of US NRC (10 CFR 100.11, 50.34 and Appendix A to Part 50).

The revision of the NSR regulation has started in 2009, taking account of the latest developments in international standards and guides on siting, with the purpose of providing a formalised set of criteria to be used in the selection of new sites and also in the periodic re-evaluations of all the site-related factors in the framework of the PSRs. The new regulation, "Nuclear Safety Requirements on Siting of Nuclear Power Plants" has been formally issued at the end of 2010.

The requirements on the quality assurance for site evaluation and selection activities are formalised in the regulation NMC-03 (Specific requirements for the quality management systems applied to the evaluation and selection of the sites for nuclear installations). The regulation NMC-03 contains provisions for the different stages of the siting process, including the examination and assessment of various potential sites, the confirmation of the chosen location and the arrangements for site monitoring for the lifetime of the nuclear installation.

The licensing documentation for the siting of Cernavoda NPP has been prepared in accordance with the provisions of the NSR regulation. The documentation substantiating the safety demonstration for site acceptance is constituted by the Initial Safety Analysis Report (ISAR), together with the supporting technical studies and evaluations. The ISAR provides adequate justification for the site selection and summarises the assessments performed to ensure that the site characteristics are suitable for the design, construction, commissioning and operation of the facility. Although the emphasis of the report is on the identification and investigation of those site characteristics, which bear on safety, the report must also contain sufficient information on the conceptual design and operation of the nuclear installation. The preliminary evaluations of the impact on the environment are also included in the ISAR.

The site licence for Cernavoda NPP (intended for five units) has been granted in 1979 by CSEN (see Article 7 for information on the development of the nuclear regulatory authority in Romania). The safety documentation for demonstrating the fulfilment of regulatory requirements and criteria comprised of the Initial Safety Analysis Report (ISAR) and the supporting technical studies and evaluations.

The factors taken into account in the evaluation of the site from the nuclear safety point of view included both those related to the characteristics of nuclear reactor design and those related to the specific site characteristics. In accordance with the regulatory requirements, comprehensive safety assessments have been performed to demonstrate that the reactor design ensures a very low probability for accidents resulting in significant radioactive releases and that the site choice and the technical measures taken to mitigate the consequences of the accidents, should these occur, ensure adequate protection of the public and environment.

### 17.2 Safety assessment of site related factors

The data collected during the examination, assessment and confirmation of site belong to the following categories:

a) data on the current and historical status of the site, resulting from censuses, geological, hydrological, meteorological and seismic data, records of examinations and other similar sources;
b) data regarding indirect explorations, resulting from direct or calculated information, from the collection of data, from testing and investigations performed in other purposes;
c) data from direct explorations, obtained from sampling, direct examination or from site tests;
d) laboratory tests.

The collection of data on site characteristics continued throughout the construction and operation phases, to verify the information obtained before the construction stage and to update it as necessary, to provide reassurance with regard to the adequacy safety margins.

The assessments performed (initial and updated) for the site-related factors are provided in the technical evaluations and studies referenced in the ISAR, PSAR (Preliminary Safety Analysis Report) and FSAR (Final Safety Analysis Report) respectively. These evaluations and studies have been performed in accordance with the national regulations and the recommendations in the IAEA Safety Guides, the US NRC Regulatory Guides, applicable international standards, etc. Their results are summarised in Chapter 2 of the FSAR for Cernavoda NPP, which contains also a detailed description of the site characteristics including:

- Geography and demography: description and localisation of the site, exclusion zone control, population distribution on a 30 km radius area, density of population in the ring area between 30 and 100 km radius, transitory population, populated centres;
- Industrial facilities, transport routes and military facilities in the area: industrial facilities and activities, premises of economical and industrial development, railroad transport network and traffic characteristics, statistics of railroad accidents on a five

year period, road traffic, dangerous goods transports in the area, naval transport, technical characteristics of the Danube-Black Sea Canal, winter phenomena on the Danube and Cernavoda area, perspective of naval traffic development until 2030, civil aircraft traffic, airport aircraft crashes and flight corridors, military facilities in the area, potential accidents caused by human and industrial activities in the area including explosions, toxic gas releases, gas and oil mains explosions;

- Meteorology: regional and general climatologic conditions, local meteorology, normal and extreme values of meteorological parameters, air circulation, atmospheric stability, meteorological phenomena, potential influence of the plant on the local climate;
- Hydrology: surface and underground waters, plant siting relative to water sources, Danube river, Danube-Black Sea Canal, flooding scenarios;
- Geology and seismology: regional geology, geotectonic structure of the site, hydro geological conditions, correlation between geological structure, tectonic movement and seismic activity, seismic faults in the area, maximum observed earthquake and maximum possible earthquake, site seismic characteristics, seismic hazard assessment input data and models, seismic design data confirmation.

The human induced hazards have been evaluated by using conservative analysis methods of the actual and estimated data (for 2010-2040 prognosis period) on industrial facilities and activities, naval, terrestrial and air transports, as well as military facilities and activities. For these categories of activities, there are evaluated potential accidents (explosions, toxic substances emissions, fires, missiles generation) occurring at industrial facilities around Cernavoda NPP (30 km radius), postulated explosions on terrestrial and naval transport routes in the vicinity of the plant, potential accidents due to air transports in the surrounding area (more than 30 km from the NPP), potential accidents due to military activities around Cernavoda NPP site.

As regards to the demographic data, the study on the distribution and density of the population in the influence area of the plant is generally updated for the revision of the Final Safety Assessment Report, as required by CNCAN for the renewal of the operating licence.

The site area has been also evaluated with regard to ease of access for resources in the event of contingency and emergency response evacuation, availability and adequacy of off-site services (reliability of the grid), etc.

The applicable natural external events analysed include earthquakes, surface faulting, meteorological events (including severe weather conditions), lightning, flooding (due to precipitation, dam bursts, etc.), slope instability, behaviour of foundation materials, etc. A systematic reassessment of the site-related factors was performed in the framework of the first Periodic Safety Review for Cernavoda NPP. Screening of occurrences related to site characteristics indicated the need for a systematic update of the safety case, with special attention to the assessment against the original design bases. Some issues arising from the review of the present site safety case against current safety guides and standards were also identified, such as climatic changes and biotic considerations in the safety case. As a follow up of actions raised from PSR, Cernavoda NPP prepared and delivered to CNCAN an Action Plan. According to this plan, Cernavoda NPP contracted an external company to update the systematic review of external events. Up to date, the following analyses were elaborated: “External Hazards Systematic Analysis for CNE Cernavoda Site - Methodology”, “External Hazards Systematic Analysis for CNE Cernavoda Site – Hazards

#8 (Natural Electro-Magnetic Interference), #9 (Cosmic Rays /Particles Bombardment) and #22 (Meteorite/Satellite Falls)", following that the other external hazards to be re-assessed in future.

The licensee has re-evaluated the seismic safety of Cernavoda NPP in the framework of the project for developing probabilistic safety assessments. As a first step, the seismic re-evaluation of the site has been performed, using Probabilistic Seismic Hazard Analysis (PSHA) as the preferred methodology. The results of the Hazard Analysis have been used as input to the seismic PSA for the plant. The seismicity of the site and surrounding 300 km area was reassessed with state of the art methodology, seismic hazard study confirming the design data. Assistance from IAEA has been received in the development and the review of the PSHA and seismic PSA of the plant. The PSHA done for Cernavoda NPP confirmed the design provisions for qualification of the plant to a seismic event (design basis earthquake).
The latest studies of the site-related factors relevant to safety are reflected in the current Final Safety Analysis Reports (FSAR) and in the reports on the re-assessments performed after the Fukushima Daiichi accident ("stress test" reports).

## 17.3 Evaluation of the impact on the population and the environment

As required by the legislation on environmental protection, a detailed assessment of the impact of the installation on the environment has to be prepared by the applicant, and submitted to the governmental and local environmental agencies for their review. The environmental agreement issued by the central authority for environmental protection has to be obtained prior to the issuance of the siting licence, or of the construction licence (for the case in which a unit is built on an already licensed site) granted by the nuclear regulatory authority. The environmental authorisation is issued by the central authority for environmental protection (the Ministry of Environment) after the issuance of the operation licence by CNCAN.

For Units 3 and 4 of Cernavoda NPP, the actions required by the procedure established by the Ministry of Environment for issuing the environmental agreement have been initiated in 2006. During this process, the report on the environmental impact assessment was completed, including aspects related to thermal impact of discharge water and biodiversity protection. The environmental agreement procedure included national public consultations as well as transboundary consultations (under ESPOO Convention auspices) on the environmental impact assessment report. The environmental agreement for Units 3 and 4 is was issued by the Governmental Decision no. 737/2013.

During the preoperational stage, the licensee is responsible to monitor the distribution and the characteristics of the population around the installation, its occupations and habits, food consumption rates and origins of consumed food, ways to spend the time, as well as agricultural and aquatic characteristics (species, agricultural practices, gardening activities, etc.). All these data have to be periodically verified during the operational stage of the plant. Also, the use of the river water must be monitored in the vicinity of the plant and as far downstream as might be subject to significant contamination.

According to CNCAN requirements on the monitoring of the radioactive discharges into the environment, the licensee is responsible for supplementing the environmental radioactivity monitoring programme with support studies, dedicated to other types of measurements and/or activities of collecting general data about the environment and population characteristics. In this respect, the licensee is responsible to ensure, not only during the preoperational stage, but also for the entire period of operating the plant, the monitoring of climate conditions and hydrological characteristics of the rivers receiving the liquid effluents (according to the CNCAN requirements on meteorological and hydrological measurements for nuclear installations).

The general objective of the above mentioned support studies is to detect the occurrence of important changes of the environment, which may significantly affect the radionuclides transfer into the environment and thus the exposure pathways. In such cases, the licensee shall reassess and accordingly modify the environmental radioactivity monitoring programme, and submit it for approval by CNCAN.

Starting with 1984, Cernavoda NPP deployed a preoperational monitoring programme, which was contracted by two Romanian Nuclear Research Institutes (IFIN Magurele and ICN Pitesti). The sampling points were established taking into consideration the distances from the future NPP effluents discharging points, the predominant wind direction, the presence of the population and its food consumption habits. The procedures for sampling, sample preparations and measurements were established and agreed by the two contractors. Generally, samples of air, surface, drinking and ground water, soil, sediment, spontaneous and cultivated vegetation, as well as food and feed were quarterly collected and analysed for their radioactive content by total alpha and beta measurements, gamma spectrometry, tritium, uranium and Sr-90 determination. The results were reported to the NPP quarterly and annually.

The measurements made under the preoperational program detected the environmental radioactivity changes resulted following the Chernobyl accident in 1986; starting with 1990, the radioactive concentrations in the majority of the environmental media returned to the normal values, registered before 1986, excepting the Cs-137 in soil and sediment which is still present in some points, in low concentrations, showing a decreasing tendency. The results of this program are used as reference values in the estimation of the impact of Cernavoda NPP operation on the surrounding environment.

Cernavoda NPP operates a meteorological tower, 80 m high, located at approx. 1.5 km from the plant and equipped with sensors placed at 3 levels (10 m, 30 m and 80 m). The meteorological data (air temperature, wind direction and speed, precipitations) are automatically sent to the MCR and SCA at 10 minutes intervals; in 2004, the system was updated by changing the sensors, modifying the software and setting up a new monitoring point.

Starting with 2002, Cernavoda NPP contracted, besides the meteorological prognosis services, monthly diagnosis services provided by Constanta Regional Meteorological Centre of the National Administration for Meteorology. The data provided through this contract are in good agreement with the data provided by the onsite meteorological tower, even if there are differences between the two locations (in terms of level, data collecting techniques, physical distance between them of about 2 km).

The hydrological data (level and temperature, daily flows, monthly upstream/downstream temperature gradient) of the Danube river are provided for Cernavoda NPP on a contractual base, by the National Company "Apele Romane". All these data are reported annually by the plant, together with the environmental radioactivity data, as resulted from the monitoring program.

More information on the environmental radioactivity monitoring programme is provided under Article 15.

## 17.4 Consultation Procedure

The procedure for obtaining a construction license for a nuclear installation includes the obligation to perform and submit an environmental impact assessment (EIA).

The neighbouring countries that could be affected by the installation are notified on the basis of the international Convention on Environmental Impact Assessment in a Transboundary Context (ESPOO Convention), to which Romania is a contracting party.

## 17.5 Significant developments for the last reporting period

After the Fukushima Daiichi accident, a complex safety review of the protection against external events was undertaken in the context of the European "stress tests". More information has been provided in the Romanian National Report for the 2nd Extraordinary Meeting under the Convention on Nuclear Safety, which is publicly available.
(http://www.cncan.ro/assets/Informatii-Publice/06-Rapoarte/RO-National-Report-for-2nd-Extraordinary-Meeting-under-CNS-May2012-doc.pdf)

A summary of the results of the re-assessment of Cernavoda NPP protection against external events is provided as follows.

**Protection against earthquakes**

A seismic margin assessment was performed for Cernavoda NPP, with a review level earthquake (RLE) established at a reasonably high level seismic ground motion, based on site seismicity and plant specific design features. The seismic margin assessment shows that in comparison with the original design basis earthquake of 0.2g, which has a frequency of 1E-3 events/year, all SSCs which are part of the safe shutdown path after an earthquake would continue to perform their safety function up to 0.4g, which has an estimated frequency of 5E-5 events/year. This margin is considered adequate as it meets the safety goals applied internationally for new NPPs.

Based on deterministic studies performed by national institutes for earth physics, seismic events yielding a PGA > 0.2g are considered physically not possible. Based on the seismic margin assessment performed, there are no cliff-edge effects occurring for PGA ≤ 0.4g. Additional margins exist beyond the value of 0.4g, but they have not been quantified.

The potential of Cernavoda NPP units flooding induced by an earthquake exceeding the DBE has been analysed by considering all the failure mechanisms consisting of failure of dams and other hydrological or civil structures collapsing and the tsunamigenic potential of a Black Sea originating earthquake. The results of these analyses show that the effect of these failure mechanisms has physically no potential for seismically induced flooding of the Cernavoda site.

The potential for seismic induced internal plant flooding was also analysed and it was concluded that this does not pose a threat to the equipment qualified to perform the essential safety functions after an earthquake. As for the potential for earthquake-induced internal fires, the inspections conducted post-Fukushima confirmed the design robustness and good material condition regarding the fire protection.

The seismic walk-downs and subsequent seismic robustness analyses done as part of the seismic margin assessment have not revealed a need for any safety significant design change. However, several recommendations resulted from these inspections, such as increasing the seismic robustness of the batteries, have been implemented by the licensee as part of the regular plant seismic housekeeping program.

**Protection against external flooding**

Based on the analysis results obtained by making use of the latest deterministic tools and complemented by probabilistic approach, it was concluded that the Cernavoda NPP design intent in relation with flooding hazards provides sufficient safety margins, therefore no further measures for improvement were envisaged in this area. However, following a generic recommendation from a "stress test" peer review, concerning the improvement of volumetric protection of the buildings containing safety related equipment located in rooms below plant platform level (so that protection does not rely solely on the elevation of the platforms), potential measures have been identified and design modifications were approved and implemented to replace selected doors with flood resistant doors and penetrations sealing. Sand bags have also been made available on site to be used as temporary flood barriers, if required.

Currently, improvement initiatives for volumetric protection are done (replacement of selected access doors with flood resistant doors and room penetrations sealing of several areas were safety related equipment are located underground), in addition to the passive protection measure ensured by the plant platform elevation.

Based on review of the enhanced design provisions and operating procedures, the plant strategy in response to internal and external flooding events was revised and required modifications of plant procedures performed. Flood protected areas are periodically inspected as per dedicated plant routines.

**Protection against extreme weather events**

Based on the assessment performed, the licensee concluded that adequate safety margins exist in relation to extreme weather conditions, taking account margins provided in the design of the safety related SSCs as well as the time available for preventative measures in slow developing scenarios.

For cases in which the extreme weather conditions could affect the availability of the off-site power supply and / or the transfer of heat to the ultimate heat sink, based on the review of severe weather conditions and their impact on the plant, it was concluded that these would not generate worst accident scenarios as compared with SBO (Station Black-Out), LOUHS (Loss of Ultimate Heat Sink) and SBO + LOUHS events.

The examination of extreme weather events consistently performed with international practice revealed that none of the external events related to severe weather has the potential to induce accident sequences not covered by the existing safety analysis, plant operating documentation or response capacity of the Cernavoda NPP. Nevertheless, the specific procedure for responding to extreme weather conditions has been revised to include more proactive actions.

**Regulatory reviews**

CNCAN has reviewed the methodology used for the assessment of external events and the results and has acknowledged that these reflect the current standards and good practices and state-of-the-art knowledge. The "stress test" peer-review for Romania acknowledged the comprehensive studies and work performed to increase protection of the Cernavoda plant against seismic events and the substantial and recent studies for the assessment of flooding hazards.

The peer-review report for Romania recommended that CNCAN further investigates safety margins to cliff-edge effects for extreme external events. This is a generic issue and further studies will be required and performed once a common methodology is developed and agreed upon at international level.

## ARTICLE 18 - DESIGN AND CONSTRUCTION

*Each Contracting Party shall take the appropriate steps to ensure that:*
*(i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;*
*(ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;*
*(iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.*

### 18.1 General description of the licensing process for the design and construction phases

The general aspects regarding the regulatory framework and the licensing process have been provided under Article 7. This section gives details specific to the licensing process for the construction phase.

As a first step in the licensing process for the construction of a new unit (provided that the site licence had been issued, as it is the case for Cernavoda NPP), a Licensing Basis Document (LBD) is submitted for approval to CNCAN. The LBD includes all applicable regulatory documents (including those established by other authorities than CNCAN), codes and standards, safety design requirements, the list of all the design basis events, safety analysis requirements, and the general requirements for the stages of construction, commissioning and operation. The applicable international safety standards and guides are also endorsed by means of the LBD.

The LBD is reviewed by CNCAN, which imposes changes and/or additional requirements, as the case may be. Once approved, the LBD becomes the main document based on which the licence applicant establishes arrangements for the work to be performed in the preparation of the Preliminary Safety Analysis Report (PSAR).

The PSAR constitutes the main document submitted by the applicant to CNCAN for review and approval for obtaining the Construction Licence. The PSAR includes, as a minimum, the following information:

- Description of the site and of the site-related safety factors;
- Analysis of the compliance with the safety requirements for the main systems of the installation at the nominal design values of operation;
- Presentation of any new or unusual design solutions used and evaluation of their impact on the safety;
- Preliminary data and solutions adopted in the design, construction, commissioning and operation of the nuclear installation so that to ensure compliance with the general design requirements in the national nuclear safety regulations;
- Preliminary safety evaluation of the plant systems to confirm that they assure an acceptable safety margin during normal operation, transients and accidents and the existence of the adequate technical and administrative measures to cope with postulated events, including severe accidents;
- Description of the technical limits and conditions;
- Description of the organisation in charge of construction and the measures taken to comply with the nuclear safety requirements;

- Description of the quality assurance programme;
- Identification of the systems, components, design solutions, etc. which need a special research programme to be completed prior to operation in order to demonstrate the full compliance of the installation with the safety requirements.
- Description of the emergency plan to be implemented up to operation.

The PSAR, SDGs (Safety Design Guides), DMs (Design Manuals) and any other documents referenced in the PSAR and later on in the Final Safety Analysis Report (FSAR), such as technical evaluations and studies, safety analyses, procedures, commissioning reports, drawings, etc., constitute the documentation that substantiates the safety demonstration for the operation of the plant.

The main licensing milestones during the construction phase for a CANDU unit include the reception and storage of the heavy water, the reception and storage of the nuclear fuel and the heavy water loading into moderator system. After these are completed and compliance with all the applicable requirements is demonstrated, the application for the commissioning licence is submitted to CNCAN. The complete list of licensing milestones is given under Article 19.

The regulatory oversight during the construction stage consists of audits, inspections and periodic licensing meetings, with the most comprehensive assessments and inspections performed on the occasion of the licensing milestones. For each of the licensing milestones a formal approval/authorisation is granted by CNCAN to the licensee to further proceed with the work, provided that all the specific requirements and conditions have been fulfilled. For example, prior to granting the approval for heavy water loading into the moderator system, one of the conditions for the licensee is to demonstrate that all construction activities related to the plant systems needed for that milestone are completed, that the necessary verifications and tests have been performed with acceptable results and also that all the required documentation is available and adequate.

During the construction phase, the main process used by the licensee to confirm that the structures and systems are installed and completed as per design is the Construction Completion Assurance (Construction CA). The Construction CA process encompasses all the assessment and verification activities necessary to provide reassurance that the as-built plant fulfils all the design requirements, as well as all the requirements deriving from the applicable regulations, codes and standards on nuclear safety and quality assurance.

The independent verification of the work performed during construction and of the construction completion status is done by the commissioning personnel, in the process of turnover from construction to commissioning, in which the responsibility is transferred from the Construction organisation to the Commissioning organisation. This turnover process is done by systems or groups of systems. A controlled process is in place to manage incomplete items. All the Construction Managers are responsible for the turnover process in their discipline and for preparing the respective Construction CA Statements and submitting them to the Construction General Manager, who is in charge of preparing the Overall Construction Completion Certificate. This Certificate is forwarded to the licence holder for review and endorsement. The Construction Completion Certificate, approved by the legal representative of the licence holder, is submitted to CNCAN as part of the application for Fuel Load, which is the first licensing milestone after the commissioning start.

## 18.2 Safety Philosophy and Defence in Depth

The safety philosophy of CANDU reactors, based upon the principle of defence-in-depth, employs redundancy (using at least two components or systems for a given function), diversity (using two physically or functionally different means for a given function), separation (using barriers and/or distance to separate components or systems for a given function), and protection (seismically and environmentally qualifying all safety systems, equipment, and structures).

An important aspect of implementing defence-in-depth in the NPP design is the provision of a series of physical barriers to confine radioactive material at specified locations. In CANDU design these barriers are the fuel matrix, the fuel sheath (clad), the Heat Transport System (HTS), and the Containment. An additional administrative barrier is the exclusion area boundary.

For design purposes, the safety related systems and structures have been defined as those which, by virtue of failure to perform the safety functions in accordance with the design intent, could cause the regulatory dose limits for the plant to be exceeded, in the absence of mitigating system action.

The safety related systems and structures of a CANDU NPP can be broadly categorised as follows:

- Preventative: Systems and structures that perform safety functions during the normal operation of the plant, to ensure that radioactive materials remain within their normal boundaries. These are systems and structures whose failure could cause a release exceeding the regulatory dose limits during normal plant operation, in the absence of further mitigating actions, or whose failure as a consequence of an event could impair the safety functions of other safety related systems.
- Protective: systems and structures that perform safety functions to mitigate events caused by failure of the normally operating systems or by naturally occurring phenomena.

Some systems may perform both protective and preventative safety functions, and therefore may have more than one safety category designation.

The protective systems defined above are further identified as:

- Special Safety Systems, which include Shutdown System No. 1, Shutdown System No. 2, Emergency Core Cooling, and Containment.
- Safety Support Systems, which provide essential services needed for proper operation of the Special Safety Systems (e.g., electrical power, cooling water). These systems may have normal process functions as well.

The Special Safety Systems are always in stand-by during the normal operation of the plant and ready to mitigate the consequences of any serious process failure. They are totally independent from the process systems.

The Special Safety Systems and stand-by safety related systems have been physically separated by their assignation into two groups (Group 1 and Group 2) in order to provide adequate protection against common cause failures from events such as:

i) Turbine disintegration and resultant missiles;
ii) Fires that can lead to uninhabitable control centre, wide spread system damage, etc.;
iii) Aircraft crash;
iv) Failure of a common process e.g. Electrical Power Systems, Service Water System, etc.;
v) Common adverse environment e.g. extremes of temperature, pressure, humidity, radiation, toxic gases, etc.

In addition, within each group, there is separation between each the Special Safety Systems and between the channels of a system. The separation is achieved by the physical arrangement of equipment and of protective channels.

The essential safety functions that can be performed by either Group 1 or Group 2 are:

- reactor shutdown;
- fuel cooling;
- confinement of radioactivity;
- providing the operators with the alarms and indications required to assess the state of the unit and to take the necessary actions to mitigate the consequences of an accident.

Each group includes one SDS and either the ECCS or the Containment, because the analyses of the most severe cases, as presented in the Safety Report, assume one SDS system is unavailable and that either the ECCS or Containment is unavailable. As it is not possible to suffer more than those unavailabilities, it follows that the safety of the facilities is ensured at all times. Component redundancy is built-in for the Special Safety Systems to ensure that the single failure criterion is satisfied. Special Safety Systems satisfy an unavailability target of $10^{-3}$ years/year, which effectively requires redundancy of all critical components.

The availability of these systems is verified during operation by regular safety system component tests. Specific requirements are applied to the triplicated instrument cables and the duplicated power and control cables for safety-related systems. The odd and even concept of on-site power distribution is applied to equipment, the raceway system and junction boxes, in order to maintain physical separation between the odd and even systems to achieve maximum reliability under normal and abnormal conditions

To satisfy reliability requirements to meet safety objectives, the Group 1 Electrical Power System is equipped with stand-by Diesel generators supplied with support services from Group 1 systems. The power distribution system is designed to prevent propagation of electrical faults to the Group 2 Emergency Power Supply System and vice-versa. The portions of the distribution system needed to supply electrical power from the Group 2 Emergency Power Supply System to components required for the earthquake events are seismically qualified.

For the purpose of safety assessment all major systems in CANDU reactors are categorised as “process systems” and “special safety systems”. All special safety systems are independent from all process systems and from each other.

The CANDU safety philosophy is based on the concept of single/dual failures. “Single failure” is a failure of any process system which is required for the normal operation of the plant and “dual failure” represents a combination of the single failure events and a simultaneous failure or impairment of one of the special safety systems. Coincident failure analysis is a systematic assessment of postulated dual failures.

Each postulated process failure is systematically coupled with a failure of one of the special safety systems. Loss of the shutdown systems is excluded from required dual failure sequences because the design includes two independent shutdown systems which are each capable of shutting down the reactor.

A distinguishing feature of dual failure assessment is that the analysis of CANDU 600 reactors must show that:
- coolable core geometry is retained, even if the ECCS were to be impaired;
- radioactive releases are adequately prevented, even if the containment system were to be impaired.

The deterministic analyses, including the description of initiating events, event sequences, acceptance criteria, methodology, results and interpretation are provided in Chapter 15 of the FSARs. Each of process systems failures (initiating events) considered were analysed for the case in which the ECCS and the containment subsystems are available, and also in combination with various failures/impairments to either ECCS or containment subsystems.

Feedwater events and main steam line breaks were also analysed in combination with loss of Class IV power. Large LOCA and small LOCA events are analysed also in combination with loss of off-site power and with impairments to either ECCS or containment system functions.

CANDU-600 is a proven design and sufficient information is publicly available on the general design features and on the CANDU safety philosophy and approach to prevention, mitigation and management of accidents. Therefore, this section only gives some examples of CANDU design features relevant for each of the levels of the defence in depth.

**Prevention**

- The reactor coolant pressure boundary is designed in accordance with ASME Section III - Class 1 requirements, as supplemented by Canadian Standards in the areas not covered by the ASME Code. The pressure tubes of the PHTS have “leak-before-break” characteristics. The plant is provided with extensive and sensitive leak detection systems. The presence of tritium in the PHTS makes the leak detection very efficient even for very small leaks.
- The on-line tritium in water detection system is used for revealing leaks to heat exchangers and to the S/G tubes.
- PHTS leaks open to Reactor Building atmosphere are revealed by the increasing of $D_2O$ vapours recovery or by balance of heavy water into PHTS.
- The probability of occurrence of a sudden large-size break in a pressure tube is extremely low, in view of the following considerations:

i) as per design, the tube-wall thickness was selected such that leakage will precede tube rupture (“leak-before-break” concept);

ii) a leak of a pressure tube can be detected quickly (by means of the surveillance system analysing the gas contained in the annular space between pressure tubes and calandria tubes) thus allowing ample time for corrective action;

iii) the pressure tubes and their end-fittings can be inspected by means of ultrasonic techniques, thus providing an up-to-date overview of the state of the pressure tubes;

iv) although the pressure tubes are designed to serve for the entire life time of the plant, they can be replaced with relative ease, thus permitting early elimination of tubes showing any signs of faults.

- On-power refuelling implies that the power distribution reaches an equilibrium in less than a year from initial start-up, and remains virtually unchanged for the reactor's operating life. This greatly simplifies the analysis of core behaviour as a result of postulated accidents.
- CANDU fuel is highly reliable, being composed of natural uranium oxide. On-power refuelling allows for defective fuel to be detected, localised and removed from the core, reducing the contamination of the reactor coolant piping and simplifying maintenance.
- There is no criticality hazard in the handling or storage of the $UO_2$ fresh/spent fuel because it is not enriched and cannot be arranged in a critical array, except for in heavy water.

**Control**

- CANDU NPPs are provided with extensive instrumentation and control systems, capable of monitoring those variables and systems that can affect the fission process, the integrity of the reactor core, the PHTS pressure boundary and the containment. Most control functions for the reactor and the Balance of Plant, including automatic start-up, are performed by two identical, independent digital computers, each capable of complete station control. The two computers run simultaneously, one acting as instantaneous back-up to the other. Protection functions are, however, not performed by the digital process control computers but by Programmable Digital Controllers (PDCs), there being strict separation between control and protection systems.
- The Reactor Regulation System (RRS) is part of the fully computerised control system. This computerized control system is also responsible for boiler pressure and level control, unit power regulation, primary heat-transport pressure and inventory, and turbine run-up.
- The design philosophy for the RRS is to limit the maximum rate of reactivity additions to a value low enough to achieve safe control in all conditions. The neutronic flux spatial control system is designed to maintain stable control of the power distribution for any of the normal movements of other control devices such as adjuster rods or liquid zone controllers. The reactivity change due to refuelling is also adequately controlled by liquid zone controllers.
- The low excess reactivity of the CANDU core leads to relatively low reactivity worth of the control devices, limiting the potential severity of postulated loss-of-regulation accidents.
- Apart from the four systems employed by RRS, using control rods, adjuster rods, light water compartments and poison addition into the moderator region, two independent and diverse fast-shutdown systems are provided.
- Furthermore, the relatively open core lattice of the CANDU reactor permits complete separation between control and protection functions also for the neutron poison devices (i.e. the control rods used by RRS are the 4 mechanical control absorbers - MCA, while the SDS #1 uses 28 shutoff rods; poison addition to the moderator is done by RRS through the moderator liquid poison system, while the SDS #2 inserts poison from its own liquid injection shutdown units).
- To ensure that localised overrating of the fuel does not occur an array of self-powered flux detectors is provided for application in the regional overpower protective (ROP) system. A separate array of detectors is provided for each of the two shutdown systems.
- The self-protection functions of the RRS (Stepback and Setback) are essential to ensure that station operation is within the boundaries assumed in the analyses. In the

majority of event scenarios, the above mentioned self-protection functions can avoid reaching the trip set points of the Shutdown Systems (SDS#1 & SDS#2). The availability of the Reactor Regulating System (RRS) is absolutely required for maintaining the reactor in the critical state. Consequently, on a loss of RRS, the reactor is tripped immediately, with no attempt at re-start.

- Heavy-water neutron kinetics is slower by several orders of magnitude than light-water kinetics, this making the control easier because of the inherent kinetic behaviour of the delayed neutrons.
- Provision of passive heat sink after common mode events like loss of electrical power is ensured by thermosyphoning through the steam generators.
- The plant is provided with two separate control rooms in different locations, each with capability of shutting down and cooling the reactor to cold conditions, and providing continuous monitoring-of-the-plant information to the operating staff; this capability is still maintained in each control room even if total failure of all equipment in the other control room is assumed.

**Protection**

- The Safety Systems are fully automated, although they can be actuated also manually if required. Each system is independent of the others, employing its own sensors, logic, and actuators. Each system uses triplicated logic in two out of three logic configuration, (three sensor circuits, with two-out-of-three voting), with the ability to be tested on-line. Also, the fail-safe design principle has been implemented in the design of the Safety Systems.
- SDS#1 uses solid shutoff rods (stainless steel sheathed cadmium absorbers), dropping by gravity into the core, and is capable of shutting down the reactor for the entire spectrum of postulated initiating events. SDS#2 uses high-pressure liquid poison (gadolinium nitrate) injected into the (low-pressure) moderator, and is also capable of shutting down the reactor for the entire spectrum of postulated initiating events.
- Each SDS, acting alone, is capable of shutting down the reactor within less than 2 seconds and maintaining it subcritical under cold conditions, for all accident scenarios. In safety analysis, the two most effective of 28 shutoff units for SDS#1 are assumed unavailable. Likewise, one of six liquid poison injection nozzles for SDS#2 is assumed unavailable. Prompt criticality is not reached in accident conditions, as shown by analysis.
- The positive reactivity that would be introduced by loss of coolant accidents is well within the capability of mechanical and hydraulic shutdown systems.
- An important intrinsic safety feature of the CANDU reactor is that all neutron control devices are installed in the low-pressure moderator region, where, in case of a postulated LOCA due to a break in the headers or feeders, they are not subjected to potentially severe hydraulic forces. The moderator also provides a low-pressure environment for the control rods, eliminating the "rod-ejection" scenarios. In addition, the location of neutronics measurement devices in the moderator avoids subjecting this equipment to a hot, pressurised environment.
- Under any operating state, the CANDU 6 has a number of heat sinks. At full power, the main heat sink is provided by the four steam generators. The other heat sinks become more important when in a shutdown state or during abnormal events. This can be either through the Shutdown Cooling System (SDCS), the Emergency Water Supply System (EWS), or the Boiler Make-up water system (BMW).
- The steam generators with the Feed Water System remove reactor heat during normal plant operation. The Auxiliary Feedwater System and/or the Shutdown Cooling System removes the decay heat during plant shutdown. These systems belong to Group 1,

they are designed to remove normal and decay heat and are powered by the normal (Class III, II and I) electrical power systems.

- The Shutdown Cooling System (SDCS) is designed for the full nominal operating pressure and temperature of the PHTS, so it can, if needed, be connected to the PHTS immediately following reactor shutdown, precluding the need for depressurisation after a loss of heat sink.
- Following a common mode event that may disable the above means of decay heat removal, a second independent means of decay heat removal is provided by the Emergency Water Supply (EWS) System which is powered independently by the Emergency Power Supply (EPS) System. Accordingly, the EWS and EPS Systems belong to Group 2.
- The EWS system has a function/feature known as the Boiler Makeup Water (BMW). This subsystem automatically feeds water under gravity to the secondary side of the boilers when they become depressurised following a loss of boiler feedwater. The source of BMW system is the water stored in the dousing tank.
- It should be noted that the Group 1 and Group 2 means of removing decay heat have the PHTS and the steam generators in common. Open path to atmosphere is ensured by Group 1 (ASDV) and Group 2 (MSSV) relief devices.
- The ECCS can maintain or re-establish core cooling by supplying coolant to all reactor headers. It consists of three phases: high-pressure water injection (used during the early stages of an event), medium pressure water supply from the containment building's dousing tank (used during the intermediate stages), and low-pressure water supply based on recovery from the building's sump. The ECCS is designed for LLOCA - 100% break of the largest pipe (reactor header). The discharge area is equal to twice the cross-sectional area of the pipe assumed to fail. Sensitivity analysis for the comparison of a 100% longitudinal break and a double ended guillotine break has shown very similar results, so longitudinal breaks have been modelled for all break sizes up to 100%.
- Considerations with regard to the ECCS:
  i) the simple configuration of the individual fuel channels facilitates coolant delivery to all core locations;
  ii) the correct performance of the ECCS does not constitute the final defence against core meltdown in case of LOCA; the accident analyses, supported by experiments, indicate that a LOCA combined with ECCS failure, though resulting in limited fuel damage (including partial melting of the cladding) and some deformation of the pressure and calandria tubes, does not result in fuel melting; the decay heat can be removed by conduction through the walls of the pressure and the calandria tubes into the moderator, and rejection by the moderator cooling system, which can remove than 4% of the total thermal power, enough to accept decay heat indefinitely.
- The Containment System forms a continuous, pressure-confining envelope around the reactor core and primary heat-transport system. In the CANDU 6 design it consists of a pre-stressed, post-tensioned concrete structure, an automatically-initiated dousing system, building coolers, automatic isolation system and a filtered air discharge system. The containment system prevents releases of radioactivity to the public in the event of failure of the nuclear components of the heat transport system. The design basis event considered is any LOCA event concurrent with dousing failure. This event presents the highest potential in terms of peak pressure. However, the events related to steam systems breaks are also considered in terms of maintaining structural integrity of containment. The containment structure and all other parts of the containment boundary, are pressure and leakage tested before first criticality and leakage tested periodically thereafter. Another inherent safety characteristic of CANDU 6 plants is the low ratio of reactor thermal power to containment volume.

**Mitigation**

- The large-volume, low-pressure, low-temperature moderator surrounding the fuel channels acts as a heat sink in LLOCA + LOECC scenarios (which for CANDU are included in the design basis), rendering negligible the risk of fuel meltdown. The pressure tubes will sag and/or strain into contact with the calandria tube where further deformation will be arrested by the cooling of the moderator system.
- In a loss of heat sink or loss of flow event (such as a total station black-out), the reactor coolant will heat up and pressurise which can cause the pressure boundary to fail. In a CANDU reactor experiencing the same initiating event the fuel heat-up in the fuel channels will cause one of the many pressure tubes to rupture, depressurising the system by blowdown into the moderator well before boiler tube might fail and before a high pressure melt ejection can occur. The pressure tubes act like fuses in this instance. Failure of one channel is sufficient to limit widespread channel failures because it results in rapid heat transport system depressurisation and induced blow down cooling. Furthermore, heat transport system depressurisation occurs well before potential formation of molten core conditions, thereby assuring that high pressure melt ejection does not exist as a containment challenge in CANDU reactors.
- A large volume of light water surrounds the calandria vessel in the calandria vault. Thus, the design ensures a passive heat sink capability which, in many event sequences, would provide significant time delays in the progression of the accident. The calandria vault provides the third line of defence (after the ECC and the moderator) in cooling the reactor core during a severe accident. The large volume of water in the calandria vault has adequate thermal capacity to passively prevent calandria vessel failure. Water in the calandria vault can provide continued external cooling of the core debris relocated at the bottom of the calandria. During this process, the significant volume of water inside calandria vault cools the outer calandria vessel wall, maintaining the external cooling of the vessel. As long as calandria vessel is mostly submerged in water and the calandria vault water inventory can be maintained, it is expected that corium will be retained in the calandria vessel and accident progression arrested in-vessel. The externally cooled calandria vessel acts as a "core catcher" containing the core debris. Core disassembly and relocation take place only at low heat transport system (PHT) pressures and that melting of core materials is avoided until after the debris has relocated to the bottom of the calandria vessel.
- Overall, high volumes of water in the Heat Transport System, in the calandria vessel and in the calandria vault, notwithstanding the water volume from the dousing tank, all ensure a CANDU-specific extensive heat sink capability that confers a slow progression of severe accidents
- Since the geometry of the CANDU core is near optimal from a reactivity standpoint, any rearrangement under severe accident conditions ensures shutdown. Therefore, re-criticality under is not a concern for a CANDU reactor.
- The bottom of the large calandria vessel provides a spreading and heat removal area for core debris following a severe core damage accident.

## 18.3 Specific consideration of human factors and man-machine interface

The reliable, stable and easily manageable operation of the CANDU reactors is facilitated by the use of a digital computer system, which offers many advantages over the human operator in terms of carrying out routine data handling, decision making and control functions.

Control Computer System functions are:
- Control/Monitoring;
- Alarm/Annunciation;
- Display/Data Recording.

Those functions for all the NSP side of the plant and part of the BOP side are accomplished via the control computer system (DCCs), which consists of two identical computers DCC-X and DCC-Y.

The control computer system is designed to work permanently with one control computer active and the back-up control computer in “warm stand-by”, each computer being capable of independent and complete overall plant control. Each control computer has an availability greater than 99% which results in an availability of 99,99% for two computers system (computers, peripheral equipment and input-output interface).

The keyboards associated to the computer system have been custom designed and manufactured “on demand” and they consist of dedicated keys for specific display and numeric keys for input data. The requests for display of variables and all the requests to change the setpoints and controls can be transmitted via the display keyboard. In order to reduce the probability of errors inputs when making a request or a command two different keys shall be successively pushed (i.e. ENTER and EXECUTE).

In case of a control computer (DCC) failure, the associated contacts scanner is automatically transferred to the stand-by control computer in order to process the contact inputs that will generate the alarm messages on colour CRTs. The transfer can also be done manually. When both computers fail, the reactor is shutdown and the annunciation alarm windows system only will continue to provide alarms for the systems remaining in operation after reactor shutdown. The operator can determine the cause of a trip annunciated by the alarm system, both considering the displayed alarms and analysing the printed copy and comparing the information.

In addition to the information provided under Article 12, examples of operating design features that positively influence the operators’ capacity of control and action are summarised as follows.

**Centralisation**

The Main Control Room (MCR) design is based on the philosophy of having sufficient information displayed to allow the operator to safely control the plant. All equipment (main control panels/desks, panels for signal processing, annunciation and alarming) and information required for the safe operation of the nuclear power plant in all its anticipated (configurations and/or situations) modes of operation are centralised in Main Control Room (MCR) in order to provide an overall control of the plant.

The information related to safety systems status, along with the information referring to the other plant systems, is sufficient to allow the operator to estimate the initiation, nature and the extent of a transient or accident and to intervene in accordance with the relevant emergency operating procedures. The display of information necessary for the operator to evaluate plant status or the evolution of certain process parameters is redundant, using conventional technique as well as colour CRTs, allows correlation of information and has a high reliability. These features, together with general characteristics of display (availability, readability, accuracy, uniformity, standardisation, hierarchy) help the operator to easily understand the information.

**Layout**

Operator's desk is located in the MCR, in such a manner that allows him to see all the control panels, and is provided with a keyboard and a monitor associated to the computer system which constitutes the interface between the operator and DCC. Enough space is available in the MCR to allow access at the different control panels and free moving.

The control panels for the safety systems are grouped (in the left side of the MCR) and the process system control panels arrangement reflects the power generating and transport process from the reactor to the turbine-generator. Control panels are separated in four distinct groups:

a. Special safety system control panels;
b. NSP control panels, Steam generation and power generation control panels;
c. Control panels for the electric part and the auxiliary systems;
d. F/H (Fuel Handling) control panels.

In the layout of each system, consideration was given to the location of the controls based on process function and/or plant area, as well as to the location of the controlled elements. Complex process systems and electrical systems are displayed on mimic diagrams. The information is compactly displayed and grouped by channel and by operational function. For example, the instrumentation required to control a process is located near the instrumentation providing process information.

The control panels have been designed for "operator standing", because of the low number and frequency of manoeuvres that the operator has to perform from these control panels. Operator's desk and F/H panels are designed for "operator sitting down".

The annunciation windows are located on the upper part of the control panels which is slightly inclined to the operator; the indications, CRTs, Auto/Man stations of the loop controllers and sometimes certain control devices are located on the central part of the panel; the control devices (handswitches) are located on the panel's desk.

**Annunciation devices**

Annunciation is made in the MCR directly or on local panels, which transmit to MCR bulk alarms. Process parameters exceeding specified limits, equipment failures and actions not accomplished or incomplete are annunciated. The alarm annunciation setpoints for the situations that need operator's intervention are set so that the operator has sufficient time to react to the alarm conditions.

In order to select the alarms by importance, the following classification was made:
- centralised alarms in the MCR;
- local alarms in the field with a regrouped alarm provided in the MCR.

The MCR alarm annunciation system consists of: two colour CRTs (located on the main control panel) for alarm messages annunciation, a facility to provide a printed record of all alarm messages (on a system basis or for the entire unit, with sufficient information to enable them to be arranged in the chronological order of their occurrence to provide the sequence of events) and alarm windows located on different MCR panels. It also provides Hand-Switches Off-Normal annunciation on corresponding MCR panels.

Types of displays available on demand on monitors:
- bar charts;
- graphic trends;
- status displays;
- special displays;
- numerical variable displays;
- liquid zones displays;
- simplified process diagram displays;
- process limits and setpoints displays.

The format of the display is adequate to the task and helps the operator to determine the faults in case of an event. For example, the bar charts allow comparison between parameters, the graphic trends allow the analysis of a parameter evolution, and status display gives an overview upon systems and equipments.

Alarm windows and control panels in MCR are normally free of visual annunciation in normal mode of operation, this helping the MCR operator to identify any discrepancy or abnormal situations by the presence of annunciation from alarm windows, from Off-Normal annunciation or from discrepancies lights. Centralised alarms are selected by priority. The operator’s attention will be caught by the priority through a colour code. Alarm windows annunciate reactor trip, setback, stepback, turbine generator trips, high voltage breaker trips as well as any other relevant process alarms. The alarm windows are grouped and they correspond with system allocation on panels. Audible annunciation is also provided in association with the visual annunciation.

The annunciation system has been designed to be flexible, by allowing the suppression of low importance alarms during major events in order not to distract the operator’s attention.

**Labelling**

Inscriptions (labels) on the alarm windows and the alarm messages displayed on annunciation CRTs have been elaborated in two stages: first the system engineers have created them, and then they have been passed through a process of standard and suggestive abbreviation.

There have been taken a number of measures in order to optimise the balance between the lack of space and the necessity of having explicit inscriptions, as well as to reduce the need of consulting the operating manuals:
- the labels are colour coded function of the systems they refer to: safety systems, process systems and power supply classes;
- the labels are located under the equipments;
- the texts are comprehensible, with minimum abbreviation; the abbreviations have an unique sense (so that there is no coincidence between two abbreviations coming from different texts).

**Control devices**

The components of the control devices are characterised by function, operating mode, aspect and reliability.

Generally, control elements are located on MCR panels so they can be easily operated, their position being correlated to the indicating devices (which sometimes confirm the action), located at operator's eye level.

The most important control devices are located in the middle of the panel. As much as possible, handswitch position succession is standardised. The handswitches are integrated in the mimic diagrams where practical. When they are not integrated in the mimic diagrams they are grouped on a system/equipment basis. Button type control devices are arranged based on the operation sequences, usage frequency and priority. The buttons that should not be activated by mistake are provided with protection, by being physically separated or protected by lids.

All the above-mentioned measures are meant to provide a support for the operator so he can maintain the skills acquired during training.

**Secondary Control Area**

In case of DBE (Design Basis Earthquake) or MCR unavailability, the safe shutdown condition of the plant is maintained from the Secondary Control Area (SCA).

SCA provides the necessary controls and indications in order to accomplish the following safety functions:

1) shutdown the reactor and maintain it in a safe shutdown state for an indefinite period;
2) remove decay heat from the reactor core and thus prevent any subsequent process failure which might lead to the release of radioactivity to the public in excess of allowable limits;
3) maintain a containment barrier against radioactive release;
4) display of post-accident parameters in order to enable the operator to assess the state of the Nuclear Steam Supply System (NSSS).

The equipment necessary to initiate and monitor the shutdown of the reactor and the cooling of the core is kept in four seismically qualified control panels. The SCA panels contain the controls and indications for the following main parameters and systems:

- Emergency Core Cooling System;
- Moderator temperature;
- PHT temperature;
- SG level and pressure;
- Emergency Water System;
- Dousing system;
- Containment Isolation system.

Controls, indications and alarm windows are provided for SDS#2 and a SDS#1 trip pushbutton is also provided. The reactor is maintained in a safe shutdown state by an interlock between SDS#2 and the poison extraction system.

## Manual actions

The design ensures that the number of operator actions that need to be performed on a short time scale is kept to a minimum. All special safety systems actions following an initiating event are performed automatically. All automatic actions have the capability of being initiated also manually, from the MCR and SCA. The manual actions credited in the accident analysis are assumed to occur not earlier than 15 minutes after a clear and unambiguous information (alarms) requiring operator action has been received.

## 18.4 Measures for ensuring the application of proven technologies

An important general requirement in the Romanian regulation “Specific requirements for the quality management systems applied to the design of nuclear installations” (NMC-05) is that the design and associated design documentation are to be verified to ensure its correctness and that all specified requirements have been fulfilled. Provisions relevant to the area of design are specified also in the regulation “Specific requirements for the quality management systems applied to the activities of producing and using software for research, design, analyses and calculations for nuclear installations” (NMC-12).

The design verification can be done through reviews (supervisory review, independent third party review, etc.) and / or by testing. Complexity, novelty, safety implication of the design, standardisation degree, etc., determine the extent of the design verification.

The verification requirements are identified in the engineering quality plans implemented during manufacturing, construction, commissioning and operation stages. These plans identify the design activities to be verified, the extent of verification, persons involved in verification, methods and position in the design cycle, etc. All the above requirements are covered by specific verification procedures. Any improvements in the existing design or redesign of the systems or components are subject to the same verification as the original design in order to confirm that all the existing analyses are valid and the design is correct.

The design activities can be performed only by organisations recognised or licensed by CNCAN. When the design activities are contracted to other design organisations, the contractors shall be licensed or agreed by CNCAN, or it shall be ensured by other means that the design work is verified in the same manner as mentioned above. The Design Authority for the plant has the responsibility to check that the contractors have performed such design verifications and that the particular designers have used correctly the design inputs.

Verification or certification, where required, of design reports, stress reports, seismic or environmental qualification reports, are usually carried out by the supplier or other specialised and authorised organisation, in accordance with applicable codes, standards and procedures. Test requirements, procedures, assumptions, data and results are documented and records are kept for ensuring design traceability.

The design authority evaluates the test results against acceptance criteria and conclusions of the test are recorded and filed in design history files. When tests are required to be performed by a contractor, test requirements are specified in the procurement documents.

Computer software programmes used for design, design analysis, plant and safety system control, safety analyses, and computer-assisted design are verified, validated and documented. Such verifications, validations and documentation are controlled through appropriate procedures.

When selecting a manufacturer's standard product, the design is subjected to review and/or testing to demonstrate the satisfactory performance of the item. Alternatively, to ensure satisfactory performance of the item, the design authority may evaluate the manufacturer's evidence of verification.

Since the early stages of the development of the Romanian nuclear programme, the contractual arrangements between the licence holder and the designer/vendor have been focused on ensuring that sufficient design information is provided to ensure the safe operation and maintenance of the plant and to support the development of national competence and expertise with regard to CANDU design.

Arrangements are in place also to obtain technical advice and support with regard to any safety related issues for which external expertise would be needed, as the design authority of Cernavoda NPP maintains a close relation with the plant designer and vendor (Atomic Energy of Canada Limited - AECL) and with the other CANDU operators worldwide (through the CANDU Owners Group - COG).

### 18.5 Examples of design improvements implemented for Cernavoda NPP Units

The licensing basis document for each unit of Cernavoda NPP included a general overview of the design of the reference plant and the design changes to be incorporated based on the experience from the commissioning and operation of other similar NPP units (CANDU 6), results of new safety analyses, well as those needed to respond to the changes in regulations, codes and standards.

This section gives some examples of design improvements for the Cernavoda NPP Units as included in the LBDs. It should be noted that the number of design changes performed for each unit since the approval of the LBD (including changes during the phases of construction, commissioning and operation) is significantly greater than that proposed in the LBD (which only represent the notable improvements arising from the operating experience available at the time of the application for a construction licence).

### Cernavoda NPP, Unit 1

Unit 1 of Cernavoda NPP was commissioned between the years 1993 and 1996. The design installed and commissioned in Romania has incorporated most of the significant safety related design changes already made by other organisations operating CANDU-6 up to late 80's. Supplementary, during commissioning a few other hundreds of design changes were incorporated that originated from:

- CANDU 600 operating experience, especially Point Lepreau, Gentilly 2 and Wolsung;
- safety assessments performed in Canada following the occurrence of some incidents at other nuclear power plants;
- the probabilistic safety evaluations performed to verify the adequacy of design.

Some examples of modifications incorporated in the "as-commissioned" Cernavoda NPP Unit 1 are given below:

- modification of the control room design to consider human error factors;
- new material used for the pressure tubes (Zr-2.5%Nb);
- improved trip coverage;
- automation of the low power conditioning for the trip of shutdown systems on low pressurizer level and low boiler level;
- improvements to increase ECCS reliability;
- provisions for the post LOCA collection of leakage from ECC pumps;
- provision of redundant back-up cooling for RSW system;
- improvements of instrument air reliability;
- improvements of the containment liner to minimise the leak rate;
- provisions for annulus gas recirculation;
- provision for a facility for post LOCA sampling of Containment Atmosphere;
- improvements of the fire protection, etc.

Examples of design changes implemented after the start of operation:

- Removal of ADP functions from BLC program to an independent program - MIT (Mitigation Program) in order to avoid the failure of the ADP function at BLC program failure (clear separation between the safety function and process function);
- Modification of the start-up system to ensure complete independence of the redundant Diesel generators of the EPS;
- As a result of the thermalhydraulic analyses for review of LPECC flow capacity in case of LOCA event, a design modification for replacement of the two 100% capacity strainers for Cernavoda Unit 1 has been implemented in 2002, in order to prevent sump filter clogging in case of LLOCA and to ensure the required performance of the pump under the design basis operating conditions for a minimum mission period of three months;
- Replacement of Chiller Units;
- Replacement of the LISS injection valves;
- A new portable vacuum subsystem has been installed to clean the underwater surface of the spent fuel bay;
- The silicon rubber seals of the airlocks have been replaced with EPDM perimeter seals, that have better design parameters and are EQ qualified;
- The original strainer located on the suction line of the EWS pumps was replaced by a new strainer made by stainless steel and corrosion resistant.

The process for initiating, assessing and implementing design changes is defined by a set of plant procedures, with the aim of ensuring effective configuration control and conformance with the design basis of the plant. Information on the design change process has been provided under Article 14.

Cernavoda NPP has a feed-back program to implement the design modifications and improvements from Unit 2 to Unit 1 that ensure safety enhancement and that are reasonably practicable for Unit 1, in order to maintain an equivalent level of nuclear safety with Unit 2. Some of the design changes considered in the LBD for Unit 2 have already been implemented also in Unit 1, e.g.:

- lowering of the calandria outlet temperature to increase moderator subcooling, and consequently, improved moderator system capacity to act as a heat sink;
- PHT Liquid Relief Valves and Degasser Condenser relief valves modification that

increase the PHT system overpressure protection;
- changes that minimise the positive reactivity at the reactor in the event of failure of the Liquid Zone Control pumps;
- improved valve in Feedwater System to allow the auxiliary feedwater pump operation with depressurized boilers, in case of MSLB;
- manual actuation of SDS # 1 from SCA - a seismic qualified area;
- actuation of ECC System on a new parameter (sustained low pressure on PHTS);
- automatic transfer from ECCS Medium Pressure Injection phase to the Low Pressure Injection phase.

The assessment of the reasonable practicability of the above mentioned changes, has been completed in the framework of the first Periodic Safety Review (PSR) of Cernavoda Unit 1. Also, recommendations for Unit 1 design changes resulted from the Unit 1 PSR, based on the comparison with the Unit 2 newer project, which refer to:
- manual actuation of SDS # 1 from a seismic qualified area, such as SCA;
- the environmental qualification up-grade of some Unit 1 system components.

**Cernavoda NPP, Unit 2**

The work on Unit 2 restarted in 2001. The engineering documentation for Unit 1was updated to be used as reference for Unit 2 and the existing facilities and buildings were recertified.

In the period for which the construction of Unit 2 was stopped, there have been many developments in the nuclear industry worldwide. For example, CANDU plants similar to Cernavoda 1 and 2 have been built and placed in service in South Korea (3 units at Wolsung) and in China (2 units at Qinshan). In addition, during this period, additional experience has been gained from the operation of CANDU plants worldwide.

All the improvements resulting from the commissioning and operating experience were considered in the process of identification of the feasible design changes for Unit 2, account being taken of the stage of the construction work. After thorough review, 156 design changes were selected for implementation on Cernavoda Unit 2. These changes can be categorised as follows:
- Design changes to meet revised licensing requirements. These changes are in response to revision of codes, standards or regulatory requirement documents. Since the original design of Unit 1 was completed, some of the codes, standards and regulatory licensing requirements have been revised to improve consistency and to increase the margin of safety. In general, these changes can be categorised as safety improvements.
- Changes due to development of CANDU technology. In general, these changes result in improved performance or reliability of operation.
- Design changes to replace equipment where the equipment used in Unit 1 is approaching obsolescence, and modernisation will result in improved availability of spare parts and maintenance.
- Other design improvements for enhancing system or station performance.

Examples of safety improvements are given below:
- Provision of a second independent steam generator crash cooldown system, to improve reliability of the secondary circuit as a heat sink for the intact loop in case of LOCA

and for the failed loop for small breaks;
- Improved EWS reliability (protection against single failures);
- Automation of start-up of LP ECC to eliminate the need for operator action to manually switch from MP to LP ECC operation 15 minutes after a LOCA;
- provision for redundant flow paths for ECC pump suction from dousing tank and redundant dousing tank level instrumentation;
- Provision of an on-power gross containment leakage monitoring system, to give additional assurance of containment boundary integrity for the periods between the full-scale leak rate tests;
- Provision of Hydrogen igniters to prevent Hydrogen accumulation in the Reactor Building in case of LOCA;
- Increased chromium content of lower outlet feeders, to ensure better protection against flow-induced corrosion and erosion;
- Post Accident Monitoring System;
- Modification to ensure Environmental qualification for all systems' components required to manage and mitigate consequences in Reactor Building after steam line or heat transport pipe break (LOCA).

Since the approval of the LBD, there were more than 200 additional changes implemented in Unit 2. All the design changes were implemented through a rigorous Design Changes process that required the approval of the designer for all the special safety systems. All design changes were assessed for impact on plant safety and when it was the case (for the modifications classified as major) they were also submitted to CNCAN for review and approval.

Examples of design changes implemented after the start of operation of Unit 2:
- The original strainer located on the suction line of the EWS pumps was replaced by a new strainer made by stainless steel and corrosion resistant;
- The Alarming Area Gamma Monitors (AAGM) have been upgraded by replacing the silicon detectors with ion chamber detectors and also, a new gamma detection loop has been installed in Service Building, near ECC pumps;
- A connection bridge was built between Unit 1 and Unit 2 service buildings in order to ensure a better operation of both units.

**Cernavoda NPP, Units 3 and 4**

The construction of Units 3 and 4 started in the early 1980s but was stopped in 1992 when the Government decided to focus resources on the completion of Unit 1. When construction works on Units 3&4 were halted, the civil buildings and structures, including the reactor building, the service building, the turbine-generator building were significantly developed. The existing civil structures have been assessed against the requirements of the latest codes and standards and improvements will be implemented as far as reasonably practicable.

The Reference Plant for Cernavoda Units 3 and 4 will be the as-built Cernavoda 2 plant, and will include the changes required to meet the latest Codes and Standards, any licensing mandated changes, design modifications to deal with obsolete equipment and address operational experience feedback from other CANDU plants identified before the project start.

The preliminary list of design changes has been derived from the following sources:

1. The Deloitte feasibility study produced in 2006 for Cernavoda Unit 3 to identify potential design changes;
2. Canadian Nuclear Safety Commission (CNSC) generic action items;
3. Identification of design changes resulting from Cernavoda Units 1 and 2 and other CANDU 6 operating experience (OPEX) available from AECL's feedback monitoring system;
4. Identification of design modifications resulting from new editions of codes and standards;
5. Identification of design changes not implemented on Cernavoda Unit 2 due to the advanced state of construction and which result from known issues such as generic action items;
6. Identification of design changes resulting from the Cernavoda Units 1 and 2 probabilistic safety assessments;
7. Identification of potential design changes resulting from the review of WENRA reactor safety reference levels and CNSC RD-337;
8. Identification of design changes resulted from Fukushima lessons learned.

The design changes currently under consideration aim to ensure that the design is in line with the current requirements for new NPPs. The recommended targets for CDF and LRF for new reactors ($CDF<10^{-5}$, $LRF<10^{-6}$) are also a target for the design of the Units 3 and 4.

### 18.6. Safety upgrades post - Fukushima

After the Fukushima Daiichi accident, a complex safety review of the design was undertaken in the context of the European "stress tests". In order to increase the protection against severe accidents, several design improvements have been implemented or are under implementation in accordance with the National Action Plan Post-Fukushima (presented in Appendix 2 of this report). A summary of these improvements is provided as follows.

The licensee has increased the protection against SBO (Station Black-Out) and LOUHS (Loss of Ultimate Heat Sink) scenarios by specific design changes and operational measures, so that such events would not lead to fuel failures. Two new emergency operating procedure for responding to SBO has been developed and issued.

Two mobile Diesel generators 2 x 1.2 MW (to cover entirely the EPS loads) have been procured and tested. In order to minimize the time for connecting the mobile Diesel generators to the critical loads, the licensee has installed special connection panels.

A mobile Diesel engine driven pump was procured and it is available on site along with 2 electrical mobile submersible pumps that had been already available on site. Also, two smaller Diesel generators were procured to supply electrical power for the two pumps from deep underground wells that can provide water in the domestic water system in case of LOUHS (Loss of Ultimate Heat Sink).

The licensees implemented also modifications to manually open the MSSVs (Main Steam Supply Valves) after SBO. Connection facilities were provided for adding water using fire fighters' trucks and flexible conduits to supply the primary side of the RSW/ RCW heat exchangers and SGs under emergency conditions.

Several design improvements have been identified and have been implemented to maintain fuel cooling during severe accident conditions and to enhance the capability to maintain containment integrity in case of severe accidents. These include the provision of water make-up to calandria vessel and calandria vault to arrest the progression and relocation of the core melt, the provision of hydrogen monitoring systems and passive autocatalytic recombiners for hydrogen management and the installation of filtered containment venting systems. The status of the implementation of these improvements in presented in Appendix 2 of this report.

Improvements have been made to Spent Fuel Bay (SFB) for water level and temperature monitoring from outside the SFB building, to facilitate operator actions in preventing a severe accident in SFB. Also, a seismically qualified line to Spent Fuel Bay has been installed, to ensure cooling under severe accident conditions, and have been assured provisions for natural ventilation of vapours and steam evacuation.

The on-site Emergency Control Centre seismic qualification and the communication system during an emergency situation have been improved.

The above mentioned modifications refer to Units 1 and 2 of Cernavoda NPP. The majority of the safety upgrades dedicated to increased protection against severe accidents had been included in the LBD for Units 3 and 4 before the Fukushima accident.

More detailed information has been provided in the Romanian National Report for the 2nd Extraordinary Meeting under the Convention on Nuclear Safety.

## 18.7 Significant developments for the last reporting period

- Since 2013, the station continued to focus on further improving the Cernavoda NPP project, to achieve safer and more reliable plant operation. Examples of design changes implemented are listed below: Following the recommendations of WANO GAP SOER 11-1 “Large Power Transformers Reliability”, the station large power transformers have been equipped with an on-line dissolved gases detection and alarm system;
- Implementation, at large power transformers, of a system to prevent explosion hazard (SERGI);
- Design modification to increase redundancy of the cooling circuit for the Auxiliary FW pump, to be used during plant outages;
- Change of the EPS Diesels starting system in order to ensure two independent groups, each one composed by a rectifier, a battery and a starter;
- Modification to improve reliability of the cooling system for U1 Instrument Air compressors;
- In case of a non-seismic induced Station Blackout event a design modification has been implemented in order to ensure a water make-up path from fire water hydrant to the Calandria Vault;
- Considering the OPEX from an external event “Stepback with Control Absorber (CA) Rod 2 or 3 stuck”, a design modification of Mechanical Control Absorber Logic within RRS control program was implemented;
- The controls of the DN Scan system (location of failed fuel) were refurbished. This design modification replaces the old control system with a modern system;

- The redundancy of electrical power suply Reactor Building air dryers (D2O recovery system) was increased by providing a second source for each drier;
- The 110 kV Station has been refurbished to increase its reliability;
- Replacement of the obsolete temperature control loops for the spent fuel bays cooling; the new loops are equipped with programmable digital controllers for better temperature control;
- Refurbish the Cathodic protection for the U1-EPS underground fuel tanks;
- Increase the reliability of the U1 main electrical generator by replacing the Excitation System with a new generation one;
- manual actuation of SDS # 1 from SCA - a seismic qualified area;
- Improve reliability of U1 Standby Diesel Generators by installation of an air drying system on the starting air system;
- actuation of ECC System on a new parameter (sustained low pressure on PHTS);
- automatic transfer from ECCS Medium Pressure Injection phase to the Low Pressure Injection phase.

After the Fukushima Daiichi accident, several design improvements have been implemented in accordance with the National Action Plan Post-Fukushima (presented in Appendix 2 of this report).

The licensee has taken measures to respond to SBO and LOUHS scenarios, has implemented operational provisions and performed a number of design changes for this purpose e.g.:

- Procurement for each unit of an additional mobile DG set (1.2 Mw) and the connections to the existing EPS buses;
- Provision of a mobile Diesel engine driven pump and flexible conduits to supply fire water trucks, under emergency conditions;
- Provision of two electrical mobile submersible pumps powered from mobile DG to supply firewater truck, under emergency conditions;
- Provision of two mobile diesel generators (110Kw) for electrical power supply to two domestic water pumps to supply firewater truck, under emergency conditions;
- The seismic robustness of the existing Class I and II batteries has been improved;
- Provision of two separate means to manually open the MSSVs after a SBO;
- Provision of connection facilities required to add water using fire fighters trucks and flexible conduits to supply the primary side of the RSW/ RCW heat exchangers and SGs under emergency conditions;
- Facilities for water addition to the calandria vessel and to the calandria vault, and increase of the in-vessel retention reliability;
- Installation of PARs for hydrogen management;
- Provisions of a seismic qualified fire-water line to Spent Fuel Bay from the S/B exterior, and of natural ventilation of vapours and steam evacuation;
- Seismic qualification improvement of the on-site Emergency Control Centre;

- Installation of satellite phones in each unit Main Control Room (Intervention Support Centre) and Secondary Control Area.
- Emergency filtered containment venting systems;
- Improvements to the instrumentation necessary to support SAMG implementation;
- Special system for hydrogen concentration monitoring in different areas of the Reactor Building.
- Completion of the off-site Emergency Control Centre.

The seismic walk-downs and subsequent seismic robustness analyses done as part of the seismic margin assessment have not revealed a need for any safety significant design change. However, several recommendations resulted from these inspections and have been included in the regular plant seismic housekeeping program.

Several measures to improve protection against flooding by flood resistant doors and penetrations sealing have been implemented. Also, sand bags have been provided on-site to be used as temporary flood barriers, if required.

The reviews performed after the Fukushima accident confirmed the safety margins available and the design robustness against severe accidents and conditions caused by extreme external events.

# ARTICLE 19 - OPERATION

*Each Contracting Party shall take the appropriate steps to ensure that:*
*(i) the initial authorisation to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;*
*(ii) operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;*
*(iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;*
*(iv) procedures are established for responding to anticipated operational occurrences and to accidents;*
*(v) necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;*
*(vi) incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;*
*(vii) programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;*
*(viii) the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.*

## 19.1 Description of the licensing process for commissioning and operation

The general licensing process has been described under Article 7. This section only provides additional information specific to the licensing process for the stages of commissioning and operation.

### 19.1.1 Commissioning

**Regulatory requirements and licensing process for the commissioning stage**

The main document based on which the Commissioning License is issued is represented by the Final Safety Analysis Report (FSAR) - which includes the following:

- updates on technical evaluations/assessments and safety analyses performed at PSAR stage;
- the results of the environmental monitoring program on-site and for the surrounding areas;
- a description and analysis of the structures, systems and components of the installation, with emphasis upon performance requirements, the technical justification of their selection and the evaluation required showing that the safety functions will be accomplished;
- the types and quantities of radioactive materials expected to be produced during operation and the means provided for controlling and limiting the radioactive

effluents and the associated radiation exposures;
- the organisational structure, including the responsibilities and authorities, and personnel training programmes;
- managerial and administrative controls to be used to ensure the safe operation of the facility;
- plans, programs and procedures for pre-operational testing and initial operation;
- plans for conduct of the normal operation, including maintenance, surveillance, and periodic testing of structures, systems and components;
- emergency plans and emergency preparedness arrangements.

General regulatory provisions, focused on the quality management of the commissioning activities, are given in the regulation "Specific Requirements for the Quality Management Systems Applied to the Commissioning Activities of Nuclear Installations" (NMC - 09).

CNCAN also establishes detailed requirements with regard to the licensing deliverables needed to demonstrate compliance with nuclear safety requirements, for each milestone of the commissioning stage. The licensing deliverables are constituted by the documentation that is submitted to CNCAN as support of the licensing applications, including the applications for the approvals associated with each of the milestones. The milestones of the licensing process are given as follows.

**Phase A Milestones**

Pre-operational and Operational testing:
- Acquire and store D2O – AD;
- Moderator D2O Fill – MD;
- Reactor Building Leak Rate Test – LT;
- Acquire and Store Nuclear Fuel - AF;
- Hot Conditioning of the Heat Transport System - HC;
- Power Failure (Loss of Class IV Power) – PF;
- Load Fuel – LF;
- PHT Fill with D2O – HD;
- Hot Performance Tests with D2O – HP.

**Phase B Milestones**

Tests at Low Power:
- First Reactor Criticality – CR

**Phase C Milestones**

At Power Testing:
- Power Increase to 5%FP – PI;
- Power Increase to 25% (PP1), 50% (PP2), 75% (PP3) and 100%FP (PP4);
- Tests at Full Power Operation (FP).

For the commissioning stage of each of the Cernavoda NPP units, a licensing schedule was established, including the provision of separate approvals for each licensing milestone, based on the appropriate support documentation. Based on the experience gained during the commissioning of Unit 1, a similar process was used also for Unit 2, with regard to both the activities of the commissioning organisation and the regulatory activities for review and inspection. Based on the experience gained and practices used by CNCAN during licensing process of Cernavoda 1 NPP, more detailed requirements for various licensing milestones have been established for Cernavoda 2 NPP. Since the processes followed for the commissioning of Units 1 and 2 of Cernavoda NPP are very similar, the information provided in this section is applicable to both units, unless specified otherwise.

**Overview of the Commissioning Programme**

The commissioning Programme for Cernavoda NPP consisted of comprehensive plant systems functional and operational tests and integrated tests. The main objective was to confirm that the entire plant is ready for normal full power operation as designed.

The principal safety functions and requirements for the safety related systems, structures and components are documented early in the design process, in Safety Design Guides (SDGs). The list of all the systems and structures deemed to have a safety function is included in the SDGs and for each item an explanation is given on the specific safety function(s). From there the high level safety requirements are derived to ensure effectiveness of the specified safety functions.

With SDGs giving high-level safety design requirements, other project documentation specifies more detailed requirements. Examples of such project documentation include other design guides, design manuals, program specifications, safety (thermal-hydraulic, stress, reliability) analysis reports, manufacturer's manuals, etc.

The Commissioning Specifications and Objectives (CSOs), which include Safety Objectives, define the system commissioning requirements necessary to assure that sufficient checks and tests are performed to demonstrate that the plant systems comply with the applicable design, safety and regulatory requirements. Unit 2 CSOs incorporated the relevant Key Commissioning Objectives (KCOs) developed during Unit 1 commissioning.

The commissioning programme was conducted on a milestone basis in parallel with the Licensing Programme agreed with CNCAN. Each milestone was achieved, and documented processes were set in place to demonstrate that:

- the testing activities were well defined and clearly detailed and the objectives of the tests were well established, in such a manner that the equipment and systems are placed in service, design specifications confirmed, and safety assumptions validated.
- the testing activities were scheduled, reviewed and performed without jeopardizing at any time the plant safety, and the status of the plant was appropriate for the corresponding commissioning activities.
- the process of test results evaluation provided assurance that all the applicable assumptions and conclusions included in the safety documentation were adequately demonstrated.
- all the required operating documentation including baseline data collection forms for systems and components was prepared and available to the operating personnel.
- test records essential to demonstrate that commissioning activities have been performed in accordance with specified requirements were collected, assembled, validated and filed to storage by the Operations Document Control Centre, as a part of the individual system commissioning packages.
- the Commissioning test results together with the process in place to review, evaluate and approve them, referred to as Commissioning Completion Assurance (CCA), were used to obtain approval to proceed beyond the licensing milestones and release hold

points agreed with CNCAN.

All of the above were sustained by a framework of processes described within the following procedures:

- System Commissioning Procedures;
- Standard Commissioning Procedures;
- Commissioning Records and Files;
- Transfer of Operating Control to Shift Crews;
- Commissioning Completion Assurance (CCA);
- Commissioning Technical Process;
- Commissioning Planning Process;
- Commissioning Reports;
- Commissioning Specifications and Objectives;
- Work Permit and Equipment Guarantee System during Commissioning;
- Temporary Modifications during Commissioning Prior to Fuel Load;
- Temporary Modifications during Commissioning after Fuel Load;
- Commissioning Execution Process;
- Operating Manual Tests;
- Work Request System;
- Work Plans;
- Operating Flowsheet Preparation;
- Operating Manuals;
- Commissioning Temporary Operating Procedures;
- Preparing, Issuing and Revising Commissioning Program Documents and Directives;
- Document and Template Management;
- Commissioning / MT Engineering Interface;
- Integrated Commissioning Tests Coordination;
- Commissioning Unplanned Event Reports (CUERs).

The Commissioning Program Phases and Objectives are summarised in Table 19.1.

**Table 19.1 – Commissioning Programme Phases and Objectives**

| Commissioning Phases | Main Objectives |
|---|---|
| **Commissioning Phase A**<br><br>Pre operational Testing<br>Hot conditioning<br>Initial fuel loading<br>Zero Power Hot Functional Testing | ▪ To verify the adequacy of plant design and prepare the plant systems and equipment for power operation<br>▪ To confirm that critical parameters and system performance are as designed before taking the plant to high power<br>▪ To test systems to meet jurisdictional requirements<br>▪ To operate the systems in the pre-power mode and demonstrate their operability<br>▪ To load the initial fuel charge<br>▪ To obtain baseline data for systems and component performance |
| **Commissioning Phase B**<br><br>Initial criticality and Low Reactor Power Physics Testing | ▪ To confirm reactor core and reactivity mechanisms configuration as per design<br>▪ To confirm the effectiveness of both shutdown systems<br>▪ To confirm the neutronic instrumentation performance<br>▪ To confirm reactivity coefficients applicable to the reactor at low power<br>▪ To validate the reactor core model<br>▪ To demonstrate the adequacy of the Reactor Regulating System |

| | |
|---|---|
| **Commissioning Phase C** (at-power testing) | ▪ To commission feed water, turbine, main generator and auxiliaries<br>▪ To confirm that under both steady state and upset conditions, reactor and balance of plant parameters behave as per design<br>▪ To demonstrate that plant can be safely operated at any power level up to full power under expected normal and abnormal operating conditions |

After completion of system by system commissioning in phase A and with appropriate systems turned over to Operations, nuclear operation began with the first approach to criticality of the reactor and subsequent low power testing.

The main purpose of these tests was to detect and correct any problems related to design, fabrication or installation of equipment and instrumentation that could affect the optimal operation of the reactor or could result in the reactor being operated in an unanalysed configuration (i.e. in a state not covered by the safety analysis). The following checks were performed:

- the reactor regulating system performance at low power;
- the performance of reactor shutdown systems;
- the fundamental characteristics of the reactor core by reactivity and flux distribution measurement and assessment.

All the prerequisites for the approach to criticality were fulfilled. In other words, all the required systems for the start-up of the reactor were available and in an operational state. This included both reactor shutdown systems.

Prerequisites for performing a test were specified in each individual test procedure. The sequence of testing was outlined in start-up test sequences, such that required prerequisite testing was completed prior to performing a subsequent test. Any special test instruments required were specified to be installed, calibrated and checked in the test procedure that specified the test equipment. Where these test instruments were not intended for future use, they were removed from the systems and systems returned to their normal states.

A special procedure was set-up to issue a "Summary Test Report" (STR) by each commissioning engineer after each test of power step of Phase B (or C). The purpose of the STRs was to assure that:

- The Phase B or C or power step of Phase C commissioning program clearly demonstrated that the systems involved met their design intent.
- The results of the commissioning program showed that the systems involved operated within the limits and according to the performance stated in the Safety Report.
- The plant could go into the next phase or power step of Phase C.

Through the review processes set in place for the verification and assessment of the Commissioning Test results it was ensured with reasonable confidence that all the objectives were met and the assumptions and conclusions from the safety support documentation were adequately demonstrated during Phase B Commissioning.

Examples of phase B tests:
- SDS#1 trip test;
- SDS#2 trip test;
- Power manoeuvres to verify RRS response;
- Stability check of Average Zone Level;
- Reactivity calibration of Liquid Zone control System;
- Transfer of RRS control from DCCX to DCCY and back;
- Manual stepback test;
- Reactivity calibration of Adjuster Absorbers, mechanical control absorbers, shut off rods and moderator poison addition system;
- SDS#1 and SDS#2 Ion Chamber shutter speed;
- Confirm response to loss of RRS at low power.

Examples of phase C tests:
- Transport System parameters at various power levels;
- Complete HTS LRV Hot Stroke Timing Tests;
- Functional Test of DCC restart and transfer of control at 2% FP;
- Complete thermo syphoning test on Main Heat Transport System;
- Dual Computer Failure Test at 15%FP;
- Monitor Solid Control Absorber System response to the dual DCC failure;
- Monitor system response to dual DCC failure;
- Load Rejection Test at various power levels;
- Loss of class IV test;
- SDS#1 and SDS#2 trip tests.

**Regulatory Surveillance Programme**

The detailed programme for tests to be performed on a system by system basis and for integrated tests for all phases has been elaborated by the licensee and submitted to CNCAN for review and approval. The programme, including specific safety objectives and acceptance criteria has been reviewed for compliance with the design intent and the safety analyses and approved by CNCAN. From this programme, safety relevant tests have been selected to be witnessed by CNCAN inspectors and included in the regulatory surveillance programme (RSP).

CNCAN programme for surveillance of the commissioning activities for Unit 2 included more than 180 Witness Points (WP) for all the phases of the commissioning programme. The Hold Points (HP) coincided with the licensing milestones.

During the commissioning stage, the regulatory authority granted the following permits/approvals:
- permit to load fuel;
- permit to load D2O in the Primary Heat Transport System;
- permit for the first criticality;
- permit for power increase up to 5% FP;
- permits for power increase in stages, up to 100% FP.

Before granting each of these permits, CNCAN inspectors performed comprehensive inspections and verification of documentation related to the status of construction and commissioning activities for systems important for safety, as well as verification of results of important tests like reactor building leak rate test, channel flow verification, loss of class IV power supply, loss of both digital control computers, thermosyphoning test, etc.

As an example, with regard to the assessment of the project status for the first criticality, the licensee submitted to CNCAN, in compliance with the Commissioning Licence conditions, a report regarding the plant status, containing a detailed review of all scopes of work that have an impact on the plant readiness for criticality. The results of the review had to demonstrate that the activities have been completed as necessary for ensuring safe and reliable plant operation.

This report was submitted to CNCAN in support to the application for the permit for reaching first criticality. The report took into consideration the following activities:

1. Systems, structures and equipment turnover from Construction Department to Commissioning Department, clarification of deficiencies, completeness of as-built documentation;
2. Systems, structures and equipment turnover from Commissioning Department to Execution/Operations Department;
3. Commissioning activities;
4. Clarification of deficiencies;
5. Design changes;
6. Radiation protection program (procedures, preparing, equipment);
7. Reference Documents and Station Instructions;
8. Personnel training (based on the minimum training requirements);
9. Training manuals (elaboration and approval for use);
10. Chemical control (safety related systems);
11. Quality management system;
12. Physical protection;
13. Operating manuals (preparation, approval and acknowledgment);
14. Operational flowsheets (revised);
15. Operating manual tests (preparing, approval and acknowledgment);
16. Call-ups and routines (elaboration, approval, acknowledgement);
17. Maintenance programmes and procedures (elaboration, approval, acknowledgement);
18. Housekeeping and housecleaning (equipment, systems, buildings, site).

The adequacy of the commissioning tests was judged based on the review of the test results, which have to demonstrate that all the relevant requirements and procedures have been observed and that safety objectives and acceptance criteria are met. The review of acceptance criteria formed part of the review of the document containing specific commissioning safety objectives and acceptance criteria for all safety related systems, which has been approved by CNCAN well in advance of the actual tests performance. The commissioning test results were listed in the commissioning completion assurance reports (CCA) containing a comparison to the acceptance criteria.

The regulatory surveillance plan (RSP) enabled CNCAN to effectively control step by step the commissioning process to verify that the plant, as built, meets the design safety requirements.

Meeting of Pressure Vessel Authority (ISCIR) requirements was a prerequisite for obtaining the licences and permits issued by CNCAN. The reactor coolant pressure boundary was subject to a pre-operational hydrostatic test and leakage test. Periodic inspection consists of visual inspections, surface inspections, volumetric inspections, integrative inspections, dimensional inspections, etc., in compliance with the provisions of accepted codes and standards.

### 19.1.2 Trial Operation

The trial operation license is granted by CNCAN based on the first revision of the Final Safety Analysis Report, which includes the results of the commissioning phase (conclusions of the commissioning reports, the achievement of key commissioning objectives, etc.). Also, some other documents regarding the assessment of significant changes from safety point of view and the status on the implementation of different station programmes are submitted to CNCAN as support documentation for the license. Summary of these station programmes is presented below:

- Nuclear Safety Policy;
- Reliability Programme;
- Unplanned Events Assessment Programme;
- Safeguards Programme;
- System Surveillance Programme;
- Radiation Safety Programme;
- Radiation Waste Management Programme;
- Effluent and Environmental Monitoring Programme;
- ALARA Programme;
- Emergency Preparedness and Response Programme;
- Fire Protection Programme;
- Quality Assurance Programme;
- Training Programme;
- Design Modification Control Programme;
- Periodic Inspection Programme;
- Maintenance Programme;
- Housekeeping Programme;
- Safety Analyses Strategic Programme.

### 19.1.3 Operation

For the first operating licence, each of the Cernavoda NPP Units has prepared a second update of the Final Safety Analysis Report, to include the main results obtained during the trial operation period.

The reports on the design modifications and the status of the station programs were updated. A special focus was directed to the assessments of the unplanned events and the major objectives during that period, as for example the annual planned outage.

The operating license has then been renewed periodically. The main support documents based on which the license was granted were the revisions of FSAR which included all the design changes implemented in that period. Also, the applications contained descriptions of the major plant processes including the surveillance, configuration management, preventive maintenance, training, etc. and the implementation status of the actions required by CNCAN.

The Final Safety Analysis Reports (FSAR) for the Cernavoda NPP Units are reviewed and updated periodically. The updates to the FSAR are submitted to CNCAN and address mainly the following aspects:

- new or updated deterministic safety analyses;
- new or updated probabilistic safety assessments;
- design and procedural changes;
- implementation of actions resulting from the PSR programme;
- implementation of actions resulting from various safety reviews and from operational experience feedback;
- the status of the plant programmes with regard to:
  - physical condition of the nuclear power plant;
  - control of modifications;
  - systems surveillance;
  - ageing and environmental qualification;
  - radioprotection;
  - environmental impact;
  - organisation and administration;
  - shift structure for maintenance and operating personnel;
  - plant personnel training;
  - periodic inspections;
  - systematic revision of spare parts;
  - preventive maintenance;
  - emergency planning;

Based on the results of the surveillance programme and periodic review of safety performance, the station established a set of safety performance indicators, which are reported monthly to the station management. Also, the safety performance is reported quarterly to the regulatory authority via Quarterly Technical Reports (QTR). The fourth QTR presents a safety performance review of the past year.

In accordance with the regulatory requirements, Quarterly Technical Reports present also monitoring results regarding:

- reliability and reactor safety;
- station performance;
- production summary and outages;
- station operations (plant upsets, reactor performance and fuel management, core monitoring);
- reportable events (description, root causes, corrective actions and recommendations);
- plant changes;
- nuclear fuel;
- heavy water management;
- controlled radioactive sources management;
- radioactive material transportation;
- radiation control & employee safety;
- radioactive waste management;
- radioactive effluents;
- environmental monitoring;
- alarms;
- fire protection;
- reactor safety assessment;
- special safety systems;

- stand-by safety systems;
- human resources/training;

CNCAN staff performs a daily check of plant status by means of daily reports issued by CNCAN resident inspector and Shift Supervisors Log made available by the licensee.

## 19.2 Operational Limits and Conditions

In compliance with the regulatory requirements, the FSAR includes a chapter with the technical limits and conditions for operation, established on the basis of the analyses and evaluations included in the FSAR and amendments thereto. The technical limits and conditions include items in the following categories:

a) Safety limits and the setpoints for actuation of the safety systems;
b) Limiting conditions for operation;
c) Surveillance requirements (relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met);
d) Design specific features (those features of the installation such as materials of construction and geometric arrangements, which, if altered or modified, would have a significant effect on safety and are not covered in categories described in paragraphs a), b) and c) above);
e) Administrative controls (relating to organization and management, procedures, recordkeeping, review and audit, and reporting necessary to assure operation of the facility in a safe manner).

The OLCs are derived from the safety analysis included in the Chapter 15 of FSAR and are approved by CNCAN as part of the Operating License. Chapter 16 of the FSAR is dedicated to the description of OLCs and of their technical bases. The licensee cannot change the OLCs them without prior approval of the Regulatory Authority.

A fundamental requirement of nuclear safety is to operate and maintain the nuclear power plant within a defined "safe operating envelope" in accordance with the design intent and the licensing basis. The safe operating envelope is defined by the Final Safety Report. Specific operating limits as resulted from the "safe operating envelope" are added to the safety limits as defined by the safety evaluations.

The "safe operating envelope" is defined by a number of safety requirements from which the most important are:

- Requirements on special safety systems, and safety related stand-by equipment or functions, e.g. set points and other parameters limits, availability requirements.
- Requirements on process systems, e.g. parameter limits, testing and surveillance principles and specifications, including performance requirements under abnormal conditions.
- Pre-requisites for removing special safety systems and other safety related or process stand-by equipment from service.

The safe operating envelope is implemented by means of the OLCs, which are included in the set of operating documents consisting of Operating Policies and Principles, Impairment Manual, Operating Manuals and Operating Manual Tests. These operating documents support the fulfilment of the Operating Licence conditions and ensure that the plant will be operated in safe conditions.

As it is the case with the majority of CANDU units around the world, Cernavoda NPP Units have the Operating Policies and Principles (OP&P) as the top tier document in the hierarchy of operating documentation, establishing the safe envelope the plant must be operated within. This document states operating rules, principles and limits to maintain the plant in a safe analysed state. It also describes the interface between plant management and the regulatory body. The OP&P document contains safety systems licensing limits, basically defining minimum system configuration to meet availability targets and to ensure the integrity of the physical barriers against radioactive releases.

The Impairment Manual provides further assistance for the operator to determine system availability. The Impairment Manual contains also the required actions to be taken for various safety systems or safety related systems impairments that render those systems less than fully capable to perform their functions as per design. For Special Safety Systems, which are dormant systems, specially designed to protect the public from radiological risk, a hierarchy of three levels of impairment has been defined with “Level 1” being the most severe and “Level 3” the least severe. For each level of system impairment specific actions are designated. Alarms have limits conservatively chosen to early alert the operator when impairment limits are challenged.

All operating personnel directly responsible for the conduct of operations are subjected to a rigorous selection, training and examination process to acquire and demonstrate the necessary knowledge and skills. An integral part of the training programme (that is presented in detail under Article 11) consists of specially designed training courses to explain the rationale for all OP&P limits and conditions. All modifications to plant design and/ or approved limits include, prior to their implementation, the provision of appropriate operator training on the changes and their effect. All changes to OP&P are approved by CNCAN and any OP&P limit or condition violation is an event reportable to CNCAN.

The OP&P is periodically reviewed and updated as necessary, based on the results of the latest safety assessments performed, operating experience feedback and various modifications (including organisational changes and modifications to plant systems, processes and procedures).

### 19.3 Procedures for normal operation

The operating licence issued by CNCAN includes specific references to documents such as Operating Policies and Principles, Maintenance Philosophy and Program, Integrated Management Manual. All these documents include, directly or by reference to appropriate procedures, rules that must be followed in performing activities related to operation, maintenance, inspection and testing.

The compliance with the requirements included in the operating licence and in the documents specifically referenced by this document is mandatory for the licence holder and any deviation must be timely reported to CNCAN.

The OP&P contain the general policies and limits that govern the operation of the station and the responsibilities of operating personnel. The OP&P is not as detailed as other operating procedures (e.g. systems Operating Manuals). However, it includes rules according to which the operating activities have to be authorised. Consequently, compliance with the articles of the OP&P ensures that, in the event of an expected or unforeseen situation, operation will be managed with a minimum of adverse effects.

The OP&P does not apply only to personnel performing operating manoeuvres, but to all personnel taking part in the operation of the station. Therefore, the rules established by the OP&P must be known and complied with by members of all services and administrative units working at the site. One of the main responsibilities of the Shift Supervisor is to ensure that station activities comply at all times with the OP&P, especially in situations that are not covered in operating manuals. To assist him, the Control Room Operator is also qualified to apply OP&P requirements in normal and abnormal operating situations.

OP&P require that Special Safety Systems and the other safety related systems are subjected to regular testing where their reliability or effectiveness cannot be inferred from normal operating experience. Test intervals are consistent with reliability evaluations contained in current licensing submissions. The station Surveillance Programme satisfies this requirement.

The Surveillance Programme includes planned activities carried out to verify that the plant is operated within the prescribed operational limits and conditions, and to detect any deterioration of structures systems and components that could result in unsafe conditions. These activities can be categorised as:

- Monitoring plant parameters and system status;
- Checking and calibrating the instrumentation;
- Testing and inspecting structures, systems and components;
- Test results evaluation.

The aim is to verify that provisions made in the design for safe operation and confirmed during construction and commissioning, continue to be adequate throughout the lifetime of the plant. At the same time, the verifications are aimed at ensuring that the safety margins are both adequate and provide high tolerance for anticipated operational occurrences, errors and malfunctions. The Surveillance Programme covers mandatory testing, preventive maintenance and inspections.

Detailed procedures are prepared to cover all normal, abnormal and emergency conditions. The OP&P document specifies the operating boundaries that are an integral part of the written instructions to operators, and the authorities of the station staff. Safety margins are provided for all limits by means of staggered alarms designed to maintain high confidence that OP&P limits are not exceeded during plant transients from normal operation or in the event of a plant system breakdown.

All normal operating procedures (including systems Operating Manuals) are controlled and approved instructions that support the operational strategy for preventing unsafe conditions of the plant. The alarm response procedures (ARM, WARM, and FARM) are instructions for the anticipated abnormal occurrences; their strategy is to provide the necessary instructions to limit the transient frequency.

The majority of procedures are written in English since station annunciation is in English, but a decision was made to translate procedures for selected areas or systems. Appropriate training was provided to all the originators, procedure reviewers and users. Where procedures are available both in English and Romanian, priority is given to the Romanian version if differences exist. All station personnel must follow applicable procedures and the necessary approvals must be obtained prior to any deviation from any procedure.

Plant equipment and controls in the main control room are only operated by operators licensed by CNCAN or under the direct supervision of these operators. Continuous training and refresher training including full scope simulator guarantees that the level of knowledge and skills is adequate to support safe plant operation under both normal and upset conditions. Standards are set and expectations are communicated by plant management in various types of documents. All are reinforced during periodical evaluations including simulator training sessions, coaching and observation.

The set of operating procedures for Cernavoda NPP includes documents in the following categories:

- Operating Manuals (OM);
- Annunciation Response Manuals (ARM);
- Window Alarm Response Manuals (WARM);
- Field Annunciation Response Manuals (FARM);
- Standard Operating Sequences (SOS);
- Overall Unit Operating Manuals (OUOM);
- Abnormal Plant Operating Procedures (APOP);
- Severe Accident Management Guidelines (SAMG);
- Emergency Response Operating Manual.

Initially, the operating procedures were developed by the Technical Department using equipment/ systems specifications from design manuals, guides and safety requirements, for all station systems. In the last years the decision was made to format all operating documentation using INPO guides, and a new dedicated procedure writing group was organised as part of the Operations Support Group.

All individual system OMs include references to station OP&P for easy access to all limits applicable and reflect the limitations specified in the OP&P. They include also normal and some abnormal operating procedures. The process is described by the station procedure “Operating Manual Content”. The same document describes the format for the Annunciation Response Manuals since they are derived from the original Operating Manuals as alarm and operator actions to stabilise and troubleshoot the individual systems.

Temporary operating instructions (OI) are issued anytime a change is needed in one of the OM’s until a new revision is in place, or to provide operators with information for new systems/ equipments, in the absence of an OM. The OIs are reviewed periodically to maintain the validity and cancelled when no longer required.

Standard Operating Sequences (SOS) were developed for jobs of a recurrent nature and with a certain degree of complexity to justify the use of a standard document.

For specific situations such as plant start up and shut down or plant upsets, the coordination between various system operation is provided in the form of Overall Unit Operating Manual

(OUOM) which is a PERT diagram representation of the necessary steps or procedures (from systems' OMs) to be performed for a particular plant state to be reached.

All plans shall include hazards and contingency actions for any adverse situations that may develop from the sequence of steps/ events to be performed. CNCAN approval is also necessary for activities that may challenge safety envelope as stated in OP&P document. Multiple layers of reviews and approvals are built in to process of developing non-routine activities.

The process, including detailed steps of preparation, review, safety and operational screening and approvals, including those by Station Manager and CNCAN, is described in the station procedure governing the Work Plans.

Information on the surveillance programmes and the associated procedures has been provided under Article 14, section 14.3.2.

### 19.4 Response to anticipated operational occurrences and accident situations

Specific station procedures are in place for mitigating the effect of an abnormal event initiator and direct the operator to bring the plant to a safe state that usually is defined as the cold shut down state. The response to anticipated operational occurrences and to accidents is controlled through a hierarchical system of station procedures as follows:

- Operating Manuals and Alarm Response Manuals – include procedures used by the plant operation staff during routine operation of the nuclear power plant and its auxiliaries and also information regarding abnormal operation and the alarm functions associated with the plant systems (set points, probable cause, operator response, etc.);
- Impairment Manual - includes actions to be taken by the operator in case that operation is close to or getting outside the specified limits of the safe operating envelope;
- Abnormal Plant Operating Procedures (also known as Emergency Operating Procedures (EOPs)) - which direct the operator during accident conditions (for design basis and design extension conditions) and are designed to restore the plant to a safe condition and ensure protection of the health and safety of the plant personnel and of the general public;
- Severe Accident Management Guidelines – which direct the operators and technical support groups during severe accident conditions and are designed to minimize the severe accident consequences and to bring the plant in a stable end state.
- Emergency Response Operating Manual - includes operator's actions in case of radiological, medical and chemical incidents, fire events, extreme weather conditions, spent fuel transfer/ transport incidents, spent fuel bays and spent fuel dry storage facility incidents, loss of Main Control Room; this manual provide the necessary criteria to classify the emergency and easy access to each of the sections containing the necessary measures to be taken for the different types of emergencies, with the overall process being governed by the on-site Emergency Plan.

Administrative procedures are in place to express the management expectations for the operating crew when dealing with plant transients, aiming to eliminate confusion and obtain consistency in crew performance. These documents set responsibilities and give authority to licensed personnel to recognise the abnormal event and mitigate its consequences.

When a transient occurs, it is the responsibility of the authorised operators (Shift Supervisor and Main Control Room Operator) to recognise situations that may cause OP&P or licence violations and / or a threat to plant safety or to personnel. Crew response to transient is defined in station procedure “Transient Response Strategy”, and it is declared that the transient ends when the unit is in a known and stable state.

Abnormal Plant Operating Procedures (APOPs), provided for response to design basis accidents and design extension conditions, include event-based type of procedures, as well as symptom based procedures. Two new APOPs, for responding to Station Black-out and Abnormal Spent Fuel Bays Cooling Conditions, have been issued as part of the response to lessons learned from the Fukushima Daiichi accident.

The current set of APOPs for Cernavoda NPP includes the following:

- APOP-E01 - Dual Computer Failure;
- APOP-E02 - Loss Of Feedwater;
- APOP-E03 - Loss Of Instrument Air;
- APOP-E04 - Loss Of Service Water;
- APOP-E05 - Loss Of Class IV Power;
- APOP-E06 - Large LOCA (Loss of Coolant Accident);
- APOP-E07 - Small LOCA;
- APOP-E08 - Steam Generator Tubes Failure;
- APOP-E09 - Partial Loss Of Class IV Power;
- APOP-E10 - Very Low Suction Bay Level;
- APOP-G01 - Generic Heat Sink (MCR);
- APOP-G02 - SCA (Secondary Control Area) Operation;
- APOP-G03 - Station Black-Out;
- APOP G04 - Abnormal Spent Fuel Bays Cooling Conditions.
- APOP G05 – Loss of Shutdown Cooling

Cernavoda NPP has implemented a set of Severe Accident Management Guidelines (SAMGs), to cope with situations in which the response based on APOPs is ineffective and the accident conditions progress to severe core damage. The objectives of the SAMGs are:

- to terminate core damage progression;
- to maintain the capability of containment as long as possible;
- to minimize on-site and off-site releases.

The SAMGs for Cernavoda NPP have been developed based on the generic CANDU Owners Group (COG) SAMGs for a CANDU-600 type of plant. In developing the generic SAMGs, COG adopted the Westinghouse Owners Group (WOG) approach, with the necessary technical modifications suitable for implementation in CANDU plants, based on extensive CANDU specific severe accident analysis and research.

Preparation of plant-specific SAMGs was done by customization of the generic COG documentation package for Cernavoda NPP, removing extraneous information not applicable to the station, incorporating station-specific details and information and making any other adjustments required to address unique aspects of the plant design and/or operation.

A total number of 48 documents were prepared (SAG’s, SCG’s, CA’s, SACRG’s, SAEG’s, DCF, SCST and their associated background documents). Also, another 40 Enabling

Instructions were prepared in order to support the line-ups for each strategy presented in the above mentioned documents.

The interface between APOPs and SAMGs was established by introducing the severe accident entry conditions into the APOPs. The interface with the Emergency Plans was provided by making revisions to the existing EPP documentation, to reflect the new responsibilities and requirements arising from the implementation of the SAMGs. Also, all categories of plant personnel involved in the emergency response organisation were trained for SAMG use, and drills are currently being incorporated in the overall Emergency Response Training Program.

The SAMGs have been developed based on the existing systems and equipment capabilities. A limited and focused set of information requirements was defined to support SAMG diagnostics and evaluations. The primary source is from plant instrumentation, supplemented by additional measurements and data expected to be available through emergency response procedures and Computational Aids where appropriate.

The list of SAGs (Severe Accident Guidelines) and SCGs (Severe Challenge Guidelines) is provided below:

- SAG-1 - Inject into Heat Transport System;
- SAG-2 - Control Moderator Conditions;
- SAG-3 - Control Calandria Vault Conditions;
- SAG-4 - Reduce Fission Product Release;
- SAG-5 - Control Containment Conditions;
- SAG-6 - Reduce Containment Hydrogen;
- SAG-7 - Inject into Containment;
- SCG-1 - Mitigate Fission Product Release;
- SCG-2 - Reduce Containment Pressure;
- SCG-3 - Control Containment Atmosphere Flammability;
- SCG-4 - Control Containment Vacuum.

The Emergency Response Operating Manual includes procedures to deal with the following type of emergencies:

- Radiological;
- Medical;
- Chemical;
- Fire;
- Extreme weather conditions;
- Spent fuel transfer/ transport incidents;
- Spent fuel bays and spent fuel dry storage facility incidents;
- Loss of Main Control Room.

This manual provides the necessary criteria to classify the emergency and easy access to each of the sections containing the necessary measures to be taken for the different types of emergencies. The overall process is governed by the on-site Emergency Plan.

## 19.5 Engineering and Technical Support

The station organisational chart for Cernavoda NPP documents the general areas of responsibility. The structure of the organisation considers the needs for engineering and technical support and for this reason it includes strong Technical Unit covering the departments of Process Systems, Component Engineering and Design Engineering.

A strong link is also maintained with Romanian research institutes and with the designer of the plant, Atomic Energy of Canada Limited, Romania being member of CANDU Owners Group.

The Operations & Maintenance budget also contains provisions for the funding necessary to hire external institutes for services in the areas of research, design modifications, safety analyses, maintenance, inspections, etc.

The Technical Unit, through its dedicated departments, provide strong technical support through well developed programmes. The following sections provide information on the main activities of the individual Technical Unit Departments:

**Process Systems Department:**

The Process Systems Department fulfils its responsibility and accountability for the safe and reliable operation of assigned systems through well developed programmes such as System Health Monitoring (SHM) and other related processes implemented by Responsible System Engineers (RSEs). The System Engineer’s prime role is to plan and execute System Health Monitoring and performance assurance activities for assigned systems per the SHM programme documents. The intent of their role is to have an overview for system performance in such a way so as to provide reasonable assurance that assigned systems will operate safely and perform in accordance with their design intent under normal and abnormal operating conditions.

The SHM programme is governed by one Station Instruction and six Inter Departmental Procedures. Specifically, the following tasks are completed as part of the SHM programme:

- Develop System Health Monitoring (SHM) plans, which define key parameters of assigned systems and equipment to be monitored, recorded, trended and analyzed at the specified frequency for addressing & mitigating any degradation in their performance;
- Develop system performance goals and monitor system performance against these goals according to the approved SHM plans;
- Monitor system specific equipment parameters and ensure they meet the acceptance criteria or have implement actions to address deficiencies;
- Execute system health monitoring activities including documented system walk downs, observation of system and equipment condition and transient analysis in accordance with the SHM Program;
- Prepare, issue and present System Health Monitoring reports to the SHM Review Board as scheduled;
- Prepare Action Plans to improve health of assigned systems.

**Component Engineering Department:**

The Component Engineering Department fulfils its responsibility and accountability for the safe and reliable operation of components and equipment through well developed programmes such as Component & Program Health Monitoring Processes implemented by Component Engineers (CEs) and Programme Engineers (PEs). The CEs/PEs prime role is to plan and execute Component and Program Health Monitoring Programs per the respective processes. They are expected to make sure that their assigned components and programs are effective to provide reasonable assurance that critical components will operate safely and perform in accordance with their design intent under normal and abnormal operating conditions.

The component and programme health monitoring processes are governed by appropriate station process documents. Specifically, the following tasks are completed as part of these programmes:

- Development and implementation of the Component Health Monitoring (CHM) programme for assigned components and equipment;
- Development and implementation of long and short-term maintenance & inspection programs and monitoring of designated plant equipment and components to achieve this objective;
- Development and implementation of maintenance programmes e.g. Flow Accelerated Corrosion (FAC), Periodic Inspection Program (PIP), Valve Programs, EQ, Preventive Maintenance, Generic Instrumentation, Supports/ Snubbers, etc.;
- Development and implementation of a Plant Life Management (PLiM)/ Plant Life Extension (PLEX) programme;
- Development and implementation of a Thermal Performance Monitoring programme.

**Design Engineering Department:**

The Design Engineering Department fulfil its role by ensuring that design and configuration control activities under its responsibility are performed / verified using applicable codes, engineering standards, technical specifications, and safety analysis reports in accordance with the license conditions. Additionally, it is also assured through approved processes that plant design bases as well as the licensing bases are not affected by design modifications and that the design configuration control is maintained. The design processes ensure accuracy and completeness of work through review, verification and approval processes by qualified staff. It is expected that the design work done is free of errors and covers all aspects of design before it is considered ready for implementation.

The Design Engineers are expected to design, coordinate, manage, execute and document design modifications in accordance with the established and approved Design Change Policy process. Specifically, the following main tasks are completed as part of the design engineering functions:

- Perform design related activities for design modifications approved by Cernavoda Management Design Review and Approval Committee (DRAC);
- Coordinate and manage the Modification Proposals & Approval process.
- Perform all design related activities ensuring they meet applicable codes, standards, design specifications, safety analysis and operating license requirements;
- Develop design & support implementation of approved design modifications;
- Ensure upkeep of the station’s design configuration control, including the station design basis record;
- Perform procurement engineering related activities;
- Perform material / components equivalency assessments and substitutions as required.

- Establish and implement a process for liaising with the regulators on matters related to plant modifications.

## 19.6 Reporting of incidents significant to safety

The Operating Licence requires reporting of abnormal conditions/ events according to the station procedure “Events Reportable to CNCAN”, which establishes the criteria and the method for reporting of events to CNCAN.

The document includes 47 criteria related to public safety, environmental protection, radiation protection, production, and security, and also events of interest to the regulatory (outside the scope of the reportable events). The procedure is kept updated by periodic revisions to address the current Regulatory reporting requirements, and to clarify the scope and intent of the reporting criteria regarding the impact of the event on the nuclear safety, in accordance with the latest international practices.

Operator’s responsibilities during a transient include also notifying management. If the situation requires immediate notification to the Regulatory, as per guidance in the station procedure “Events Reportable to CNCAN”, the on-call station manager will inform CNCAN as appropriate. Specific steps for communicating via telephone and fax are set with CNCAN, such as this communication to be effective whenever it is performed. A written notification will be made to CNCAN during the next working day.

The current process for reporting the abnormal conditions within CNE Cernavoda ensures that for any abnormal occurrence a report is issued immediately when the condition occurs or when it is acknowledged. Thus the report for the abnormal event will be issued immediately after stabilising the situation and having the plant in a stable and safe state.

This report will be analysed according to station procedure for “Abnormal Conditions Reporting”, which means taking necessary steps for investigating, determining causes and taking adequate corrective actions to prevent recurrence.

At the end of investigations, when the corrective actions plan is approved by Management, a written Assessment Event Report will be submitted to CNCAN. This report will contain information related to the chronology of the event, significance to safety, causes and corrective actions taken by the plant to prevent recurrence.

Assessment Event Reports (AER) are prepared for those events that could have significant adverse impact on the safety of the environment, the public, the personnel, such as: serious process failures, failures of the special safety systems, trips of the shutdown systems, actuation of the ECCS or Containment system, violations of the OP&P/ licence conditions, release of radioactive materials in excess of target, doses of radiation which exceed the regulatory limits, events which interfere with IAEA safeguards system, etc.

## 19.7 Operational Experience Feedback

For Cernavoda NPP the station goal with regard to operating experience is to ensure effective and efficient use of lessons learned, from own operating experience as well as from that of other plants, to improve plant safety and reliability.

Station events and human performance problems result from weaknesses or breakdowns in station processes, practices, procedures, training, and system or component design that were not previously recognised or corrected. This is the reason why Cernavoda NPP considers, as the main topic of the Operating Experience Programme, the Event Analysis System, comprising identification, evaluation and analysis of operational events (both internal and external) in order to establish and implement corrective actions to avoid re-occurrence. The procedures that support the OPEX Programme have been listed in the chapter corresponding to Article 10.

The basis for Operating Experience Program was set in place since the early stage of the commissioning phase of Unit 1, with the objective to ensure:

- the reporting, review and assessment of the station unplanned events and the establishment of the necessary corrective actions;
- information exchange within CANDU Owners Group (COG) and WANO, regarding abnormal conditions, technical problems, research and development projects, etc.

### 19.7.1 Internal operating experience

Classification of the abnormal conditions is based on their impact (actual or potential) on nuclear safety, personnel safety, environment or production. The detail of level investigation is based on the classification of the abnormal conditions, starting from registering trend analysis for the minor abnormal conditions, to systematic analysis of root causes for major impact events.

For each event investigated, previous similar conditions are taken into account and if an emerging trend is identified, the classification of the abnormal condition will be upgraded to reflect the significance of the condition because of the re-occurrence (i.e. even if an abnormal condition, considered as a singular occurrence, is deemed to be classified “minor”, it will be investigated as “important”, if a series of similar occurrences is identified).

According to the current station instruction “Abnormal Condition Reporting” (ACR), events that meet the investigation threshold established by this procedure are investigated using root cause analysis methodologies. A management sponsor (at management/senior superintendent level) for each root cause analysis event is responsible for establishing investigation scope and depth, and provide oversight of the investigation team. The investigation team is formed of specialists from all disciplines involved in the analysis of the event. Members of analysis team are responsible to provide technical support for all steps of investigation using a root cause methodology (HPES or ASSET).

Each stage of the investigation is requested to be performed within a specific time frame. For instance, a root cause analysis will be performed within 20 working days from the occurrence of the event, an apparent cause investigation in 15 days and an evaluation (assignment of corrective actions at supervisory level) will be normally done in 10 days. These targets are assigned and followed using the computerized database for the event reports.

The process of event investigations and identification of corrective actions is standardised. Standard templates for Apparent Cause Evaluations, Root Cause Analysis Reports are available in Station Intranet together with instructions for filling in the reports. The reports evaluate previous similar events and determine if previous corrective actions were effective, and also extent of condition/causes of the events is taken into account.

Apparent cause evaluations are reviewed by the Abnormal Condition Review Committee (ACRC). Proposed corrective actions, approved by ACRC are transferred into Action Tracking for follow-up.

When a root cause analysis is finalised, and the proposed Action Plan is prepared, a Root Cause Analysis Review Committee (RCARC) meeting is arranged. The meeting is chaired by the Station Manager; RCARC approves the root cause analysis and the corresponding action plan. Proposed actions are then transferred into Action Tracking, and followed to completion.

The apparent cause evaluation reports, root cause analysis reports and other documents (TOE, ODM, etc…) are available in the station events database for further reference.
Relevant OPEX information is brought to the attention of working groups via pre-job briefings and just-in-time training.
If necessary, specific training and reinforcement actions are set for specific working groups, to discuss the lessons learned from these events. For most important events, like plant transients or serious human performance events, training materials and station information bulletins are issued, with emphasis on the most important aspects of the events.

The use of the procedure “Abnormal Condition Reporting” has been addressed also under Article 10, where the list of ACR initiation criteria has been provided.

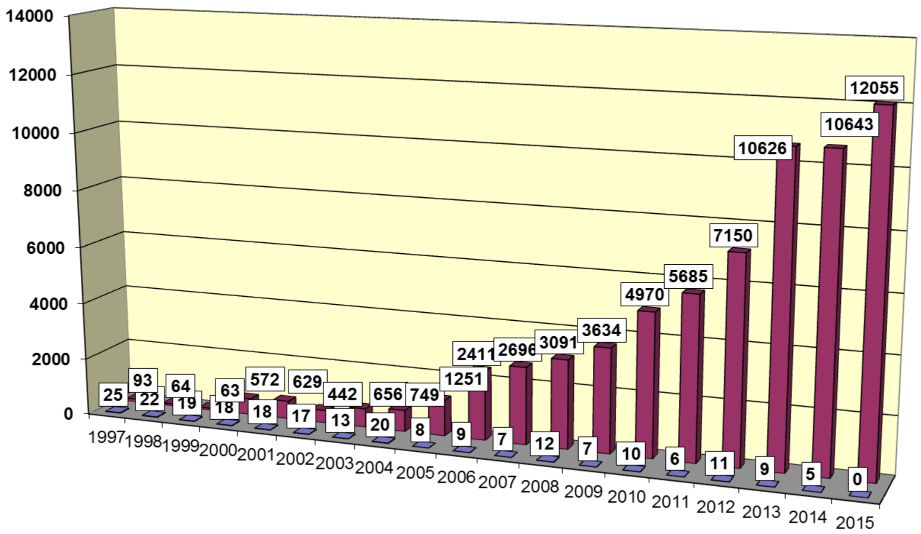
Starting with 2007, since commercial operation of Cernavoda Unit 2, the operating experience program at Cernavoda NPP comprises both Units, based on the same set of procedural guidance which was accordingly revised to reflect operation with two Units.

The number of abnormal condition reports (ACRs) initiated has been steadily increasing, reaching 12055 ACR in 2015. It is a management priority to reinforce the expectations for initiation of ACRs for all abnormal conditions encountered, especially low-level events which may represent precursors or near misses, and for any minor deficiency encountered in plant processes, work practices or human performance. The steady safety performance is demonstrated by the low number of reportable events,

In order to improve the quality of the event analysis process, a significant focus was placed on the training program for the plant personnel. The training courses envisaged the process of initiation of ACRs, the use of the computerized databases and of the operating experience websites. A large number of plant personnel were involved in the training programs. Another aspect followed through training courses is related to improving the quality of the apparent cause evaluations and root cause analyses. For this, a “Root cause analysis manual” was issued based on the common investigation techniques such as WANO Human Performance Enhancement System (HPES) and IAEA ASSET.

The OPEX database is maintained for internal/ external ACRs, for both Units.. Corrective actions associated with the ACR are managed through WMS Action Tracking Module, as Action Requests / assignments.

A graph for the evolution of the number of Abnormal Condition Reports and the AERs showing the continuous trend for improvement is provided in Fig. 19.1.




| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reportable events | 25 | 22 | 19 | 18 | 18 | 17 | 13 | 20 | 8 | 9 | 7 | 12 | 7 | 10 | 6 | 11 | 9 | 5 | 0 |
| Total number of ACRs | 93 | 64 | 63 | 572 | 629 | 442 | 656 | 749 | 1251 | 2411 | 2696 | 3091 | 3634 | 4970 | 5685 | 7150 | 10626 | 10643 | 12055 |

**Fig. 19.1 Trending of Abnormal Condition Reports and of Assessment Event Reports**

## Trending of the low-level events

The general interest in a "learning organisation" is to report and record as many low-level events as possible. These are non-consequential events that highlight latent organisational weaknesses and increase the chances of error during the performance of a specific task by a particular individual.

Analysing the trends of low level events allows identifying underlying organisational weaknesses that may generate events with significant impact. Identification of low-level events and understanding the common aspects that connect those events provides adequate justification to proactively establish new barriers (or strengthen old ones) in order to prevent future significant events.

The information regarding the abnormal conditions reports is maintained in a database that tracks all the related information. The events are coded against causal codes and other parameters that allow periodically trend analysis to show emerging trends and new issues. Coding of ACRs has been continually improved to provide for meaningful parameters and clear quantitative criteria for identification of an adverse trend.

The trend analyses are performed quarterly, or at station management request, and presented graphically, with comments and proposal for corrective actions. The Trend Analysis report contains all the analyses performed by the OPEX group, is verified and approved by the senior management (Safety, Compliance & Performance Improvement Senior Superintendent, Station Manager) and is also discussed during periodic management meetings.

Adverse trends are subject of ACRs and they are analysed in order to identify the common causes and to assign the corrective actions, the main purpose being to fix the adverse trend. Corrective actions efficiency review is done in the following trend analysis reports performed for the next quarters.

Trend analyses are also performed by the key departments using the ACR codes. The analyses are documented as Information Reports and are approved to the Senior Superintendent level. For any adverse trending identified, ACRs are issued and analysed for common cause identification and corrective actions are assigned, addressing the causes.

### 19.7.2 External operating experience

The external information on operating experience proved to be a very important tool in improving station performance. Therefore, the second main topic of the operating experience program is the Information Exchange Program, with bi-directional use:

- collecting of external information and distribution to the appropriate station personnel;
- submitting the internal operating experience information to external organisations.

The station procedure "External Operating Experience Feedback" is in place for screening for applicability the information provided by external organisations like COG, WANO, INPO and IRS.
For any applicable external event identified an external ACR is issued and recorded in OPEX database. External ACRs are analysed using a specific template.

For the major events (e.g. WANO Significant Operating Experience Reports/Significant Event Reports, IRS events level 2 or higher on INES scale), an Abnormal Condition Report is issued, and the analysis is performed using a gap analysis template.
This means that the station actual processes, procedures and work practices are compared with the recommendations given in the reports, a gap is identified between current situation and recommended aspects, and actions are defined to fill in the gap. Further processing is performed according to station instruction "Abnormal Conditions Reports".

Except this formal processing and tracking of significant industry events, plant personnel has access to the COG Operating Experience Database and to WANO/INPO websites and operating experience posts and monitors daily the new events posted on these websites. The majority of the records is posted only for information, but might be used while reviewing in-house events, design modifications or looking for relevant just-in-time operating experience for certain operational evolutions or other activities.

The international nuclear organisations require a prompt notification regarding events occurred at the station in order to offer well-timed information to the world community. For the information exchange programme, a contact person, appointed by the station management, with the following general responsibilities maintains the relation between Cernavoda NPP and COG / WANO:

- serving as a liaison between COG / WANO and Cernavoda NPP;
- reviewing the incoming messages and distributing them to the appropriate plant personnel;
- ensuring the transmittal of the required information/reports to COG / WANO;
- ensuring optimum participation by the station personnel.

The criteria for reportable events to COG and WANO are defined by these organisations in reference documents. These criteria are:

- Severe or unusual plant transients;
- Malfunctions or improper operation of safety systems;
- Major equipment damage;
- Excessive radiation exposure or severe personnel injury;
- Unexpected or uncontrolled release of radioactivity in excess of off-site or on-site regulatory limits;
- Fuel handling or storage events;
- Deficiencies of design, analysis, fabrication, construction, installation, operation, configuration management, man-machine interface, testing, maintenance, procedure or training deficiencies;
- Other events involving plant safety, reliability or significant loss of production;
- Any other events of generic interest to CANDU NPPs.

Still, a number of events that do not meet these criteria but are considered of interest to the industry, representing various opportunities for improving work practices and procedures or finding about particular design or equipment flaws that could be corrected before they occur in site are reported. Thus, the reports shared with the industry might not reach the level of reporting, but still contain significant learning points.

Cernavoda NPP level of event reporting to external organisations has continuously improved. The number of event reports to the external organisations is monitored at the station level and complies with the targets for reporting set by these external organisations. CNE Cernavoda has met the requirements imposed by WANO for the number and timeliness of reports. Also, the number of external events which were formally reviewed through the ACR process has steadily increased, reaching 340 external ACRs in 2015. This results in a better utilisation of the external information and a greater awareness of the plant personnel for the industry events.

At regulatory level, CNCAN is member of the International Reporting System (IRS), contributing to international experience exchange by reporting generic events or issues of interest for the nuclear community. All events reported to CNCAN by the Cernavoda NPP are independently assessed by CNCAN from two points of view: INES rating and analysis using a recognised methodology (ASSET, HPES) for direct and root causes determination as well as appropriateness of the corrective actions established by the licence holder. The applicability of corrective actions resulted from nuclear events reported through IRS is also assessed, their implementation in Cernavoda NPP being surveyed by means of regulatory topical inspections.

Information obtained from the internal and external operational experience is used for multiple purposes, such as:

- Improving the operating practices and plant staff training programmes;
- Improving the plant design;
- Input for Ageing Management Programme;
- Assessment of necessity for updating of the safety analyses (deterministic and probabilistic), etc.

## 19.8 Management of Spent Fuel and Radioactive Waste

### Minimisation of waste

Waste minimisation is considered in Romania as an important issue, having direct impact on radioactive waste management.

An important means for the reduction of the volume of radioactive waste generated is the clearance of the waste and incineration of the combustible radioactive waste. CNCAN has issued the "Requirements for clearance from licensing regime of materials resulted from licensed nuclear practices". The above mentioned regulation establishes clearance levels, both for conditional and free release of materials from radiological areas.

Waste streams are defined and waste are collected and segregated depending on generation source and activity levels. Significant quantities of metallic, organic liquid and textiles (protective equipment) waste have been unconditionally released from CNCAN control, the clearance process being an important way to minimise waste volumes.

Also, the ALARA policy is applied for material management during preparation and executing radiological activities inside of radiological areas, in order to minimized radioactive waste produced

The main objectives of waste management programme at Cernavoda NPP are:
- Complete waste identification and control by corresponding work procedures;
- Maintaining of waste production as low as possible.

Control measurements applied during plant operation and maintenance activities consist in the following:
- Waste production minimisation
- Equipment reutilisation as per initial destination;
- Materials recycling;
- Materials clearance from licensing regime;
- Waste treatment methods specific to waste stream cjharacteristics;

Waste production is minimised as volumes and activities, by:
- proper operation and maintenance procedures both for primary and secondary waste..
- Volume reduction by controling the types and quantities of materials entering radiological areas;
- Thorough waste characterisation procedures from physical, chemical and radiological point of view;
- Activities planning and using coresponding waste handling equipment; in order to avoid secondary waste production;
- Equipments surfaces decontamination to avoid contamination spreading;

Radioactive waste conditioning technologies are selected in order to minimize the volume of temporary stored waste, for example solidification of organic liquid using high capacity absorbents. This requirement is considered by CNCAN in the licensing process.

Generation of radioactive waste associated with CANDU spent fuel is minimized through:
- the quality of fuel;

- timely detection and removal of the failed fuel,
- canning of the failed fuel.

Good fuel management resulted in significant reduction or radioactive waste generated by loss of fission and activation products from faulty fuel bundles. Also the volume of purification filters (spent resins) is maintained at relatively low values.

For all spent fuel, the control of water parameters in wet storages, and control of confinement and of the isolating air parameters for dry storage minimises the generation of radioactive waste associated with spent fuel management.

The tritium removal facility project (mentioned under Article 15) reached conceptual design completion and agreement of licensing basis with the Regulatory Body. The implementation of the project (currently under approval) will result in decreasing the tritium concentration in the moderator circuit and will contribute to significant reduction of tritium contaminated waste.

**Control of treatment and interim storage of radioactive waste**

The solid radioactive waste is pre-treated and treated into stainless steel drums. The waste is then temporarily stored into interim storage pending recovery, conditioning and disposal. Studies for best available international practices related to treatment and conditioning methods have been undertaken by expert third parties and analysis are undergo to decide the most suitable option for Cernavoda NPP for radioactive waste characterization, treatment and conditioning for disposal.

**Programmes to manage radioactive waste**

Cernavoda NPP has all operational arrangements including special designated facilities for proper current management of its gaseous, liquid and solid operational radioactive wastes, in order to assure the protection of the workers, the public and the environment.

The gaseous wastes are collected by ventilation systems, filtered and released through the ventilation stack under a strict control to minimize the environmental impact. The aqueous liquid wastes of NPP are collected and after adequate purification by using ion exchange resins (if necessary), are discharged into the environment.

The aqueous liquid waste having higher gamma radioactivity which prevent releasing through plant system are send to a decontamination facility outside Cernavoda NPP in order to retain gamma contaminants.

Spent ion resins are collected and stored into special tanks.

The organic liquid waste is solidified in polymeric absorbent structure and stored on site, the arising of the secondary waste streams being taken into account from the treatment and conditioning of the radioactive waste.

The solid waste from NPP is collected, segregated, and compacted (if it is the case) into stainless steel 220 l drums.

Currently, the combustible waste are incinerated by sending them to a licensed operator, at Studsvik, in Sweden and plans are under development to send waste metallic parts to melting at Studsvik (Sweden).

At present at Cernavoda NPP the implementation of the waste characterisation process is in progress, followed by implementing of clearance process. The waste characterisation process will lead to the implementation of a new classification system according to both CNCAN order "Radioactive Waste Classification System Regulation" and the acceptance criteria for disposal to be issued by national Nuclear and for Radioactive Waste Agency when available.

As per Cernavoda NPP licenses for each unit, Cernavoda NPP is authorized to unconditionally clear 100 tons of waste and materials yearly from each unit based on approved procedures.
Clearance process has been started in 2008 by releasing a number of 77 drums x 0.22 $m^3$ of spent oils produced from various plant systems, the major route of contamination being represented by contact with the reactor primary coolant.

In the years to follow the process continued by releasing solid radioactive waste such as:
- metallic waste consisted mainly in cranes components replaced from both units (aprox. 5 tonnes in 2012, 5 tonnes in 2013);
- metallic waste consisted mainly in aluminum covers from ventilation filters units replaced from both units and from spend MSA tritium filters cartridges (aprox. 6 tonnes in 2014);
- textiles waste consisted in used radiation protection equipment (brown coveralls) (360 kg in 2014 and 3360 kg in 2015).

**Management of spent fuel**

The spent fuel system of Cernavoda NPP Units 1 and 2 were designed to meet adequate safety standards as used in Canada. The Spent Fuel Bay of Cernavoda NPP – Unit 2 design meets the general requirements as described in the IAEA Safety Series 116 – Design of spent fuel storage facilities by including the following:
- measures to limit radioactive releases and radioactive exposures of workers and the public (including detection of leakage through the bay walls and floor);
- measures to prevent anticipated operational occurrences and accident conditions from developing into unacceptable severe accident conditions;
- provision for ease of operation and maintenance of essential equipment;
- provisions, through equipment and procedures, for retrieving spent fuel from storage.

Even though it is generally accepted that the Fuel Handling and Storage Systems of Cernavoda NPP Unit 1 and of the Unit 2 ensure required safety, it has to be noted that in order to enhance safety, modifications for the fuelling/defueling machine design were introduced by the designer, due to the application of new design requirements issued by CNSC and endorsed by CNCAN, and due to feedback of operational experience.

It should be mentioned also that, prior the restarting of the construction of Unit 2, a review of the nuclear safety of the unit under construction was performed through a PHARE project. One of the ten tasks of this project, entitled Task 5 - Assessment of Nuclear Safety of On-Site Facilities regarding Nuclear Fuel and Radioactive Waste, concluded that the safety is assured according to western standards. However, recommendations were made for supplementary analyses and for initiating design changes, if the results of the analyses show that design changes are recommended. Also, in Task - 6 Evaluation of Adequacy of Engineered Provisions for Radiation Protection, it was recommended to review the suitability and application of the spent fuel pool surface finish and to consider the installation of a suitable metallic liner, to fulfil the secondary containment requirement. This design change was already implemented in the construction of Unit 2.

After 6 years of storage in the Spent Fuel Bay, the spent fuel is transferred to the Spent Fuel Dry Storage. The Spent Fuel Dry Storage Facility is located on the NPP site, close to the containment building of Unit 5. Its designed storage capacity will be expanded gradually from 12,000 to 324,000 spent fuel bundles. (It can accommodate the spent fuel inventory from two reactors).

The dry storage technology is based on the MACSTOR System. It consists of storage modules located outdoors in the storage site, and equipment operated at the spent fuel storage bay for preparing the spent fuel for dry storage. The spent fuel is transferred from the preparation area to the storage site in a transfer flask. The transportation is on-site. Currently seven storage modules are operational providing a total storage capacity of 74,000 spent fuel bundles.

Currently, a new strategy for the future development of the Dry Spent Fuel Storage has been approved, the main 2 major changes being the future use of double capacity MACSTOR 400 modules instead of actual MACSTOR 200 as well as the increase of the storage area. Based on this revised strategy a better use of the existing storage area and adequate storage capacity for the planned long term operation of Units 1 and 2 will be achieved.

### 19.9 Significant developments for the last reporting period

In the last reporting period, a complex safety review was undertaken following the Fukushima Daiichi accident, in the context of the European "stress tests", and several improvements have been implemented or are under implementation in accordance with the National Action Plan Post-Fukushima (presented in Annex 2 of this report).

Regarding the use of operational experience feedback, an increasing trend of abnormal conditions reported for the two Cernavoda units is evident for the last years. This shows a built-up of a culture for reporting abnormal conditions at all levels.

The ACR screening process includes a daily screening meeting of the Abnormal Condition Review Committee to classify ACRs. This multidisciplinary screening also has accountability to immediately assess operability concerns and the need for compensatory actions.

An OPEX Intranet website is available for all plant personnel, containing links to relevant internal and external operating experience. A large number of technical, operations and maintenance staff are subscribed to COG newsgroups and have WANO/INPO website access rights.

The main improvement in radioactive waste management programme at Cernavoda NPP for the last reporting period was the reduction of the volume of generated radioactive waste by clearance and incineration of the combustible radioactive waste.

## LIST OF ACRONYMS

ACR - Abnormal Condition Report

ALARA - As Low As Reasonable Achievable

ANCEX - National Agency for the Control of Exports

ANCST - National Agency for Research and Technology

ANDR - Nuclear Agency and for Radioactive Waste Management

APOP - Abnormal Plant Operating Procedure

BE - Basic Events

BOP - Balance of Plant

CANDU - Canadian Deuterium Uranium Reactor

CBT - Computer Based Training

CNCAN - National Commission for Nuclear Activities Control

CNU - National Uranium Company

COG - CANDU Owners Group

CPR - Centre for Radio-Isotopes Production

CRO - Control Room Operator

CSRG - CANDU Senior Regulators' Group

IFIN – HH - R&D Institute for Physics and Nuclear Engineering "Horia Hulubei"

IR - Information Report

ISCIR - State Inspectorate for Boilers, Pressure Vessels and Hoisting Installations

JRTR - Job Related Training Requirements

DCC - Digital Control Computers

DEL - Derived Emission Limit

DM - Design Manual

DNDR - National Repository of Radioactive Waste

EBP – Extra Budgetary Programme

ECCS – Emergency Core Cooling System

EFD - Event Free Days

EFT - Event Free Tools

ENSREG – European Nuclear Safety Regulators Group

EOOS - Equipment Out Of Service

EPRI - Electric Power Research Institute

GEM - Gaseous Effluents Monitor

HP - Human Performance

IAEA - International Atomic Energy Agency

ICSI - Institute for Cryogenics and Isotopes Separation

ICRP - International Committee for Radiation Protection

IDP – Inter-Departmental Procedure

IGSU - General Inspectorate for Emergencies

INPO - Institute of Nuclear Power Operations

IPSART - International Probabilistic Safety Assessment Review Team

IR – Information Report

ISO - International Organisation for Standardisation

LEM - Liquid Effluents Monitor

LEPI - Post-Irradiation Examination Laboratory

LSC - Liquid Scintillation Counting

MCR - Main Control Room

MPA - Modification Proposal and Approval

NMC - Norms on Quality Management

NPP - Nuclear Power Plant

NSP - Nuclear Steam Plant

ODM - Operational Decision Making

OJT - On-the-Job Training

OLC - Operational Limits and Conditions

OM - Operating Manual

OMT - Operating Manual Tests

OPEX - Operating Experience

OP&P - Operating Policies and Principles

OSART - Operational Safety Review Team

PHWR - Pressurised Heavy Water Reactor

PJB - Pre-Job Briefing

PSA - Probabilistic Safety Assessment

PSOC - Plant Safety Oversight Committee

PSP - Process Specific Procedures

PSR – Periodic Safety Review

QMS - Quality Management System

QTR - Quarterly Technical Report

RAAN - Autonomous Company for Nuclear Activities

RCA - Root Cause Analysis

RD - Reference Document

RSE - Responsible System Engineer

RSP - Regulatory Surveillance Plan

SADL - Safety Analysis Data List

SAMG - Severe Accident Management Guidelines

SCA - Secondary Control Area

SDG - Safety Design Guide

SDM - Safety Design Matrix

SER - Significant Event Report

SI - Station Instruction

SITON - Centre for Nuclear Projects Engineering

SNN - National Company “NUCLEARELECTRICA”

SOER - Significant Operating Experience Report

SOS - Standard Operating Sequence

SS - Shift Supervisor

SSC - Systems Structures and Components

TLD - Thermo Luminescent Dosimeter

TOE - Technical Operability Evaluation

WANO - World Association of Nuclear Operators

WENRA - Western European Nuclear Regulators Association

## ANNEX 1

### Structure and content of the Law 111/1996 on the safe deployment, regulation, licensing and control of nuclear activities

The purpose of the Law is to provide for a comprehensive legal framework for the regulation, licensing and control of all activities related to the peaceful use of nuclear energy. The content of the Law is described as follows:

### Chapter I - General Dispositions

This chapter defines the purpose of the law, the activities which are within the scope of the law, as well as the authority, mandate and responsibilities of CNCAN.

The Law applies to the following activities and sources:

- research, design, possession, siting, construction, assembly, commissioning, trial operation, operation, modification, preservation, decommissioning, import and export of nuclear installations;
- design, possession, siting, construction, assembly, commissioning, operation, preservation and decommissioning of installations for milling and processing of uranium and thorium ores and of installations for the management of wastes resulted from the milling and processing of uranium and thorium ores;
- production, siting and construction, supply, leasing, transfer, handling, possession, processing, treatment, use, temporary or permanent storage, transport, transit, import and export of radiological installations, nuclear and radioactive materials, including nuclear fuel, radioactive waste, and ionising radiation generating devices;
- production, supply, and use of dosimetric equipment and ionising radiation detection systems, materials and devices used for the protection against ionising radiation, as well as containerisation or means of transport for radioactive materials, especially designed for such purposes;
- production, supply, leasing, transfer, possession, export, import of the materials, devices, and equipment specified in Annex 1 to the Law;
- possession, transfer, import and export of unpublished information related to materials, devices and equipment pertinent to the proliferation of nuclear weapons or other explosive nuclear devices, as specified in Annex 1 to the Law;
- manufacturing of products and supply of services designed for nuclear installations;
- manufacturing of products and supply of services designed for radiation sources, dosimetric control instruments, ionising radiation detection systems, materials and devices used for the protection against ionising radiation.
- orphan sources, from their detection to their final disposal as radioactive waste.

In accordance with the Law, CNCAN is the national competent authority that exercises regulation, licensing and control attributions in the nuclear field. CNCAN is a public institution of national interest, with legal personality, having its headquarters in Bucharest, chaired by a President with the rank of State Secretary, coordinated by the Prime Minister through the Prime Minister's Chancellery. The first chapter of the Law also establishes the modality of CNCAN financing.

The general dispositions also include statements with regard to the banning of nuclear proliferation activities and import of radioactive waste and spent fuel (unless the waste and spent fuel originates from Romania).

**Chapter II - Licensing Regime**

This chapter is structured in two sections: "Licences and Permits", and "Licensing Conditions."

The first section defines all the activities for which a formal authorization from CNCAN is needed, under the form of a licence or permit. It also set the general framework for the licensing process, including the licensing stages for the nuclear installations.

The licences for nuclear installations are granted to legal persons, at their request, if they prove compliance with the provisions of the Law and specific regulations issued by CNCAN. According to the Law, the licences issued by the CNCAN shall be drawn up by levels of exigency, depending on the risks associated with the activities that are subject to licensing.

The licenses are applied for and issued, respectively, either simultaneously or successively, separately for each kind of activity or for each nuclear or radiological installation operating independently, belonging to the applicant's property. The licensing of construction or operation phases for any nuclear or radiological facility may only take place if for the previous phases have been granted all the types of necessary licenses.

For a nuclear installation such as a nuclear power plant, the licensing stages include design, siting, construction, commissioning, trial operation, operation, repair and/or maintenance (as major refurbishment), modification (as major upgrades), preservation and decommissioning.

Partial licences may also be issued to cover the construction or operation stages of nuclear and radiological facilities. Partial licences issued simultaneously or successively for one and the same stage may have the character of a provisional decision of CNCAN, if the applicant expressly requests so. In such a case their validity shall extend up to the issuing of the final licence of that type, but no more than two years with an extension right, on request, for two more years, when all necessary information is not available in due time. The partial licence can be withdrawn by CNCAN whenever it finds a lack of concern on the part of the licence holder for the completion of the necessary information in support of the application.

The licences and the permits are granted for a period established in accordance with the regulations developed by CNCAN. The licences and permits are not transferable.

Apart from situations when the licence holder is no more legally constituted or loses the legal personality, the licences can be suspended or withdrawn, partially or in total, for all cases of:

- non-compliance with the legal and regulatory provisions, or with the limits and conditions of the licence;

- failure to implement the corrective actions dispositioned as a result of the regulatory control;

  new situations, from technical point of view, or of other nature, that had been not known prior to the issue of the licence, and which could impact upon the safe deployment of the licensed activities.

The practice permits can be suspended or withdrawn for all cases of non-compliance with the provisions of the applicable regulations.

The second section of Chapter II provides the general conditions that an applicant shall meet for obtaining a licence, such as:
- to demonstrate the provision of adequate resources for carrying out the activities in a safe manner;
- to take all the necessary measures, at the level of the current technological and scientific standards, to prevent the occurrence of any damage that may result due to the construction and operation of the nuclear installation;
- to prove that has organisational capacity and responsibility in preventing and limiting the consequences of failures having the potential for a negative impact on the life and health of his own personnel, on the population, on the environment, on the property of third parties or on his own assets;
- to have arranged indemnification for liability in case of nuclear damage;
- to ensure that the decision-making process for safety matters in not unduly influenced by third parties;
- to have established arrangements, in accordance with the provisions of the specific CNCAN regulations, for ensuring radiological safety, physical protection, quality management, on-site emergency preparedness;
- to have established a system for the information of the public.
- to prove that has adequate and sufficient material and financial arrangements for the collection, transport, treatment, conditioning and storage of radioactive waste generated from the licensed activities, as well as for the decommissioning of the nuclear installation upon termination of operations, and has paid the contribution for the establishment of the fund for the management of radioactive waste and decommissioning;
- to prove that has obtained all the other licenses, agreements, approvals in accordance with the legislation in force, that are prerequisites for the licence issued by CNCAN.

Further information on the general conditions regarding the assurance of sufficient financial and human resources is provided under Article 11, while the conditions for obtaining a licence for the quality management system are described under Article 13.

**Chapter III - Obligations of the Licence Holder**

This chapter establishes the general obligations of the licence holders and responsibilities for the safety of their licensed installations, including nuclear waste management and decommissioning. Relevant excerpts from the Law are provided in this report under Article 9 of this report.

**Chapter IV - Control Regime**

The legal provisions stated in this chapter empower CNCAN to carry out inspections at the licence holders as well as at the applicants for a licence, to control the application of the relevant regulatory requirements.

CNCAN inspectors are empowered to perform the necessary control activities at the site where the activities subject to licensing are deployed, as well as at any other location which may be connected to these activities, including the home or other location of any natural or legal person that may carry out activities related to nuclear and radiological installations or have possession of any nuclear or radiological materials, including related information.

The control activities are performed for any of the following situations:

- before granting the licence for which an application has been submitted;
- for the whole period of validity of the licence (periodic, as well as unscheduled or unannounced inspections);
- based on a notification/request made by the licence holder;
- for cases when it is suspected that installations, devices, materials, information, activities, etc., that are under the scope of the Law, exist or are performed without having been registered and subjected to licensing/authorisation process.

Following the control, CNCAN may disposition, if deemed necessary, the suspension of the activities and cease of operation/use of the respective installation, materials, devices, equipment, information, etc. that are possessed/operated/used without a licence or the operation/possession of which could pose a threat.

In exercising the control mandate, CNCAN representatives are empowered to:

a) access any place in which activities subject to the control may be deployed;
b) carry out measurements and install the necessary surveillance equipment;
c) request the taking or receiving of samples from the materials or products directly or indirectly subject to the control;
d) compel the controlled natural or legal person to ensure the fulfilment of the provisions mentioned under points a) – c) and to mediate the extension of the control to the suppliers of products and services or to their subcontractors;
e) have access to all the information necessary for achieving the objectives of the control, including technical and contractual data, in any form, with observance of confidentiality if the holder makes explicit requests in this sense;
f) compel the licence holder to transmit reports, information, and notifications in the form required by regulations;
g) compel the licence holder to keep records, in the form required by regulations, of materials, of other sources and activities subject to the control, and to control these records;
h) receive the necessary protective equipment, for which the applicant or licence holder shall arrange.

For the whole duration of the control activities, CNCAN representatives have the obligation of observing the applicable licensing conditions, as imposed upon the personnel of the licence holder.

CNCAN representatives have the following attributions, to be exercised after conclusion of the inspection/control activity:

a) to draw up a report stating the results of the control, the corrective actions requested, and the deadlines for their implementation;
b) to propose the suspension or withdrawal of the licence or practice permit, under the terms of the Law;
c) to propose the information of the legal prosecution bodies in the cases and for the violations specified under the Law;
d) to request that the licence holder to applies disciplinary sanctions to the personnel guilty of violations specified in the Law;
e) to apply the sanctions for contraventions, as specified in the Law, to the persons vested with the statutory responsibility of representing the licence holder in the relation with the public authorities;
f) to apply the sanctions for contraventions, under the terms of the Law, to the personnel guilty of commission of the respective violations.

**Chapter V - Attributions and Responsibilities**

This chapter defines the attributions and responsibilities of CNCAN, as well as those of the other governmental organisations that have different roles in the regulation, monitoring or control of the various nuclear activities. The provisions stated in Chapter V of the Law are described in this report under Article 8.

**Chapter VI - Penalties**

This chapter defines the violations, including criminal offences, acts of terrorism and contraventions, and the respective penalties entailed, specifying that the offences of attempt are also subject to prosecution. The unauthorised deployment of any of the activities subject to licensing or approval under the terms of the Law constitutes a criminal offence.

**Chapter VII - Provisional and Final Dispositions**

This chapter includes provisions with regard to the validity of the licences and permits issued prior to the coming into force of the Law, the possibility of appealing against any regulatory decision claimed to have caused a prejudice, etc.

The Annexes to the Law include the following:

**Annex 1**: List of materials, devices and equipment pertinent to nuclear proliferation;

**Annex 2**: Definitions;

**Annex 3**: Authorities having various attributions in the review and inspection of nuclear activities:

1. CNCAN;
2. Local Authorities for Public Health;
3. State Inspectorate for Environmental Protection;
4. State Inspectorate for Boilers, Pressure Vessels and Hoisting Installations (ISCIR);
5. The National Committee for Emergency Situations;
6. General Police Inspectorate;

7. State Inspectorate for Labour;
8. National Agency for the Control of Exports;
9. National Authority for Customs;
10. The Romanian Bureau of Legal Metrology.

**Annex 4**: List of organisations without legal personality, which can hold a licence under the terms of the Law.

# ANNEX 2

## Romanian Action Plan post-Fukushima - Summary of improvement activities

The latest status of the Romanian National Action Plan is summarised in the table below, which provides an outline of the main improvement activities resulting from the post-Fukushima safety reviews performed to date. The table identifies, for each action, the organisation(s) responsible for implementation (SNN - the licensee, CNCAN, or both), the status of the action (implemented, in progress, planned or under evaluation) and the target date for completion. The status of the actions reflects the situation as of July 2016.

CNCAN monitors the licensee's progress in the implementation of the planned improvements and continues to perform safety reviews and inspections to ensure that all the opportunities for improvement are properly addressed taking account of the lessons learned from the Fukushima accident.

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **Topic 1 – External events (earthquakes, floods and extreme weather conditions)** | | | |
| **1.** Review the specific procedure which is in place for extreme weather conditions in order to include the appropriate proactive actions for plant shutdown. | SNN | Implemented | - |
| **2.** Identification of potential measures to improve protection against flooding. | SNN | Implemented | - |
| **3.** Provision of on-site of sand bags to be used as temporary flood barriers, if required. | SNN | Implemented | - |
| **4.** Improvement of the seismic robustness of the existing Class I and II batteries. | SNN | Implemented | - |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **5.** Design modifications to replace selected doors with flood resistant doors and penetrations sealing (for improving the volumetric protection of the buildings containing safety related equipment located in rooms below plant platform level). | SNN | In progress | November 2016<br>The target date for implementation was initially the end of 2014.<br>All identified flood resistant doors (around 50) were installed in Unit 1 and Unit 2. All design changes identified in rev. 0 of the MPA#1094 (flood doors and penetration sealing) are implemented.<br>Still in progress are the activities to improve penetrations sealing of selected T/B rooms as per rev. 2 of MPA#1094.<br>The last two Design Packages (DRP) are in approval stage.<br>The change of the target date for implementation was due to the complexity of the engineering solutions for penetrations' sealing.<br>The remaining activities are introduced in the Work Management System and are monitored. |
| **6.** The seismic walk-downs and subsequent seismic robustness analyses done as part of the seismic margin assessment have not revealed a need for any safety significant design change. However, several recommendations resulted from these inspections, which have been included in the regular plant seismic housekeeping program. These do not impact on the seismic margin assessment. | SNN | Implemented | - |
| **7.** The regulator to consider routine inspections of the flood protection design features. | CNCAN | Implemented | - |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **8.** The peer review recommended that a seismic level comparable to the SL-1 of IAEA leading to plant shutdown and inspection is established.<br>It was suggested to the regulator to consider implementing adequate regulations. Currently the actions taken by the licensee following an earthquake are based on decision making criteria that include the estimated damage to the plant (walkdowns using a specific procedure) rather than on pre-defined level. | CNCAN | Implemented | Cernavoda NPP has established the SL-1 level.<br>The regulation NSN-06 on the protection of nuclear installations against external events of natural origin has been published in January 2015. |
| **9.** Elaboration of more detailed regulatory requirements on the protection of NPPs against extreme external events, taking account of the lessons learned from the Fukushima accident and of the results of the "stress tests" peer reviews. | CNCAN | Implemented | The regulation NSN-06 on the protection of nuclear installations against external events of natural origin has been published in January 2015. |
| **10.** The peer review concluded that there is only little information about margins to cliff edges due to external events and weak points. Further work is proposed in this area and it is recommended that CNCAN obtains good quality programmes from licensees and ensures that the work is appropriately followed up. | CNCAN | Planned | Depending on the development of a common methodology, at EU-level, for assessing margins to cliff-edge effects due to external events.<br>The regulation of NSN-06 includes requirements on the assessment of cliff-edge effects due to external events of natural events. |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **Topic 2 – Design Issues** | | | |
| **11.** Procurement and testing of mobile equipment (e.g. mobile diesel generators, mobile pumps, connections, etc.). | SNN | Implemented | - |
| **12.** Provision of a facility to open the MSSVs after a SBO. | SNN | Implemented | - |
| **13.** Provision of connection facilities required to add water using fire fighters trucks and flexible conduits to supply the primary side of the RSW/RCW heat exchangers and SGs under emergency conditions. | SNN | Implemented | - |
| **14.** Specific emergency operating procedures to cope with Station Blackout and Loss of Spent Fuel Pool Cooling events. | SNN | Implemented | - |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **15.** The option of charging the batteries or the installation of a supplementary uninterruptible power supply for the SCA is being considered by the licensee as a potential improvement. | SNN | In progress | End of 2016<br>The initial target date had been set for the end of 2015.<br>A few options to supply plants critical parameters from SCA, during severe accident (SBO), from a seismically qualified power supply, were analysed and documented. These options are in addition to existing modification for supplying SCA panels from the large mobile Diesel generators, which is implemented.<br>The solution selected for implementation, documented in MPA#EC1973, was to add a new power supply to SCA instrumentation panels from 100 kV mobile Diesels, which are already procured.<br>The design modification package (MWP) is approved. The change of the implementation date is due to time required to procure the new, seismically qualified, electrical panels that need to be installed. |
| **Topic 3 – Severe Accident Management and Recovery (On-Site)** | | | |
| **16.** Validation of the station Severe Accident Management Guidelines (SAMG) through emergency exercises. | SNN | Implemented | - |
| **17.** Training for severe accident scenarios, including as part of the emergency drills. | SNN | Implemented<br>(Refreshment training is performed periodically) | - |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **18.** Special agreements were established with the local and national authorities involved in the emergency response in order to ensure that in case of a SBO coincident with loss of primary UHS the plant has absolute priority to grid re-connection and supply of light and heavy equipment and the necessary diesel fuel. | SNN | Implemented | - |
| **19.** Accident management provisions for events in the spent fuel pools (natural ventilation for vapours and steam evacuation, seismically qualified fire-water pipe for water make-up). | SNN | Implemented | - |
| **20.** Improvement of the existing provisions to facilitate operator actions to prevent a severe accident in SFB (water level and temperature monitoring from outside the SFB building). | SNN | Implemented | Design improvements have been implemented at both units. Water level gauges were installed to allow operators SFB level measurement in case of severe accident from an accessible location, outside the SFB building. Portable devices will be used for water temperature measurement. |
| **21.** Installation of PARs for hydrogen management. | SNN | Implemented | - |
| **22.** Installation of dedicated emergency containment filtered venting system for each NPP unit. | SNN | Implemented | - |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **23.** Additional instrumentation for SA management e.g. hydrogen concentration monitoring in different areas of the reactor building. | SNN | Implemented | - |
| **24.** Improvements to the reliability of existing instrumentation by qualification to SA conditions and extension of the measurement domain. | SNN | Implemented | The design changes implemented at both Cernavoda Units to improve survivability to SA addressed the following parameters:<br>- R/B pressure,<br>- Calandria Vault level,<br>- moderator level,<br>- Heat Transport temperature. |
| **25.** Implementation of a design modification for water make-up to the calandria vessel and the calandria vault | SNN | Implemented | - |
| **26.** Verification of the completeness of event-based and symptom-based EOPs for all accident situations. | SNN<br>CNCAN | Implemented | - |
| **27.** Severe accident management requirements to be included in a regulation. | CNCAN | Implemented | The regulation with requirements on severe accident management was issued in January 2014. |
| **28.** MCR habitability analysis to be continued (e.g. assessment of total core melt with voluntary venting, implementation of close ventilation circuit with oxygen supply). | SNN | Implemented | - |
| **29.** Review of Level 1 PSA & completion of Level 2 PSA (to include SFB accidents). | SNN | Implemented | - |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **30.** Measures have been identified (and will be implemented) that aim to improve the reliability of the: (i) communication system and (ii) on-site emergency control centre. | SNN | Implemented | - |
| **31.** Cernavoda NPP will establish a new seismically qualified location for the on-site emergency control centre and the fire fighters. This location will include important intervention equipment (mobile DGs, mobile diesel engine pumps, fire-fighter engines, radiological emergency vehicles, heavy equipment to unblock roads, etc.) and will be protected against all external hazards. | SNN | In progress | End of 2017<br>The target date was initially set for the end of 2015. It was changed due to legal and administrative issues related to transfer of property of the physical location.<br>Until the completion of this action, equivalent measures have been implemented to ensure that all intervention equipment (mobile Diesels, Diesel fire pump, fire trucks, and so) are protected from external hazards (e.g. the equipment have been relocated so that they would not be impaired by external events). |
| **32.** Review of SAMGs taking account of plant modifications and upgrades performed after Fukushima. | SNN<br>CNCAN | Implemented | - |
| **33.** The development of SAMGs specifically for shutdown states is under consideration. | SNN | Implemented | - |
| **Topic 4 – National Organisations** | | | |
| **34.** Improvement of on-site emergency organisation. | SNN | Implemented | - |
| **35.** Review of lessons learned from the Fukushima accident with regard to organisational factors and applicability to national organisations in the nuclear sector. | CNCAN<br>SNN | Implemented | - |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **36.** Implementation of recommendations from the 2011 IRRS mission. | CNCAN | In progress | End of 2016 |
| **37.** Review of the national regulatory framework for nuclear safety to identify and implement actions for improvement. | CNCAN | In progress | Continuous activity<br>Work continues for the revision of the regulations, in particular to incorporate the new WENRA Reference Levels |
| **Topic 5 – Emergency Preparedness and Response and Post-Accident Management (Off-Site)** | | | |
| **38.** Review the existing protocol with Public Authorities in order to ensure the necessary support for the Cernavoda NPP personnel in case of severe accident, when the roads are blocked due to extreme meteorological conditions, natural disasters (earthquakes, flooding, etc.) or other traffic restrictions. | SNN | Implemented | - |
| **39.** Installation of Special Communication Service phones in each Main Control Room (Intervention Support Centre) and Secondary Control Area. | SNN | Implemented | - |
| **40.** An alternative off-site emergency control centre is being developed. | SNN | Implemented | The new offsite emergency control center was tested during a drill, in December 2015. |
| **41.** A review of the national off-site response is in progress to take account of the lessons learned from the Fukushima accident. | CNCAN + other national authorities | In progress | End of 2016<br>(Actions for improvement have been identified and are under implementation) |

| Action | Responsible for implementation | Status | Target date for implementation |
|---|---|---|---|
| **Topic 6 – International Cooperation** | | | |
| **42.** Identification and consideration of additional relevant peer-review services. | CNCAN<br>SNN | Implemented | This is a continuous activity, controlled by the OPEX processes.<br>WANO-PEER Review Missions at Cernavoda NPP, from October 2013 and November 2015, had a specific section to evaluate the actions taken in response to Fukushima event.<br>A specific Benchmarking on the subject of Emergency Preparedness was carried out in the week of 23-27.11.2015, at Pickering (OPG).<br>OSART and IRRS missions are planned for 2016. |
| **43.** Participation in international activities for sharing experience on lessons learned from the Fukushima accident and on actions taken to improve safety. | CNCAN<br>SNN | In progress | Continuous activity |