ROMANIA

National Assessment Report for the EU Topical Peer Review on Fire Protection for Nuclear Installations

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FOREWORD

This report has been prepared by the National Commission for Nuclear Activities Control (CNCAN), the nuclear regulatory authority of Romania, following the ENSREG specification developed by WENRA for the European Union Topical Peer Review (TPR) on Fire Protection for Nuclear Installations.

In preparation of the National Assessment Report (NAR), CNCAN has reviewed the reports prepared by the licensees, the National Company Nuclearelectrica (SNN) and the Institute for Nuclear Research (RATEN – ICN) and has conducted inspection activities at the nuclear installations.

The report presents the regulatory framework for fire protection, the measures implemented by the licensees, as well as the specific information required in accordance with the TPR specification.

Based on the regulatory reviews and inspections performed so far, CNCAN is satisfied with the adequacy of the licensees' fire protection programs and with their overall implementation. No major issues have been identified. However, several opportunities for improvement have been identified, both with regard to the regulatory framework and to the licensees' fire protection programs and will be included in an action plan.

1. GENERAL INFORMATION

1.1 Nuclear installations identification

In accordance with the ENSREG specification, developed by WENRA, the scope of the Romanian national assessment report (NAR) for the EU Topical Peer Review (TPR) on fire protection for nuclear installations covers the following installations:

- Cernavoda Nuclear Power Plant (NPP) Units 1 and 2, in operation, with their associated spent fuel storages and radioactive waste management facilities, including the Intermediate Dry Spent Fuel Storage Facility (IDSFS) located on the Cernavoda site for the spent fuel long term storage;
- The TRIGA Research Reactor, in operation, with its associated spent fuel storage and radioactive waste management facilities;
- The Nuclear Fuel Manufacturing Plant, with its associated radioactive waste management facilities.

All these nuclear installations and their associated activities are licensed by CNCAN.

1.1.1. Qualifying nuclear installations

All the above-mentioned installations are included in the scope of the TPR on fire protection.

Table 1.1 provides a summary of basic data on these installations.

Table 1.1: Nuclear installations addressed in the Romanian NAR

Name	Licensee	Type of reactor / installation	Power output	Year of first operation	Scheduled shutdown
Cernavoda NPP Unit 1	National Company Nuclearelectrica (SNN)	Pressurized heavy-water reactor (PHWR) – CANDU 6	Design net capacity: 650 MW(e)	1996	N/A
Cernavoda NPP Unit 2	National Company Nuclearelectrica (SNN)	Pressurized heavy-water reactor (PHWR) – CANDU 6	Design net capacity: 650 MW(e)	2007	N/A
Cernavoda Intermediate Dry Spent Fuel Storage Facility (IDSFS)	National Company Nuclearelectrica (SNN)	Intermediate Dry Spent Fuel Storage Facility, naturally air-cooled	N/A	2003	N/A
Cernavoda Solid Radioactive Waste Interim Storage Facility	National Company Nuclearelectrica (SNN)	Solid Radioactive Waste Interim Storage Facility for medium and lowe level waste	N/A	1998	N/A

TRIGA research reactor	Institute for Nuclear Research (RATEN - ICN)	Dual core pool type TRIGA reactor	TRIGA SSR (Steady State Reactor) - 14 MW	1979	N/A
Nuclear Fuel Manufacturing Plant	National Company Nuclearelectrica (SNN)	Natural uranium nuclear fuel fabrication plant	N/A	1983	N/A

1.1.2. National selection of installations for TPR II and justification

All of the nuclear installations mentioned in section 1.1.1. of this report have been selected for inclusion on the scope of the TPR on fire protection, based on their conformity with the criteria in the specifications for the TPR.

1.1.3. Key parameters per installation

1.1.3.1. Cernavoda NPP

Romania has one nuclear power plant, Cernavoda NPP, with two units in operation, pressurised heavy water reactors of CANDU 6 design (CANadian Deuterium Uranium), each with a design gross output of 706.5 MWe. Unit 1 and Unit 2 started commercial operation on the 2nd of December 1996 and on the 1st of November 2007, respectively.

The plant was initially intended to have 5 units. 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.

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 resuming of construction and 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 license 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.

Each unit is provided with a dedicated Spent Fuel Bay (SFB) for the spent fuel temporary storage. The SFB is designed to accommodate the fuel discharged during 8 years after its removal from the reactor core. After 6-7 years of cooling in the SFB, the spent fuel bundles are transferred to the on-site, naturally air-cooled Intermediate Dry Spent Fuel Storage Facility (IDSFS) for the spent fuel long term storage.

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 in a controlled manner into the environment. Spent ion resins are collected and stored in vaults made of reinforced concrete lined with epoxy, located in the basement of the service building, in the proximity of the reactor building. The organic liquid waste is solidified in polymeric absorbent structure and stored on site. After pre-treatment (collection, segregation, decontamination) and treatment (compaction or shredding, as appropriate) the solid wastes are confined in 220L stainless steel drums (type A container) and transported to the Solid Radioactive Waste Interim Storage Facility which is located on the plant site and is designed for storage of low and intermediate level radioactive waste.

More detailed information on Cernavoda NPP design and operation is provided in the Romanian National Report for the Convention on Nuclear Safety, 9th edition, published in August 2022 (https://www.iaea.org/sites/default/files/22/08/romania_nr_9th_cns_.pdf).

1.1.3.2. Intermediate Dry Spent Fuel Storage Facility on Cernavoda NPP site

The IDSFS is designed to provide safe, reliable and retrievable storage for spent fuel produced by the Cernavoda NPP Unit 1 and Unit 2 for a period of time of at least 50 years.

The facility consists of seismically qualified MACSTOR 200 modules. The MACSTOR System 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.

Each MACSTOR-200 module is a parallelepiped structure made of reinforced concrete, which embeds 20 metallic storage cylinders positioned vertically. Once filled, the cylinder is covered with a reinforced concrete shield plug and a welded metallic cover plate, both of which are seal-welded to the upper flange of the storage cylinder. The fuel is air cooled, by natural convection.

The spent fuel storage facility is designed according with the Canadian Standard CSA N292.2-96 "Dry Storage of Irradiated Fuel". A conformity assessment was performed against the new edition of the standard CSA N292.2-13 (R2018), issued under the title "Interim dry storage of irradiated fuel" and compliance was confirmed. The standard has been reaffirmed in 2023.

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, to take into account Units 1 and 2 refurbishment and long-term operation. 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.

1.1.3.3. Cernavoda Solid Radioactive Waste Interim Storage Facility

The Solid Radioactive Waste Interim Storage Facility is located on the Cernavoda NPP site and is designed for storage of low and intermediate radioactive waste. It has a storage capacity sufficient for the radioactive waste produced by the operation of the 2 Cernavoda NPP units, except for spent resins and reactivity control rods.

It consists of three above ground structures:

- Structure no. 1 (concrete warehouse)
- Structure no. 2 (concrete cylindrical cells)
- Structure no. 3 (concrete cubes - Quadricell).

The Structure no. 1 is a concrete building warehouse in which are located stainless steel drums of 220L, containing compactable and noncompactable solid radioactive waste (Type 1 and Type 2), which can be stacked on four levels.

The Structure no. 2 is a concrete structure which consists of cylindrical concrete cells dimensioned to accommodate spent filter cartridges resulted from plant operation. Inside the concrete cells there are metallic cells with bottom and cover designed to avoid spreading of contamination.

The Structure no. 3 (Quadricell) is a concrete structure for large and highly contaminated pieces of equipment. It consists of eight concrete cubes which can be removed together with the waste content. Currently, the structure does not contain any waste.

1.1.3.4. TRIGA Research Reactor

Romania has one research reactor in operation. It is a dual core pool type TRIGA reactor, which has achieved the first criticality on the 18th of November 1979. The research reactor is primarily used for materials testing. The Institute for Nuclear Research (RATEN - ICN) in Pitesti is the operator of this research reactor.

The reactor is composed of the following cores which are contained in the same pool:

- TRIGA SSR (Steady State Reactor) - 14 MW reactor; the conversion of the TRIGA-SSR Reactor started in 1992, from HEU fuel (Highly Enriched Uranium) to LEU fuel (Low Enriched Uranium) and was completed in 2006; the modernization of the reactor safety systems and of the control room has been completed in 2011 to support the long-term operation of the facility;
- TRIGA ACPR (Annulus Core Pulse Reactor); the ACPR reactor, with LEU fuel, can be operated for a maximum pulse of 20.000 MW; it has a single large central irradiation channel for fuel and structural materials irradiations under pulsed modes.

The TRIGA research reactor has the following spent fuel management facilities:

- Spent Fuel Pool;
- Dry Storage Pits of the Post Irradiation Examination Laboratory, designed to receive experimental CANDU type irradiated fuel rods as well as fragments resulted from destructive testing of these rods.

ICN Pitesti has a Radioactive Waste Treatment Facility designated for treatment and conditioning of waste produced on site from research activities and from operation of TRIGA research reactor and for recovery of uranium from liquid effluents from fuel fabrication.

1.1.3.5. Nuclear Fuel Manufacturing Plant

The Nuclear Fuel Plant (FCN) in Piteşti represents the national qualified producer of fuel bundles of type CANDU 6 for Cernavoda NPP. FCN is located on the same site with the

TRIGA research reactor and the Institute for Nuclear Research (RATEN – ICN). The FCN Pitesti is part of SNN, together with Cernavoda NPP. SNN is the license holder for FCN.

FCN Pitesti produces the nuclear fuel for both Unit 1 and Unit 2 of Cernavoda NPP. The high quality of the defect free nuclear fuel manufactured by FCN Pitesti has been proven in operation.

FCN has its own designated facilities for the current management of its gaseous, liquid and solid wastes:

- The Gaseous Radioactive Waste System: air from potentially contaminated indoors areas (areas dedicated to the fuel manufacturing and laboratories) is collected, filtered with high efficiency prefilters and discharged through the plant's stacks.
- The Liquid Radioactive Waste Temporary Storage Tanks: the storage of the liquid radioactive wastes is provided in tanks located inside the basement of the plant building.
- The Solid Radioactive Waste Temporary Storage Platform: storage of low contaminated solid radioactive waste is provided on this platform on the ground located in the vicinity of the building of fuel manufacturing; it is dedicated to temporary storage of different categories of solid waste collected in the plant.

1.1.4. Approach to development of the NAR for the national selection

The present report has been prepared by the National Commission for Nuclear Activities Control (CNCAN), the nuclear regulatory authority, following the ENSREG specification developed by WENRA.

CNCAN has requested the licensees, the National Company Nuclearelectrica (SNN) and the Institute for Nuclear Research (RATEN - ICN), to prepare reports covering the contents in the specification for the NAR and conducted reviews and inspections to verify the information provided in the licensees' reports. Following these reviews and inspections, CNCAN prepared the NAR report.

1.2. National regulatory framework

1.2.1. National regulatory requirements and standards

CNCAN has specific regulations on fire protection for nuclear power plants – NSN-09 (Regulation on the protection of nuclear power plants against internal fires and explosions). This regulation is under revision to extend its scope to all types of nuclear installations.

NSN-09 requirements on fire protection for NPPs cover the following:

- defence in depth
- fire protection program
- fire hazard analysis
- fire prevention
- fire detection, alarm and extinguishing
- limiting the spread and effects of fires
- separation

- ventilation
- radiological hazards in case of fire
- considerations regarding seismic qualification
- fire protection during construction and commissioning
- fire protection during operation
- organization of fire fighting intervention
- personnel training and qualification
- fire protection during decommissioning
- licensing basis documentation relevant for fire protection.

Requirements on the protection against external fires are established in the regulation NSN-06 (Nuclear safety requirements on the protection of nuclear installations against external events of natural origin). This regulation applies to all nuclear installations and will be revised to extend its scope to cover also the protection against human induced external events.

The fire protection of all types of nuclear installations has been addressed through the requirements in the regulation NMC-10 (Specific requirements for the quality management systems applied to the operation of nuclear installations), regulations on safety analyses and evaluations (NSN-24 - Regulation on deterministic nuclear safety analysis for nuclear installations ; NSN-08 – Regulation on probabilistic safety assessment for nuclear power plants) and guides on safety analysis reports (for NPPs, for research reactors and for nuclear fuel fabrication plants).

The regulation NSN-07 (Nuclear safety requirements on the response to transients, accident management and on-site emergency preparedness and response for NPPs) includes provisions applicable for the response to all transients, accidents and emergencies, including events caused by fires and explosions and events that may have fires and explosions as a consequence.

In 2020, CNCAN issued a Regulation on the use of standards for the assessment and continuous improvement of nuclear safety for nuclear power plants (NSN-27) and revised it and updated it in 2021. Among other requirements, this regulation imposes that the licensees and license applicants for nuclear installations, for all phases of development:

- systematically use the relevant and applicable IAEA Safety Standards (listed, by categories, in an annex to the regulation and including the standards relevant for fire protection),
- produce self-assessments of the conformance with these standards and
- include them in the licensing basis documentation, in PSR (Periodic Safety Review) evaluations and also
- take into account any new edition of these standards.

Starting with 2023, compliance with the applicable WENRA Reference Levels and the applicable IAEA Safety Standards is required, for all nuclear installations, by the provisions of NSN-22 - Regulation on the licensing of the nuclear installations (the regulation was initially issued 2019 and was supplemented in 2023).

In addition to the specific nuclear regulations issued by CNCAN, all licensees implement also the provisions of the general national legislation on fire protection.

1.2.2. Implementation/Application of international standards and guidance

The application of industrial standards on fire protection for NPPs is covered by NSN-27 (Regulation on the use of standards for the assessment and continuous improvement of nuclear safety for nuclear power plants) and GSN-01 (Nuclear safety guide on the industrial codes and standards for nuclear power plants). The application of IAEA Safety Standards relevant to fire protection for NPPs is required by NSN-27 and NSN-22 (Regulation on the licensing of the nuclear installations). NSN-22 also requires compliance with the WENRA Reference Levels.

The application of IAEA Safety Standards relevant to fire protection for all types of nuclear installations is required and NSN-22 (Regulation on the licensing of the nuclear installations). For research reactors, compliance with NSN-22 also requires compliance with the WENRA Reference Levels.

2. FIRE SAFETY ANALYSES

2.1. Cernavoda Nuclear Power Plant

The following sections present the fire safety analyses for the Cernavoda NPP Units 1 and 2.

2.1.1. Types and scope of the fire safety analyses

The following fire safety analyses have been performed for Cernavoda NPP Units 1 and 2:

- Fire Hazard Analyses - FHA (deterministic) – last revisions in 2023;
- Fire Safe Shutdown Analysis - FSSA (deterministic) – last revisions in 2020;
- Fire Probabilistic Safety Assessment, as part of PSA Level 1 and Level 2 studies for Cernavoda NPP – Fire PSA (probabilistic) – last revisions in 2021.

The scope of the above-mentioned fire safety analyses covers all the areas with systems, structures and components (SSC) important to nuclear safety (reactor buildings, nuclear services buildings, other nuclear buildings, balance of plant buildings) and all the different operational states (full-power operation and shutdown states). Detailed plant walk-downs have been performed for each of the fire safety analyses and for their updating.

FHA

The objectives of the FHA have been to:

- define the design basis fires (DBF);
- analyze the development and consequences of postulated fires in relation to their impact on the SSC with nuclear safety related functions;
- determine the required fire resistance of fire barriers;
- determine the passive and active fire protection measures (eg: fire-resistant walls and doors, fire dampers, detection, alarm and fire extinguishing systems, etc.) required;
- identify the situations in which additional / compensatory measures of separation or fire protection are necessary, in order to ensure the operation of the SSC with nuclear safety functions during and after a credible fire;
- verify that the special safety systems necessary to shut down the reactor, remove residual heat, contain radioactive materials and ensure monitoring and control of the plant, will be protected against the consequences of fires, so that they remain capable of performing these functions, taking into account also a single failure;
- evaluate the secondary effects of fires and fire extinguishing substances on SSC with nuclear safety related functions;

The scenarios analyzed in the FHA are bounding scenarios, as the most conservative assumptions have been used with regard to the heat load density in the rooms / areas and to the extent of the damage cause by fires to the safety related SSC.

The simultaneous occurrence of a DBF with another design basis accident with a low probability of occurrence was not taken into account. As regards the consideration of combinations of fire events and earthquake events, such combinations have not been considered in the analysis, because the design of the plant is such that systems or components containing large quantities of flammable liquids or gases are seismically qualified or have been separated from essential safety related systems by a qualified barrier.

FSSA

The objective of the FSSA is to demonstrate that the fire safe shutdown safety objectives are met. The FSSA is limited to plant areas where fires have a potential impact on the SSCs required for fire safe shutdown functions. The FSSA demonstrates that for any postulated Design Basis Fire (DBF), the safety objectives are met and at least one group of systems remains available that can ensure safe shutdown of the plant and fulfillment of all the essential nuclear safety functions (control of reactivity, cooling of the nuclear fuel, containment of radioactivity and monitoring and control of the plant).

The FSSA also has conservative assumptions and postulates the bounding DBF for each fire compartment considering the fire characteristics, the plant response to the fire and the potential fire propagation to adjacent areas.

The simultaneous occurrence of a DBF with another design basis accident with a low probability of occurrence was not taken into account.

Fire PSA

The major objective of the Cernavoda Fire PSA is to provide an understanding of the types of risks (e.g., from hardware, human, or procedural deficiencies) which are most important to consider for risk analysis and management. The results of this study have been used as the basis for developing a real-time operational risk monitoring system (EOOS – Equipment our of Service) that is implemented to support risk informed decision making for main control room operators and maintenance planning staff.

This study provides a more detailed understanding of the types of fire risks that are important to consider in future enhancements of the plant. The Fire PSA is also used as a living model to perform trade-off assessments, and to compare the impact of various design or procedural upgrades to enhance the plant safety.

The Fire PSA Level 1 provides results applicable for all Plant Operating States (POS) such as Hot/Transition POS and Cold POS. Fire scenarios developed and used in the analysis also take into consideration the Spent Fuel Bay.

Similar to Level 1 PSA, the Level 2 PSA was developed based on 90% Level 2 accident sequences for internal events, internal fires and internal floods events. The integrated models have been quantified and the cutsets generated using a truncation limit of 1E-11.

The External Plant Release Categories (EPRCs) are determined based on the time of release and the containment status and their definition is consistent with the EPRC definition for other plants of CANDU-6 design.

2.1.2. Key assumptions and methodologies

FHA assumptions and methodologies

The FHAs are based on the following assumptions:

- Considering the occurrence of a single random fire at any time in any area in the plant;
- The simultaneous occurrence of a fire with a LOCA (Loss of Cooling Accident) event or with another design basis accident with a low probability of occurrence was not taken into account; this is because, in the design of the plant, for earthquakes, systems or components containing large quantities of flammable liquids or gases have been qualified or separated from essential safety related systems by a qualified barrier;
- Minor fires that may occur in the area of safety related equipment will be extinguished with portable extinguishers.

Within the FHA, the thermal load and thermal load density were calculated for each room and the SSC with safety related functions located in the rooms/areas of the plant were identified.

For the detailed analysis, only the rooms/areas where the heat load density exceeds 200 MJ/m^2 were retained, as well as the rooms/areas where redundant equipment from systems with safety related functions are located, even if the heat load density is below 200 MJ/m^2.

As regards the identification of the safety functions and related SSCs to be protected against fire for the purpose of the FHA, all the SSCs with safety related functions have been included, with the rooms / areas where they are located.

The assessment of the consequences of the fire was performed based on the conservative assumption that the active fire protection systems are unavailable. However, an assessment of fire suppression effects on safety-related SSCswas also performed as part of the FHA.

Following the identification of the nature of combustible substances and the sources of fire initiation, the following types of design basis fires (DBF) were defined:

- DBF1 - Minor electrical fire - A fire that can occur in an electric motor, junction box, device or any electrical component, by burning small amounts of cable insulation or plastic material. The fire develops on short lengths of cables (up to 1 m in the case of fire-resistant cables), generates small amounts of smoke and causes small increases in room/area air temperature.
- DBF2 - Electrical fire starting in the cable racks - Fire that occurs in the cable racks affecting all the cables on a length of about 1 m on either side of the fire initiation point. Fire propagation is only possible vertically and not horizontally, if the separation distance is respected.
- DBF3 - Fire caused by transient combustible materials - Fire caused by combustible materials or flammable liquids used during maintenance activities.
- DBF4- Fire causes by leaks of oil or engine fuel - Fire caused by:
    - lubricating oil leaks from the bearing housings of various equipment;
    - oil leaks from hydraulic equipment;
    - engine fuel leaks from equipment tanks.
- DBF5 - Fire originated in electrical panels and components - Fire initiated from an electrical fault in a switchboard, medium voltage cell, motor control centre type distribution cabinet, affecting all the cables related to the electrical components. The fire would burn the panel or electrical components and spread along the cable trays. A

moderate amount of smoke would be generated and lead to a high rise in room/area air temperature.

- DBF6 - Fire caused by leaks of explosive gases - Fire in ventilation units caused by: air, pre-filter, charcoal and cellulose filters. Also, this type of fire can be caused by rubber, wood, flammable gases, plastic materials related to mechanical components.

The FHA has taken into consideration the plant locations where permanent combustible material is present. The rules and justifications used to consider the absence of fire in specific situations involving transient combustible material include the following:

- plant procedures against unapproved storage of transient combustible material;
- approval of the storage of transient material is done only based on an analysis and on the provision of compensatory measures;
- hot work is strictly controlled;
- fire detection and fire suppression systems are maintained and tested to confirm that they are functional;
- routine inspections are performed in all plant areas;
- fire watch and other compensatory measures are taken in case of temporary deviations from the fire protection internal regulations.

The on-site fire brigade is not credited in the FHA, but one of the objectives of the FHA is to determine the required staffing levels and fire-fighting capabilities of the on-site fire brigade.

Off-site fire brigades are not credited in the FHA and off-site support is not necessary in response to design basis events.

Uncertainties are considered addressed by the use of conservative assumptions in the FHA.

FSSA assumptions and methodologies

The FSSA has similar assumptions with the FHA (occurrence of a single random fire at any time in any area in the plant, without combination with other design basis events).

The bounding DBF is postulated assuming the worst fire that can occur within the compartment or cell considering the room and equipment characteristics, such as ignition sources, combustibles, fire protection measures etc. and the fire propagation through unprotected openings is then assessed. The bounding DBF conservatively assumed that global damage (i.e. all cables and components) occurs in a fire compartment or fire cell.

For FSSA, the fire modelling is performed using Fire Dynamic Tools (FDTs) Quantitative Fire Hazard Analysis Method (US NRC NUREG-1805), the Consolidated Model of Fire Growth and Smoke Transport (CFAST) computer code version 6.010, conservative engineering judgement or using hand calculations, depending on the nature of the DBF and the fire characteristics of the fire compartment. The consequences of the fire modelling are documented including the location where the fire started, the combustible materials involved, the fire intensity, fire duration, the potential to spread to other combustible material and the impact on the safety shutdown SSC. Potential damage may be limited to the specified fire compartment or fire cell or can involve equipment/cables within adjacent compartments / cells.

As regards the identification of the safety functions and related SSCs to be protected against fire, the FSSA addressed only the plant areas where fires have a potential impact on the SSCs required for fire safe shutdown functions.

The FSSA has taken into consideration the plant locations where permanent combustible material is present. The rules and justifications used to consider the absence of fire in specific situations involving transient combustible material are the same as mentioned above for the FHA.

The on-site fire brigade is not credited in the FSSA.

Off-site fire brigades are not credited in the FSSA and off-site support is not necessary in response to design basis events.

Uncertainties are considered addressed by the use of conservative assumptions in the FSSA.

Fire PSA assumptions and methodologies

The approach implemented for detailed Fire PSA is according to the following steps:

1. Collection of data for the room, fire barriers, fire detection and suppression, etc.;
2. Collection of fire hazard data such as ignition sources, combustibles, etc.;
3. Identify cable trays in each room and their associated information such as location, elevation, orientation, width and length;
4. Estimate fire ignition frequency for each fixed ignition source in the selected rooms by dividing the ignition frequency per identified fire type and by the number of items of the specified type of ignition sources. This step requires confirmation of ignition source list by examining General Arrangement drawings, IntEC database or plant walkdown if needed;
5. Develop fire scenarios considering ignition sources, combustibles, targets and fire protection features for mitigation;
6. Screen out scenarios that do not propagate beyond the ignition sources based on the Zone of Influence (ZOI) defined criteria;
7. Identify the set of damaged targets in each scenario. This is including damaged devices and/or cables routed in cable trays. The PSA-credited devices connected to the damaged cables trays are then obtained from IntEC database;
8. Develop fire event trees for each scenario and modify the internal events fault tree using the fire Xinit rules for each scenario. The following steps were taken in order to modify the internal events fault trees:
    - Identify for each fire scenario, the systems that are becoming unavailable because of the fire damage of the components; in some cases, only individual components become unavailable due to the respective scenario (for example panels or other electrical equipment) and they have to be identified on a case-by-case basis;
    - For the systems / components that are unavailable, create a list of Basic Events (BE), that if are unavailable will fail the respective mitigating system or component;

- The list of basic events above becomes the basis for the mapping file, where each of the BE that can fail the system / component is mapped to the specific flood/fire flag initiator;
- Using Xinit software the respective fires initiators used as flags are injected nearby the basic events that make the system/component unavailable. ASQ is performed and the initiator (IE) becomes TRUE together with all the flags, thus making the respective systems/component unavailable.

9. Perform ASQ quantification for all fire scenarios.

Table 2.1.1. Primary Guidance Documents Used for the Cernavoda NPP Fire PSA:

Reference	Description	Technical Areas of Applicability
EPRI TR-100370	Fire-Induced Vulnerability Evaluation (FIVE) April 1992	Fire area definition, fire ignition frequency calculations.
EPRI TR-105928	Fire PRA Implementation Guide, Dec 1995	Fire area definition, fire ignition frequency calculations
EPRI TR-100443	Methods of Quantitative Fire Hazard Analysis, Final Report, Frederick W. Mowrer, May 1992	Fire modeling
EPRI TR-1002981	Fire Modeling Guide for Nuclear Power Plant Applications, Aug 2002	Fire modeling
EPRI 1008239 (NUREG/CR-6850)	EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities", October, 2004	Fire modeling, system modeling. severity factors, fire detection and suppression, fire ignition frequency calculations

Table 2.1.2 General Fire PSA Assumptions

#	Assumption
1.	Uncertainty analysis was not included in the project scope. At this moment the specific standards and the methodology for the uncertainty analyses are not developed at the level required to support this task. Depending on the impact on the applicability of the results and further development of the standards and methods, this task will be reconsidered for the future improvements.
2.	Plant Operational State – The initial state of the unit is normal power operation (at 100% power) with each system operating within its limiting condition of operation (LCO) limits.
3.	Fires are independent – Only one independent fire may occur at any fire area.
4.	Fires are postulated to occur in areas or rooms where a source of ignition exists in the proximity of combustible, inflammable, or explosive materials.

Table 2.1.2 General Fire PSA Assumptions

#	Assumption
5.	The possibility of ignition from one source in several compartments simultaneously (e.g., cable overheating) is very negligible.
6.	The identification of Fire ignition sources is based on FIVE recommendations (see Table 5-3 Generic Fire Ignition Frequency Model for U.S. NPPs).
7.	Components not vulnerable to fires – Pipelines, check valves, manual valves, other mechanical devices without electrical or air drives, vessels of tanks and heat exchangers are not vulnerable to internal fires and preserve their integrity and availability.
8.	Components vulnerable to fires – The active elements, such as electrical valves, air-driven valves, instrumentation and control (I&C) sensors are vulnerable to fire. But it is assumed that the fire does not affect the integrity of the mentioned above equipment and it remains intact as the pressure barrier
9.	Component failure modes – For the equipment with an electrical drive or control circuits the failure to perform intended function as well as spurious operation shall be considered unless the resistance of this equipment to internal fires is justified.
10.	The results of spurious equipment actuation and reconfigurations analyze show that a LOCA cannot be induced by a fire event. Consequently, ECCS design intent function is not required after a fire event. Based on these results, ECCS equipment has been screened-out from the fire equipment list and ECCS was not modeled as a mitigating system.
11.	Cables – All cable are considered as vulnerable to internal fire but the fire resistance of different cables may vary function of cable fire qualification. Typical failures of the power cables caused by fire are the break of cable and ground faults.

2.1.3. Fire phenomena analyses: overview of models, data and consequences

FHA

The fire protection of the buildings covered by the FHA is structured in fire compartments and fire cells. Each fire compartment is delimited by fire-resistant barriers. All penetrations (electrical bus-bars, conduits, cable trays, etc.) through these fire-resistant barriers are sealed and comply with the fire resistance requirement of the barriers they pass through. Fire sealing details have a fire resistance of 3 hours.

Inside the Reactor Building, separation of space into fire compartments cannot be achieved due to concerns for pressurization during accidents, i.e. the atmosphere inside the containment needs to be mixed in a large free volume to cope with events such as LLOCA (Large Loss of Coolant Accident) and MSLB (Main Steam Line Break) and prevent excessive pressure buildup. SSCs are be separated by a combination of structural barriers, distance and local fire barriers around components and cables.

Within the FHA, the severity of the fire was defined, as determined on the basis of the heat load density and the burning speed of the combustible substances located in the fire area. This is correlated with the full-development phase of the fire and is expressed in hours or minutes. It is primarily used to assess the fire resistance of structural elements/barriers. The correspondence between heat load density and fire severity expressed in minutes, which provides a fire exposure equivalent to that of a standard "duration-temperature" curve, was based on industrial standards and guidelines.

The maximum temperature reached in a fire, depending on the duration of the fire, was based on the “temperature-time” curve described in ISO 834.

Fire suppression was not credited in FHA.

The conclusions of the FHA are that the NPP can be safely shutdown in case of a fire and all the essential nuclear safety functions will be maintained.

FSSA

For FSSA, the fire modelling was performed using Fire Dynamic Tools (FDTs) Quantitative Fire Hazard Analysis Method (US NRC NUREG-1805), the Consolidated Model of Fire Growth and Smoke Transport (CFAST) computer code version 6.010, conservative engineering judgement or using hand calculations, depending on the nature of the DBF and the fire characteristics of the fire compartment.

Fire suppression was not credited in FSSA.

The conclusions of the FSSA are that the NPP can be safely shutdown in case of a fire and all the essential nuclear safety functions will be maintained.

Fire PSA

A full revision of the PSA Level 1 and Level 2 has been performed in 2021 to consider plant design changes implementation and changes in the reliability data used, such as updating of failure rates and unavailability due to maintenance based on internal plant data, updating of internal initiating events frequencies, review of human error interactions, updating of CCF (common cause failure) events.

Regarding the analysis internal fires, in the updating report, modifications were implemented related to applicability of Level 1 and Level 2 fire events in cold transition, cold stable states and review of Level 2 components response on particular fire event.

The evaluation of the event trees and fault trees was conducted using the computer software CAFTA, version 5.4. The calculation engine FTREX, version 1.5 was used to generate the minimal cutsets. A truncation limit of 1E-011 was selected to generate the cutsets solution. The ASQ was conducted with PRAQUANT, version 5.1. The uncertainty quantification process was carried out using the program UNCERT version 3.0, developed by Electric Power Research Institute (EPRI). CAFTA 5.4 and FTREX 1.5 are applicable for the Cernavoda PSA event conditions being analyzed. All the programs are applicable to this work as stated in the CANDU Code Register.

2.1.4. Main results / dominant events (licensee´s experience)

FHA and FSSA

The FHA and FSSA analyses identified bounding DBF (Design Basis Fire) for each relevant fire compartment and fire area. Both analyses confirmed the robustness of the design and the achievement of safe shutdown state and the fulfillment of essential safety functions also in case of fire events.

Fire PSA

For **Unit 1** of Cernavoda NPP, the main contributors to CDF-FP from internal fires events category are the following fire scenarios that conservatively consider loss of the Group 1 systems:

- 27% Fire in Service Building Class II Motor Control Centers Room;
- 14% Fire in Reactor Building (R/B) cable spreading room;
- 10% Fire in any control panel in the Main Control Room, non-suppressed, making control room uninhabitable due to smoke and leading to the Main Control Room (MCR) evacuation; in this case, safe shutdown and monitoring of the plant is performed by the Secondary Control Area (SCA), which is also permanently staffed;
- 6% Fire in Service Building Air Conditioning Equipment Room;
- 2% Fire in K-L Gap and auto suppression fails.

The main contributors to LRF-FP from internal fires events category are the following fire scenarios that conservatively consider loss of the Group 1 systems:

- 18.2% Fire in any control panel in Main Control Room, non-suppressed, making control room uninhabitable due to smoke and leading to MCR evacuation and operation from SCA;
- 10.3% Fire in R/B room (cable spreading room);
- 7.8% Fire in Service Building Air Conditioning Equipment Room;
- 6.1% Fire in Service Building Class II Motor Control Centers room;
- 4% Fire in K-L Gap.

Due to the great contribution of fire events to CDF at full power and hot transition states, sensitivity analyses were performed considering the results of detailed fire analysis performed for the RB cable spreading room, Service Building Class II Motor Control Centers room and Service Building Air Conditioning Equipment Room.

Also, sensitivity cases were performed in order to evaluate, in CDF-FP updated results, the impact of detailed fire modeling, respectively impact of fire protection improvements in the Main Control Area (MCR and adjacent rooms).

As a result of the fire protection improvements in the Main Control Area, the updated value of CDF-FP was reduced from 3.78E-05 events/yr to 3.57E-05 events/yr and the contribution of all the accident sequences generated for these fire events decreased from 11% to 6%. The fire protection improvements include the installation of the Very Early Smoke Detection Alarm (VESDA) system and INERGEN gas suppression system.

The updated results are consistent with the findings from other Fire PSA studies performed to date. The Fire PSA study is robust such that areas of the plant containing significant fire ignition sources and multi-train cable routing configurations were identified and assessed and further design improvements are considered.

The updated results show that the Cernavoda Unit 1 core damage frequency for all internal events in all plant operating states was globally reduced with 43%, from 7.61E-05 events/yr to 4.32E-05 events/yr.

For the seismic events, the PSA-based SMA (Seismic Margin Assessment) method with the simplified Hybrid method has been used and the core damage frequency evaluated for seismic events has not been affected by this update. The Cernavoda Unit 1 core damage frequency for seismic events in all plant operating states is 3.73E-06 events/year.

The updated value of total core damage frequency for all internal and seismic events in all plant operating states is 4.7E-05 events/year.

The updated results show that the Cernavoda Unit 1 large releases frequency for all internal events in all plant operating states was globally reduced with 74%, from 2.7E-06 events/yr to 7.32E-07 events/yr.

The Cernavoda Unit 1 seismic risk for large release frequency for all plant operating states is 5E-6 events/year.

The updated value of total large releases frequency for all events in all plant operating states is 5.7E-06 events/year.

For **Unit 2** of Cernavoda NPP, the updated results for internal events, fire and flood have been obtained through sensitivity analyses performed on Unit 1 results. The contribution of internal fire events represents 57% of the core damage frequency.

The dominant contributors are from fires in same rooms as for Unit 1.

Cernavoda Unit 1 Level 1 and Level 2 PSA updated results are below and in compliance with the frequency of 1.0E-04 events/year for CDF and 1E-05 events/year for LRF for operating plants, as outlined in the IAEA INSAG-12 publication.

Even if the results of Level 1 and Level 2 internal fire PSA events show that the risk from fire events is acceptable, several design change improvements are under development.

2.1.5. Periodic review and management of changes

FHA and Fire PSA are periodically updated to reflect relevant modifications and operating experience. FHA has been updated in 2023 and Fire PSA has been updated in 2021. The FSSA has been completed in 2020.

Fire protection has been reviewed also as part of the Periodic Safety Reviews (PSR). The last PSRs have been finalized for Unit 2 and Unit 1, in 2020 and in 2023, respectively.

Inputs for the improvement of fire protection have resulted also from IAEA OSART missions, WANO (World Association of Nuclear Operators) missions, CNCAN reviews and inspections, ISU (Inspectorate for Emergency Situations of the Constanta County) inspections, focused self-assessments, benchmarks, use of external and internal operating experience, drills and exercises, compliance review with new standards (CSA, IAEA), stress tests, NSRB reviews, Nuclear Risk Insurance audits.

2.1.5.1. Overview of actions

Several design improvements have been identified based on the PSRs and based on the review of the latest standards, as well as from benchmarking activities and use of operating experience.

Compliance review with the latest edition of the Canadian standard CSA N293:23 (Fire protection for nuclear power plants) is in progress and it is expected that the the Fire Hazard Analysis (FHA) and Fire Safe Shutdown Analysis (FSSA) will be revised and additional improvements will be identified.

2.1.5.2. Implementation status of modifications/changes

The most significant modification / changes implemented or in progress are:

- Replacement of the fire detection system from NSP U1 – in progress;
- Automatic extinguishing and switching off the power transformers based on a 2 out of 2 logic (2 fire detection lines) in accordance with Romanian regulations;
- Installation of smoke and temperature detectors at the turbine bearings;
- Replace existing cables with E90 cables (90 minutes fire resisting cables) in Unit 1 as per Romanian regulatory requirement (modification in progress);
- Installation of a repeater panel in Secondary Control Room, Unit 1, for situations where the Main Control Room becomes unavailable (modification in progress);
- Installation of IR detectors in EPS (Emergency Power Supply) room in Unit 1 (modification in progress);
- Moto-pump for the fire water systems replacement;
- Equipment of the fire water pumping station will be replaced in 2024 with new ones (pumps, valves, expansion tanks, compressors, electrical wires and automation equipment).

Several improvements in the area of fire protection are planned for implementation during the refurbishment of Unit 1:

- NSP Fire Detection refurbishment and the provision of VESDA detectors in the SCA);
- Installation of piping/standpipes in the Reactor Building and connection to the station’s firewater system (internal hydrants have been installed only in Un it 2);
- Increased fire resistance rating upgrade between various areas of the station (e.g. Turbine Building, Service Building and MCR);
- Improvements in Fire Alarm Systems, such as addition of fire detectors for all unattended areas, manual pull stations, strobe lights for high noise areas, and improvement in sounding alarms;
- New requirements for Fire Water Supply Systems include: redundant, diverse power source fire pumps, and seismically qualified fire water system for seismically qualified areas & plant systems;
- Fixed Fire Suppression Systems to provide greater sprinkler coverage and an early fire detection;

- Passive design features for protection from fires due to pressurized and non-pressurized breaks in the oil systems;
- Smoke Control features to provide habitability for MCR in the event of a fire, improvements to minimize the impact of smoke to sensitive equipment, switchgear or control equipment.

Each modification change is analyzed by the Fire Protection Engineer in order to determine its impact on fire protection.

2.1.6. Licensee's experience of fire safety analyses

2.1.6.1. Overview of strengths and weaknesses identified

Strengths include:

- periodic update of the fire safety analyses;
- effective use of external reviews and benchmarks to improve fire protection;
- self-assessment for compliance with the latest applicable IAEA Safety Standards and industrial standards in the area of fire protection;
- continuous improvement of the fire protection design measures, through plant modifications.

Some weaknesses have been identified in the fire hazard analyses as regards compliance with the latest edition of the Canadian standard CSA N293:23 - Fire protection for nuclear power plants. A gap analysis is being performed and it is expected that the FHA and the FSSA will need to be updated.

2.1.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

In 2022, the Fire Protection Engineer participated in the 'Fire Protection & Safety Industry - Working Group Meeting' organized by WANO-AC. A lesson learned from this Working Group was that FHA must also take external events systematically into account. Previously, external fires have been excluded from the scope of the FHA because past assessments, such as those conducted in the framework of the post-Fukushima "Stress Tests" concluded that external fires cannot affect the nuclear-safety related buildings and cannot cause conditions that are not bounded by the events already analyzed.

The licensee will perform a gap analysis for the 2023 revision of CAN-CSA293 standard and will revise the FHA accordingly.

2.1.7. Regulator's assessment and conclusions on fire safety analyses

2.1.7.1. Overview of strengths and weaknesses identified by the regulator

The strengths and weaknesses identified by the regulator are in line with those identified by the licensee. CNCAN is in process of updating the regulation on fire protection.

2.1.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

Lessons learned from CNCAN reviews and inspections include:

- walkdowns are essential for verifying the validity of the safety analyses;
- configuration management has to systematically include, for all permanent and temporary modifications, all aspects relevant for fire protection;
- the use of international operating experience and benchmarks, both by the industry representatives and by the regulators is important for identifying and implementing the latest standards and good practices.

2.1.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

The licensee's fire safety analyses are in compliance with the national nuclear regulations and the international standards, including with the provisions of WENRA SV 6.1 Reference Level. A series of improvement actions have been identified and are in progress and the fire safety analyses will continue to be periodically updated.

2.2. TRIGA Research reactor

Deterministic fire safety analyses were performed, in accordance with the IAEA guidelines for evaluation of Fire Hazard analyses for NPPs (IAEA Safety Series No. 50-P-9) and a general national regulation applicable to all types of industrial construction (P-118). Based on thermal loads density, the fire safety analysis determined the values of the duration of the fire event with maximum consequences and the maximum temperature that could be reached in the control rooms. These values were established using the methodology based on standard ISO curves. Thermal loads density analysis showed that the greatest values are in the vicinity of the technical archive. Otherwise, thermal load values are not important for the construction strength or reactor operation, if the measures for firefighting and confinement are respected.

Fire safety analyses confirmed that, in accordance with the regulation P-118, the reactor building is in category I from the point of view of fire strength and is suitably designed. However, the passive barriers (doors, etc.) have to be qualified to fire according to the maximum design basis fire event.

The power supply and I&C systems are designed in order to achieve:

- separate cable trays of class I from class III consumers;
- separate cable trays of redundant systems;
- separate locations for batteries and rectifiers from inverters and distribution panels;
- electrical cables are shielded with delayed fire spreading; metallic rods and sealings are used for ways through floors and walls in order to avoid fire spread;
- the estimated thermal loads inside power supply and I&C systems rooms are below 400MJ/m^2, the duration is below 20 minutes, and temperatures below 500^{o}C;
- in case of a fire event, ventilation system automatically shuts down, and isolation valves are closing.

Technological spaces and nuclear safety related installations/equipment are located in:

- the reactor hall;
- the heat exchangers and primary circuit pumps room;
- water purification circuit room;
- delay tank room;
- irradiation devices room;
- liquid waste circuit room.

Combustible materials inventory inside the above-mentioned locations shows that:

- in the reactor hall and in the irradiation devices room there are no combustible materials,
- lubricant quantities are insignificant in heat exchangers and primary circuit,
- pumps room (thermal load is below 0.1MJ/m^2),
- hydrogen collected in the delay tank is continuously evacuated through ventilation system,
- the active charcoal from w ater purification circuit room is completely immersed in water.

2.2.1. Types and scope of the fire safety analyses

Only a deterministic fire hazard analysis has been performed, in 2013.

2.2.2. Key assumptions and methodologies

The FHAs are based on the following assumptions:

- Considering the occurrence of a single random fire at any time in any area in the research reactor facilities;
- The simultaneous occurrence of a fire with a LOCA (Loss of Cooling Accident) event or with another design basis accident with a low probability of occurrence was not taken into account;
- Minor fires that may occur in the area of safety related equipment will be extinguished with portable extinguishers.

Fire events have been considered for all major safety-related SSCs of the research reactor, including a fire affecting the experimental devices.

2.2.3. Fire phenomena analyses: overview of models, data and consequences

Within the FHA, the thermal load and thermal load density were calculated for each room and the SSC with safety related functions located in the rooms/areas of the plant were identified (the list of technological spaces and nuclear safety related installations/equipment mentioned in section 2.2 above). Maximum duration and maximum temperatures have been calculated for the fire events analyzed. These values were established using the methodology based on standard ISO curves.

2.2.4. Main results / dominant events (licensee´s experience)

Only qualitative conservative engineering judgements were made about the possible consequences of fires occurring in areas where safety-related SSCs are located (the technological spaces and nuclear safety related installations/equipment listed in section 2.2 above). It was concluded that none of the fire events could impair the capability for safe shutdown of the research reactor and for the fulfillment of the essential nuclear safety functions.

2.2.5. Periodic review and management of changes

The fire hazard analysis performed in 2013 has not been revised and updated.

2.2.6. Licensee's experience of fire safety analyses

The recommendations from the fire hazard analysis performed in 2013 have been used to improve the fire protection for the research reactor.

The licensee received an Integrated Safety Assessment of Research Reactor (INSARR) mission in 2013.

Based on the recommendations resulting from the deterministic hazard analysis and on the recommendations from the INSARR mission, in 2014, the following components were additionally installed in the fire alarm system:

- an analog optical smoke detector in the reactor hall;
- the smoke sampling component for the ventilation piping, in the reactor hall;
- a hydrogen detector type, on the ceiling of the battery room.

These detectors have been connected to the fire detection and warning central, located in the hall at the main entrance to the reactor building.

2.2.7. Regulator's assessment and conclusions on fire safety analyses

Based on the review of the design and safety analyses and assessments for the research reactor, CNCAN did not require additional more specific fire hazard analyses.

The fire hazard analysis performed in 2013 has not been revised and updated. An update of the FHA for the research reactor will be required.

CNCAN regulations include specific provisions on fire hazard analyses only for nuclear power plants. The fire protection regulations are in process of being revised and will be applicable to all nuclear installations.

2.3. Nuclear Fuel Manufacturing Plant

The scope of the fire safety analyses for Nuclear Fuel Manufacturing Plant is the evaluation of the fire hazards that potentially threaten nuclear safety, in order to establish appropriate fire protection measures, to prevent fires and to minimize the consequences of fires, for the protection of people and the environment but also to minimize plant down-time.

In order to evaluate how the existing measures for fire protection are adequate to achieve the fire safety requirements of the applicable national legislation to the facility, the licensee elaborated, in 2012, the study "Identification, Evaluation and Control of Fire Risks – Nuclear Fuel Manufacturing Plant". The aim of the study was to identify the possible causes of fire, to estimate the probabilities of fire occurrence, to evaluate the inventory of combustible material and sources of fire initiation, to assess the potential consequences of fire and to control fire risks.

The Integrated Safety Analysis (ISA) of the Final Safety Analysis Report, includes all relevant hazards, including fire hazards, which could result in unacceptable consequences for the installation, workers, population and the environment.

To confirm the current level of fire protection, and as a good practice, the licensee has initiated the development, in the period 2023-2024, of a Fire Hazard Analysis, using the applicable requirements provided in CNCAN regulations for NPPs and in accordance with IAEA SSR-4 requirements. The purpose of FHA is to evaluate how the existing active and passive measures ensure the protection of the facility, workers, population and the environment in order to achieve the essential fire safety requirement and, if identifies deficiencies, to establish the necessary measures to meet essential essential fire safety requirement.

The FHA will be performed in accordance with the IAEA SSR-4 requirements and will be performed on a deterministic basis.

2.3.1. Types and scope of the fire safety analyses

Fire Risk Assessment

The fire risk identification and assessment for the Nuclear Fuel Manufacturing Plant, given in the study "Identification, Evaluation and Control of Fire Risks – Nuclear Fuel Manufacturing Plant" were based on the method of fire risk analysis taken from a model used in Switzerland and approved by the Swiss Society of Engineers and Architects (S.I.A. methodology), adapted to national legislative requirements (applicable to all industrial buildings, not specific for nuclear installations), respectively:

- the national methodology regarding the identification, evaluation and control of fire risks;
- technical regulations on the fire protection of buildings and related facilities;
- the conditions for carrying out the activity and the assessment results following the existing constructive solutions, the level of equipment and technical means for the prevention and extinguishing of fires.

The fire risk analysis involved the fire hazard identification, fire risk assessment (frequency and probability of a fire occurrence, fire development, probability of failure for fire protection systems) and quantifying the consequences of fires (fire protection engineering calculations).

Fire hazards have been considered in the Integrated Safety Analysis of the Final Nuclear Safety Report. Since in the plant there are flammable and combustible materials, methane gas and hydrogen, organic solvents, diluents, Zircaloy-4 in powder / span, the fire hazard analyzes are performed to address:

- processes that use methane gas and hydrogen,

- technological processes resulting in Zircaloy-4 powders and/or shavings,
- laboratories and warehouses where flammable products are stored,
- storage of chemical substances in the form of reactive materials,
- areas with significant thermal loads,
- rooms for important security systems.

Taking into consideration the operational characteristics of the plant, the manufacturing of natural uranium based fuel (the quantities of natural uranium are limited according to the licenses issued by the national regulatory body), the Integrated Safety Analysis (ISA) based on methodology developed by the U.S. Nuclear Regulatory Commission (US-NRC) is used for the safety assessment, having as references the following documents:

- NUREG-1513, Guidance Document, „Integrated Safety Analysis”, US-NRC, May 2001
- NUREG-1601, Guidance Document, „Chemical Process Safety at Fuel Cycle Facilities”, US-NRC, 1997
- NUREG/CR-6410, Guidance Document, „Nuclear Fuel Cycle Facility Accident Analysis Handbook”, SAIC, 1998.

The methodology used in the Integrated Safety Analysis for the plant is the qualitative one of the "what-if" type (in accordance with ISO IEC/FDIS 31010, International Standard, „Risk Management – Risk Assessment Techniques”, 2019). This method allows a systematic evaluation of the installation in order to identify the internal and external hazards, their potential to lead to an accident, the possible accident sequences and the probability of occurrence as well as their consequences. Afterwards, in order of determine a level of risk or danger, the set of the identified hazards is evaluated with the Risk Matrix method (Consequences/Probability matrix), which combines the semi-quantitative classes of consequences with probabilities of occurrence.

Deterministic analysis of the consequences of a postulated fire initiating event

A set of postulated initiating events, with severity levels covering the radiological consequences (conservative), were selected in order to satisfy the dose criteria specified in the regulations issued by CNCAN. The analysis of a representative scenario for the maximum credible accident analysis was based on the results of the qualitative "what-if" analysis. This represents a complex, comprehensive accident, characterized by a high degree of severity in terms of radiological consequences and frequency of occurrence. The maximum credible accident, considered in the analysis, is the occurrence of an earthquake-type event, which generates the rupture of the hydrogen supply pipe of the sintering furnaces, leading to the initiation of its explosion. The inoperability of the hydrogen detection system supports the production of the explosion. The scenario involves the initiation of a fire, generated by the rupture of the methane gas pipe coincident with the occurrence of an electrical short circuit.

Data and technical information at the level of technological details of the plant design represent the basis for the analysis of the maximum credible accident. In the fuel manufacturing processes, significant amounts of hazardous materials (chemical and radioactive) are used, which can represent a real danger under certain conditions. Of special interest are those materials that have flammable and explosive properties, combined with the source materials processed within the facility.

Conservative hypotheses were used in order to maximize the consequences of the event and determine the maximum credible accident, respectively:

- all process and/or administrative systems that could limit consequences are considered inoperable,
- the entire amount of uranium powder in the deposit is considered to be involved in the accident so that, the estimation of the impact of smaller events can be made by referring to the maximum scenario,
- the release of the hazardous material is considered to occur through a sequence of events related to the earthquake, loss of integrity of the hydrogen pipelines, explosion and fire.

2.3.2. Key assumptions and methodologies

Fire Risk Assessment

The S.I.A. method used in the study "Identification, Evaluation and Control of Fire Risks – Nuclear Fuel Manufacturing Plant" is based on a mathematical model of analysis and fire risk quantitative assessment. The method implies compliance with general fire safety requirements, such as those related to safety distances between buildings, measures to protect workers (escape routes, safety lighting, etc.), as well as provisions related to utility installations.

To identify the fire hazards, the following factors that can generate, contribute and/or favor the production, development and/or propagation of a fire, have been considered:

- the potential ignition sources,
- thermal load density,
- fire reaction classes of construction materials and elements,
- the physical-chemical properties of the processed, handled or stored materials,
- the preliminary conditions that can determine or favor the ignition and the production, development and/or propagation of the fire.

The following elements were considered in order to assess the fire risk and to quantify the consequences:

- the fire hazard depending on the amount of the combustible materials and the method of distribution in the analyzed space;
- the potential sources of material ignition and the administrative measures used to eliminate or limit the ignition;
- the performance levels criteria regarding the fire safety requirements for personnel, the population and environment (considerations regarding the fire resistance of constructions, constructive characteristics of utility installations, constructive characteristics for limiting the spread of fire and smoke, ensuring the evacuation of personnel and intervention in case of fire, operating characteristics relevant to fire safety);
- the provision of systems, installations and equipment for water supply, fuel gases, electricity, ventilation and air conditioning, their functioning and performances;

- the human factor, determined by the number of people and fire safety training of the staff;
- elements that can influence the fires initiation, development and/or propagation.

Deterministic analysis of the consequences of a postulated fire initiating event

The Integrated Safety Analysis from the Final Nuclear Safety Report for the plant represents a systematic examination of the equipment, processes, structures and activities in order to ensure the assessment of all relevant hazards that could result in unacceptable consequences. In this analysis, the term "integrated" means the joint consideration of all relevant hazards, including radiological, chemical and fire hazards, and the provision of protection against them.

The analysis of the risks associated with the technological processes of manufacturing nuclear fuel, including the evaluation fire risk in the integrated security analysis, uses the matrix of risks identified and evaluated, as described in section 2.3.1. Through this method, the combination of the probability and the consequence of the event evaluates the risks associated with different scenarios.

The engineering judgment and data from the specialized literature represent the basis for the estimation of the probabilities of occurrence of hazards. The engineering judgment and the results of the HotSpot program are the basis for the estimation of the consequences. The combination of the hazard occurrence frequency and the level of consequences, gives the level of the risk: low, medium, acceptable and unacceptable, respectively.

2.3.3. Fire phenomena analyses: overview of models, data and consequences

The estimation of the radiological consequences for the professional workers and the population, following the maximum credible accident, was performed with HotSpot Health Physics Code. The HotSpot program provides a first-order approximation of the radiation effects associated with the atmospheric release of radioactive materials. Although the purpose of the HotSpot software development was to provide a swift tool to the emergency response personnel, being a field-portable set of software tools for evaluating incidents involving radioactive material, HotSpot is also used to nuclear safety analysis of facilities handling radioactive material. HotSpot includes atmospheric dispersion models for a uranium and plutonium explosions and fires.

The following aspects were considered to maximize the consequences of the event and determine the maximum credible accident:

- conservatively, the maximum amount of uranium powder is involved in the event, so that the impact of an event can be referred to the maximum scenario;
- the release of hazardous material occurs through a sequence of events related to earthquake, loss of integrity of H_2 and CH_4 pipelines followed by explosion and fire;
- the fraction of uranium released into the atmosphere from the amount of the considered source term is 0.01, a value defined according to data registered from the operating experience and research;
- the calculation program scenario options are based on explosion and fire.

2.3.4. Main results / dominant events (licensee´s experience)

According to ISA results, the higher risks that may occur are connected to the potential explosions/fires induced by the occurrence of an earthquake. The HotSpot results of the maximum credible accident show that in the most unfavorable scenario from the point of view of radiological consequences, the legal limits of total doses for the operating personnel and the population are not exceeded.

The results of the analysis for the maximum credible accident show that the maximum value of the total effective dose equivalent (TEDE) for professional workers is 8.17 mSv at a distance of 10 m from the source term, at 1 m/s the speed of wind, B atmospheric stability class, sunny/cloudy day and wet deposition in the first 24 hours from event, below the lower limit of the 20-100 mSv interval provided for situations of emergency in the regulations in force. At the limit of the urgent protective action-planning zone (UPZ), established at 1 km (approximate distance of the residential area), the TEDE value is 0.23 mSv, at 1 m/s the speed of wind, B atmospheric stability class, sunny/cloudy day and wet deposition in the first 24 hours from event.

The maximum value of TEDE at UPZ, for a person from the population, calculated for 30 days from the beginning of the emission, is 0.49 mSv, below the maxim value of dose provided in Annex 4 from NSN-24 regulation for class 2 events (Design Basis Accidents) and even below class 1 events (Anticipated Operational Occurrences).

2.3.5. Periodic review and management of changes

The management of changes (constructive, technological or legislative modifications) associated with fire safety include:

- Passive fire protection measures by the provision of fire-resistant walls, fire-resistant doors equipped with automatic closing system, fire dampers on the ventilation ducts when the ducts pass through the fire-resistant walls, fire-resistant materials used to seal wall gaps around cable ducts, etc., ensure the prevention of fire spreading;
- Active fire protection measures through the provision of fire detection systems, detection systems for accidental releases of flammable gases, automatic fire extinguishing installations and smoke evacuation systems;
- Permanent monitoring of specific legislative changes and updating of work plans and procedures;
- Permanent surveillance to detect fire risk opportunities, fire hazard analysis and the application of appropriate protective measures.

Technical changes associated with SSC and those related to the organizational changes take into account the current fire safety requirements.

The main changes implemented to improve fire protection include:

- The improvement and completion of the fire detection and alarm system;
- Inergen automatic fire extinguishing system in the server room;
- Fire resistant doors and walls in order to ensure adequate fire compartmentation to limit the spread of fire (e.g. the power station, the ventilation system units, the hydrogen production station, the fuel bundles and Zy-4 deposits etc.);

- The replacement of the dedusting system, serving the sheath cleaning and chamfering machines, with a new one, suitable for fire/explosion risk;
- Periodically updates of the internal fire plans and procedures to ensure the integration of legislative changes and identified opportunities based on operating experience.

The licensee is in process of performing a Periodic Safety Review (PSR) for the Nuclear Fuel Manufacturing Plant.

The licensee has initiated the development, in the period 2023-2024, of a Fire Hazard Analysis, using the applicable requirements provided in CNCAN regulations for NPPs and in accordance with IAEA SSR-4 requirements.

2.3.6. Licensee's experience of fire safety analyses

In 2011, at the request of the Romanian government and through CNCAN, an IAEA safety review mission (SEDO mission - Safety Evaluation During Operation) dedicated to the safety evaluation of nuclear facilities from nuclear fuel cycle during operation has been carried out at the Nuclear Fuel Manufacturing Plant in Pitesti.

The international experts of the SEDO team evaluated the operational practices of the licensee related to: management, organization and administration, maintenance and periodic testing, protection against ionizing radiation, fire, chemical and industrial safety management, management of radioactive effluents and environmental protection. In addition, there was an exchange of experience and technical knowledge between IAEA experts and the counterparts on how to pursue the common goal of excellence in operational safety further.

The conclusions following the SEDO assessment highlighted the management commitment to improve the nuclear and operational safety and reliability of the facility. The SEDO team identified the areas of good practice/performance and improvement and provided suggestions/proposals for improving the nuclear and operational safety and reliability of the facility.

Following the SEDO mission, the licensee implemented the recommendations of IAEA experts in the field of fire safety, such as:

- Development of the fire risk identification, assessment and control study in order to identify fire hazards and their impact and fire protection features;
- Development of the Safety Analysis Report (SAR) and Accidents Analysis for SN Nuclearelectrica SA – Nuclear Fuel Plant Pitesti and Final Nuclear Safety Report, including fire hazards.
- The licensee developed, in 2012, the study "Identification, Evaluation and Control of Fire Risks - Nuclear Fuel Factory", for the identification of the possible causes of fire, estimation of the probabilities of fire occurrence, evaluation of the inventory of combustible material and sources of fire initiation, the potential fire consequences.
- The Integrated Safety Analysis (ISA), from the Final Safety Report for the plant, includes the deterministic analysis of the maximum credible accident, represented by the occurrence of and earthquake-type event that generates the rupture of the pipe ensuring hydrogen supply of the sintering furnaces. The rupture of the methane gas pipe coincident with the production of an electrical short circuit initiates the explosion and fire. The accident scenario conservatively assumes that the entire amount of uranium powder licensed for storage is involved in the explosion.

- In order to complete the analysis included in studies mentioned above, the licensee started, in 2023, procedures for the deterministic fire safety analyses represented by the Fire Hazard Analysis (FHA). In order to include any change that affect or could affect the fire protection of the facility (changes to fire protection systems, changes to SSC important for nuclear safety, changes in thermal loads, changes in processes or procedures, temporary or permanent), the FHA will be periodically revised in accordance with the national regulations and international standards.

The licensee uses the external operating experience and lessons learned to improve the safety of nuclear fuel cycle facilities reported in the international system jointly managed by the IAEA and the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD/NEA), Fuel Incident Notification and Analysis System (FINAS).

2.3.7. Regulator's assessment and conclusions on fire safety analyses

CNCAN has reviewed and found the existing fire safety assessments satisfactory, particularly taking into account the conservative assumptions of the deterministic analysis for the maximum credible accident caused by fire.

Also, CNCAN noted that the licensee had a proactive approach, in the framework of the PSR, and initiated the process for performing a FHA in accordance with the regulation on fire protection for NPPs.

CNCAN regulations include specific provisions on fire hazard analyses only for NPPs. The fire protection regulations are in process of being revised and will be applicable to all nuclear installations.

2.4. Intermediate Dry Spent Fuel Storage Facility on Cernavoda NPP site

2.4.1. Types and scope of the fire safety analyses

The licensee has evaluated the external hazards that could affect this dry spent fuel storage facility, including fires and explosions occurring at other installations on site (e.g. fuel storage facilities, industrial gases storage facilities) and off-site. It was concluded that the credible external hazards cannot initiate a fire or explosion that could affect the spent fuel storage facility.

As regards the internal hazard analysis, a fire hazard analysis has not been performed for the spent fuel storage facility.

A conservative deterministic analysis has been performed for an event involving an aircraft crash on the dry spent fuel storage, for the purpose of emergency planning and preparedness.

2.4.2. Key assumptions and methodologies

Various types of aircraft were assumed to crash accidentally on the dry spent fuel storage, irrespective of the very low probability of such events. Deterministic analyses have been performed with very conservative assumptions.

2.4.3. Fire phenomena analyses: overview of models, data and consequences

No detailed modeling of fire phenomena was performed. Conservative assumptions have been used to maximize the damage cause by fire and the subsequent radiological consequences.

2.4.4. Main results / dominant events (licensee´s experience)

With very conservative assumptions applied in the analysis of the radiological consequences of such an event, it was determined that the such an event will trigger the activation of the off-site emergency response plan. With less conservative assumptions, it was determined that the estimated doses would exceed the dose limits for normal operation, but would not require significant off-site protective measures.

2.4.5. Periodic review and management of changes

Any changes with regard to the design of the facility or to the operational activities are analyzed also with regard to the potential impact on fire protection and related safety analyses.

2.4.6. Licensee’s experience of fire safety analyses

The licensee has performed only conservative deterministic analyses of a fire scenario affecting the facility, and submitted it to CNCAN as part of the licensing basis documentation (safety analysis report).

2.4.7. Regulator’s assessment and conclusions on fire safety analyses

CNCAN has accepted the safety analyses performed for this facility and no significant issues have been identified from the regulatory review and inspection activities.

2.5. Cernavoda Solid Radioactive Waste Interim Storage Facility

2.5.1. Types and scope of the fire safety analyses

The licensee has evaluated the external hazards that could affect this storage facility, including fires and explosions occurring at other installations on site (e.g. fuel storage facilities, industrial gases storage facilities) and off-site. It was concluded that external hazards cannot initiate a fire or explosion that could affect the radioactive waste storage facility.

As regards the internal hazard analysis, a fire hazard analysis has not been performed for the storage facility, but a deterministic analysis of a postulated fire has been included in the safety analysis report, as the maximum credible accident for this facility.

The filter cartridges are made of glass fiber fabric and do not present a fire hazard. Also, the components that are stored in the cellular warehouse are made of metallic materials, not presenting a fire hazard. As a result, the storage of filter cartridges (structure no. 2) and the cellular storage (structure no. 3) are classified in category of low hazard of fire and do not include specific fire protection measures. As regards the structure no. 1, which is a concrete building warehouse in which are located stainless steel drums of 220L, containing compactable and noncompactable solid radioactive waste, some of the general waste (paper, textiles, plastics, rubber, wood, etc.) are combustible materials, so that special measures were taken for the general waste deposit, for the prevention, detection and extinguishing of fires. The most important measure to prevent an extensive fire is the containerization of waste in closed metal barrels with lids and gaskets. The fire resistance tests of barrels with combustible waste demonstrated that a fire at the exterior of the barrels determines only the partial carbonization of the contents of the barrels directly exposed to the external flame and the fire does not spread to other barrels. However, a conservative deterministic analysis has been performed for a hypothetical fire in this facility.

2.5.2. Key assumptions and methodologies

The radiological impact of a postulated fire was analyzed in a conservative manner for the storage of radioactive waste packed in barrels. It was assumed that the storage is filled to the maximum capacity and that 25% of combustible waste burns. Although it was assumed that the fire detection and alarm system is functional and that the firefighters reacted to the alarm signal, it was conservatively assumed that the duration of the fire will be of 6 hours.

2.5.3. Fire phenomena analyses: overview of models, data and consequences

With conservative assumptions applied in the analysis of the radiological consequences of such an event, it was determined that the off-site impact is minor.

2.5.4. Main results / dominant events (licensee´s experience)

A postulated fire has been included in the safety analysis report, as the maximum credible accident for this facility. The analysis was deterministic, with conservative assumptions and no estimations were made of the probability of such an event, which is actually precluded by the design and operational measures.

2.5.5. Periodic review and management of changes

Any changes with regard to the design of the facility or to the operational activities are analyzed also with regard to the potential impact on fire protection and related safety analyses.

2.5.6. Licensee’s experience of fire safety analyses

The licensee has performed only conservative deterministic analyses of a fire scenario affecting the facility, and submitted it to CNCAN as part of the licensing basis documentation (safety analysis report).

2.5.7. Regulator’s assessment and conclusions on fire safety analyses

CNCAN has accepted the safety analyses performed for this facility and no significant issues have been identified from the regulatory review and inspection activities. However, a more systematic and realistic analysis of the internal fire hazards will be required when the revised regulation on fire protection for all nuclear installations will be issued and come into force.

2.6. Facilities under decommissioning

There are no facilities under decommissioning.

3. FIRE PROTECTION CONCEPT AND ITS IMPLEMENTATION

3.A Cernavoda NPP

Based on the principles of defence-in-depth, Fire Safety at Cernavoda consists of a series of consistent and coherent barriers designated to prevent fire from occurring and, should a fire start, to extinguish it rapidly with minimal damages. The barriers include both administrative measures and physical means which together prevent fire, limit and control fire and extinguish fire.

The key elements of the fire prevention program at Cernavoda indude adherence to fire prevention rules, basic fire training for personnel and contractors, and adequate housekeeping through walkdowns or inspections.

Fire control is achieved through passive and active means that are designed to limit fire growth and to mitigate its effects. For example, fire barriers provide fire zoning of the plant based on the fire load density.

The Fire Response is organized based on the severity of the fire. If the fire is in the incipient stage and there is no risk of injury, any person is expected to notify the Main Control Room and use the extinguisher nearby. To fight fires that develop beyond the incipient stage and require coordinated actions, professional firefighters are available.

3.1.A Fire prevention

The concept of defense in depth was implemented from the design phase of the plant , in order to ensure :

- prevention of fires;
- detection and suppression of a fire in the incipient phase;
- limitation of the effects of the fire.

3.1.1.A Design considerations and preventions means

Fire safe shutdown systems (FSSSs), sub-systems or divisions of equipment and their associated cable trays are assigned to two separate groups. These redundant groups are separated such that a fire will not damage systems in both groups. In general, the grouping for FSSSs follows the grouping for safety systems established in the CANDU-6 design, i.e. Group 1 and Group 2 safety systems and their associated equipment are considered separate fire safe shutdown paths.

Outside the RB, the redundant FSSSs are separated by 3-hour fire barriers or a lower rating determined by the fire safety analyses, when the fire separation is provided in conjunction with automatic fire suppression system. These barriers are structural barriers or enclosures on components or cables.

Inside the Reactor Building, separation of space into fire compartments cannot be achieved due to concerns for pressurization during accidents (i.e. the atmosphere inside the containment needs to be mixed in a large free volume to cope with events such as LLOCA and MSLB and prevent excessive pressure buildup). Redundant FSSSs are be separated by a combination of structural barriers, distance and local fire barriers around components and cables. The adequacy of the separation is demonstrated in the fire safety analyses.

Alternatively, for the protection of electric cables, fire resistive cables or cable wrapping are used.

3.1.2.A Overview of arrangements for management and control of fire load and ignition sources

The design requirements to minimize the likelihood of a fire may be divided mainly into two categories:

a) Control of combustible materials; and

b) Control of ignition sources.

The control of combustible materials in plant design is achieved by the following general fire protection measures:

1. Use of non-combustible materials, for the construction of buildings inside the protected area or external to the protected area but directly supporting the plant.

2. Minimizing the use of combustible materials for building fixtures and interior finishes in buildings inside the protected area or external to the protected area but directly supporting the plant. Alternatively, design shall be using non combustible materials or covered with a non-combustible barrier to reduce the chance of ignition.

3. The safe storage, location and protection of combustible materials, dangerous goods, and liquids and gases used for plant operation.

4. Combustible liquids with flash points greater than 93.3 °C shall be treated as protected liquids and considered in the fire safety analyses.

5. The flame spread of electrical cables shall be in accordance with technical specifications. The length of cable damage beyond the point of flame impingement shall not exceed 1.5 m. Damage is identified by charring and embrittlement of plastic material. In addition, specifications for low level of smoke and corrosive gases shall be made. Electrical cable trays and conduit shall be constructed of non-combustible materials.

6. Air handling ducts, duct connectors and plenums shall be made of non-combustible materials. Filter media (excluding charcoal filters and High Efficiency Particulate Air (HEPA) filters) used in air handling systems shall meet the combustibility requirements of the applicable industrial standards. Fire protection for charcoal filters shall be provided to ensure that fires do not spread beyond the filter housing and to prevent the uncontrolled release of contamination into the atmosphere.

7. The storage and use of flammable and combustible liquids should be limited. Where these liquids are used, or are present in equipment, appropriate safeguards should be provided as contained in safety standards. Storage of flammable and combustible liquids shall be according to the regulations, and in addition, shall not be located in the same fire compartment as systems important to safety. The use of combustible liquids in systems and components (e.g., lube oils in bearings and diesel fuel day tanks) is not considered storage. Where a significant quantity (e.g., 100 L or more) of combustible liquid is contained in plant systems and components, the design shall provide devices to collect, divert and safely contain leakages from pressurized and non-pressurized components in order to prevent the ignition of the oil or limit the size of fire and achieve fire safe shutdown.

8. Systems containing flammable gases shall be designed in accordance with the appropriate referenced protection standard. Use of non flammable compressed gases shall also be controlled according to the appropriate referenced protection standard. Production of hydrogen or deuterium in the moderator cover gas shall be controlled using re-combiners. Hydrogen could be released into containment in the event of certain design basis accidents and design extension conditions. Means shall be provided to prevent a hydrogen explosion (e.g. through the installation of passive autocatalytic recombiners and hydrogen igniters). Where the location cannot be changed, the alternative may be to protect the required equipment and cables by fire barriers. Hydrogen supply cylinders shall be located apart from systems important to safety to prevent their damage from fire or explosion.

9. Electric and control cabinets shall be designed to minimize flame spread across adjacent cables. This requirement may be met by maintaining a small air space between cabinet walls and sealing any openings across cabinets. Cable entry and exit points from cabinets may be provided with tightly fitted anchors or seals (not necessarily have rating) to reduce the potential for flame spread along cables.

Control of ignition sources is ensured in accordance with the following rules:

1. Electrical equipment and wiring is designed and installed in accordance with the approved standards.

2. The design shall identify and reduce potential ignition sources, including the following:

a) Enclosing spark or flame producing components,

b) Locating hot equipment away from combustible materials and fluids,

c) Using appropriately listed electrical equipment where it is located near where flammable vapours or explosive dust may accumulate, and

d) Preventing ignition of flammable vapours by static electric sparks by grounding equipment handling flammable liquids.

3. Ignition sources near combustible materials that cannot be relocated by design shall be shielded and/or insulated.

4. Outdoor transformers, the switchyard, and all structures housing systems important to safety shall be protected from lightning.

5. Effective configuration management process, which ensures that all permanent and temporary modifications to the plant and to the procedures are adequately assessed, including with regard to the impact on fire protection.

6. No combustible materials shall be deposited in any plant area without an approval based on the review of compliance with the fire safety analysis assumptions and requirements for the respective area. Strict rules, specifications and controls are established in this regard for the various plant areas.

7. Rigorous assessment and planning of the work, which includes risk assment, work authorization and supervision. Strict policies and requirements are applied to fire works.

8. Assurance of the availability and operability of the passive and active fire protection measures, in accordance with the design intent and requirements.

9. Adequate training and qualification of the personnel, to ensure that the fire protection rules and measures are properly understood and implemented.

3.1.3A Licensee's experience of the implementation of the fire prevention

The licensee has continuously improved fire prevention, using inpus from operating experience and from internal and external inspections, audits and review missions.

3.1.3.1.A Overview of strengths and weaknesses

Strengths include:

- examples of particular aspects that have been observed by external reviewers include:
    - good fire management systems in place by design; highly professional staff
    - housekeeping is good
    - good use of intumescent and fire protection coating (some maintenance required)
    - good use of fixed fire suppression systems
    - good distribution of portable fire extinguishers which are all being replaced
- updating of fire safety analyses
- good configuration management
- rigorous control over the temporary storage of combustible materials
- comprehensive risk assessment of planned work
- increase in the capacity for firefighting, with a professional firefighting unit on site.

Weaknesses resulting from emergency drills and exercises, from regulatory inspections, from operating experiences, from obsolescence problems or observed in the gap analyses for the latest industrial standards on fire protection are treated as opportunities for improvement.

3.1.3.2.A Lessons learned from events, reviews fire safety related missions, etc.

Several improvements have been implemented in the area of fire work preparation and authorization.

3.1.3.3.A Overview of actions and implementation status

Opportunities for improvement are identified on a current basis, taking into account the internal and external operating experience and the performance of the emergency drills and exercises. Based on these opportunities for improvement, the licensee devises improvement actions and implementation plans. These are also subject to the periodic regulatory review.

3.1.4. A Regulator's assessment of the fire prevention

The strengths recognized by external review missions have been observed also by CNCAN inspectors. The weaknesses identified though review and inspection activities are investigated and regulatory actions are imposed on the licensee, which generally include revised analyses, new or modified procedures and / or design modifications and upgrades.

3.2.A Active fire protection

3.2.1.A Fire detection and alarm provisions

3.2.1.1.A Design approach

3.2.1.2.A Types, main characteristics and performance expectations

Fire alarm systems are designed, installed, and verified in accordance with the approved standards (Canadian and Romanian standards), including with regard to the type of fire alarm systems, their performance levels and associated safety features

The fire alarm system is installed to detect fire, to provide specific alarm signals (visual and auditive) to the control room operators, and to provide emergency signals to plant occupants.

In the selection and installation of fire detectors and other field components of the fire alarm system, account has been taken of the environment in which the components are installed (e.g., in terms of radiation fields, electromagnetic field interference, humidity, temperature and air flow).

If the fire safety analyses would credit very early detection of fires to bring in manual fire fighting, aspirated air sampling systems or other very early warning detection technology shall be mandatorily used.

Fire detection systems in the Reactor Building are designed to remain functional under high pressure containment test conditions.

Fire alarm control and display panels are provided in both the MCR (or in its immediate vicinity) and in SCA.

Electric conductors connecting central alarm and control panels to the fire alarm control unit shall be protected against fire exposure to ensure continued operation after the start of a fire. Electric conductors that are installed in service spaces containing other combustible materials and that are used in connection with fire alarm systems and emergency equipment including fire alarm cables (e.g., fire-related smoke control equipment, pressurization equipment to limit smoke spread, equipment for the emergency operation of elevators, venting equipment to aid firefighting, the display and control centre fire-related equipment, and the voice communication system) shall be capable of performing their intended functions for a sufficient time after the start of a fire.

Fire alarm signals are provided for all occupied areas of the plant. Signals are distinctive and not capable of being confused with any other alarms in the plant. Voice instructions are provided during an emergency to occupants both within and outside buildings within the protected area.

A reliable means of communication between the MCR staff and emergency responders shall is provided.

The power supply for the fire alarm and voice communication systems is from a reliable and redundant power supply system (either Class III or II) that is in compliance with the approved standards. 12. The fire alarm and communication systems are equipped with backup batteries capable of providing supervisory functions for not less than 24-hours

3.2.1.3.A Alternative/temporary provisions

In case of fire, the operators in MCR receive an alarm on the panels and diagnose the event using the information provided by the Fire Detection and Alarm System. The main information provided includes:

- fire detector(s) and/or alarm button(s);
- fire detector(s) and/or alarm button(s) in faulty conditions;
- line or loop defect;
- missing fire detector;
- activated Deluge/Grinnell valve(s);
- lack of water pressure on the Deluge valve(s);
- fire extinguishing system activation with Inergen;
- defect in the fire extinguishing panel with Inergen;
- in addition, the fire alarms are relayed to the fire brigade indicating the plant zones affected.

The system is operated by qualified operators (qualification obtained on the basis of a dedicated trained course), on the basis of the operating manual of the system.

In addition, it should be mentioned that the soft isolation of some detectors or some areas to facilitate smoke-generating works is carried out on the basis of a "Fire Protection Systems Unavailability Permit". The detectors to be isolated and the related compensatory measures are listed in the permit. The permit is approved by the responsible system engineer / firefighters and approved by the Sjoft Supervisor. System maintenance and fire detection testing are defined according to the requirements of the Romanian regulations and the manufacturer's maintenance manual.

3.2.2.A Fire suppression provisions

3.2.2.1.A Design approach

The fire water system provides water for all fire categories from the classical and nuclear side for Units 1 and 2, through a common, ring network. The fire water system uses (filtered) water extracted from the Danube.

The fire water pumping station that supplies water for the NPP units is located at Unit 0, outside Units 1 and 2, and consists of 9 electric pumps of different capacities and a high-capacity (reserve) diesel motor pump.

Water is supplied from the external network to the external fire extinguishing systems (external hydrants, connections for powering the fire engines), but also to the fire extinguishing systems that serve the buildings belonging to units U0, U1, U2.

Internal fire extinguishing systems consist of:

- Automatic fire extinguishing systems;
- Manual fire extinguishing systems.

3.2.2.2.A Types, main characteristics and performance expectations

As determined in the fire safety analyses, fire suppression systems shall be designed and located to ensure that their rupture or spurious operation does not significantly impair the capability of SSCs important to safety and does not lead to failures of redundant FSSSs.

Fire extinguishing systems with internal hydrants are provided in all major building with safety important SSCs. An exception is the Reactor Building of Unit 1, for which internal fire hydrants and piping will be installed during refurbishment. The minimum flow for each hydrant is of 2.5 l/s, in accordance with national standards for fire protection. Technical specifications are established for the availability and performance of the fire water hydrants.

Fire extinguishing systems with sprayed water and automatic sprinkler systems are provided in plant areas and compartments where there is a substantial risk of fire.

Fire extinguishing systems with INERGEN are used for computer rooms and other areas where water extinguishing systems are not suitable for use.

3.2.2.3.A Management of harmful effects and consequential hazards

The deleterious effects of discharging fire extinguishing agents, particularly water getting into electrical equipment, shall be assessed as part of the fire safety analyses, for situations where such systems are installed and credited in the analysis. Negative effects could be prevented through appropriate choice of fire suppression systems. Where water-based systems are chosen, measures, such as splash shields, weatherproof equipment enclosures, floor drains, curbs and dikes, shall be provided to limit damage to equipment due to spray, accumulation or spread of water.

Ceiling sprinklers or room flooding gas systems may not be effective in extinguishing fires inside electrical or control equipment cabinets. Further, the deployment of these systems could also introduce equipment damage. The fire safety analyses shall establish specific fire protection objectives in areas containing these cabinets and develop alternative design measures to achieve these objectives.

3.2.2.4.A Alternative/temporary provisions

In cases of major impairments of the fire water system in case on an actual fire event, compensatory measures may be implemented with the support from the professional firefighting brigade, using water supplied with the fire trucks.

Unavailabilities in fire detection equipment are compensated with organizational measures, such as fire watch.

3.2.3.A Administrative and organisational fire protection issues

In order to ensure effective control over fire hazards, all activities that have an impact on fire protection are documented, organized and carried out in compliance with the procedures and regulations of the fire protection system. Detailed work procedures are provided for the operation and maintenance activities so that the staff has the necessary information to avoid errors that could lead to fires. The procedures align with legal requirements and international practices in the nuclear field.

Procedure 0-1-2-03410-OM-001-SM-1-29 – Fire prevention establishes the set of fire prevention rules during the usual activities carried out in the plant and completes the fire protection requirements stated in the operating manuals of the systems, as well as in the regulatory procedures of the centralized work system (SI-01365-P002-Work authorization system, SI-01365- P006-Work plans/Systematic work plans, SI-01365-P022-Order and cleanliness of the plant, SI-01365-P14-Evaluation of execution packages).

Combustible materials, other than those that are part of the constructive structures, systems or equipment, are controlled to avoid/limit the increase in thermal load in technological or administrative spaces (OM 03410, SM 1-29-Fire prevention). Firm procedural requirements are implemented for the temporary storage of combustible materials but also for the prompt evacuation of all combustible waste (SI-01365-P022 - Order and cleanliness of the plant). The evaluation method for requests for temporary or permanent storage of various materials is established in the IDP instruction – SM-PSI-017-Evaluation of requests for temporary or permanent storage.

Potential sources of ignition generated by the operation of systems and equipment are controlled by complying with the requirements regarding their operation and by implementing a rigorous preventive, predictive and corrective maintenance program.

Temporary, portable, sources that can generate fire are supervised and their use is made only after a prior assessment of fire risks. The framework for carrying out works with fire is controlles through strict procedures to ensure risk assessment and their elimination/control through compensatory measures (PSP-RP015-003-Control of works with fire, IDP-SM-PSI-026-Verification of works with fire).

The state of health of the fire protection systems is periodically monitored (SI-01365-P092-Monitoring and evaluating the performance of systems, structures and components; PSP-T010-032-Health monitoring). In addition, the fire protection installations are periodically checked by specialized prevention personnel from the fire protection department, according to the internal procedure IDP-SM-PSI-028-Routines.

All licensee personnel and permanent contractors benefit from initial and periodic training. The fulfillment of responsibilities regarding fire safety is supported by a training program that ensures the information and competence necessary to achieve the objective of fire prevention, maintenance of fire extinguishing means an action in case of fire, depending on the nature of the roles and activities with impact on fire safety.

3.2.3.1.A Overview of firefighting strategies, administrative arrangements and assurance

Based on a memorandum signed by the management of the licensee with the national Department for Emergency Situations, a professional unit of firefighters was deployed on a permanent basis on the Cernavoda NPP site, starting with the second quarter of 2022.

The continuous training of operative personnel within the Cernavoda Special Fire Department is carried out on the basis of a monthly program approved at the level of the Dobrogea Emergency Situations Inspectorate of Constanta County, which emphasizes both knowledge of military rules and those specific to Cernavoda NPP, knowledge of the procedures applicable to the activities of the unit, the equipment, methods, the intervention

techniques and the utilization of the intervention devices. Practical training is carried out by participating in the emergency exercises planned at Cernavoda NPP, by surveillance/inspection activities on the plant site, as well as by training in specific fire fighting facilities.

The response capacity of the firefighters is maintained and evaluated through emergency drills. The emergency planning and preparation process is described by procedure RD-01364-RP008 and associated lower-level instructions. This process defines:

- classification of emergency situations;
- organization in case of emergency and specific responsibilities;
- the general ability to respond to emergencies (in addition to the internal organization, it also includes staff of the public authorities);
- emergency response activities;
- emergency arrangements and equipment;
- the interface between Cernavoda NPP and the public authorities;
- preparation for emergency situations;
- evaluation of the emergency plan.

3.2.3.2.A Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

Within the Cernavoda NPP Special Fire Department, a sufficient number of military firefighters personnel are active, working on shifts and having available fire trucks and CBRN trucks.

The response capacity of the firefighters is maintained and evaluated through emergency drills. The emergency planning and preparation process is described by procedure RD-01364-RP008 and associated lower-level instructions. This process defines:

- classification of emergency situations;
- organization in case of emergency and specific responsibilities;
- the general ability to respond to emergencies (in addition to the internal organization, it also includes staff of the public authorities);
- emergency response activities;
- emergency arrangements and equipment;
- the interface between Cernavoda NPP and the public authorities;
- preparation for emergency situations;
- evaluation of the emergency plan.

3.2.3.3.A Specific provisions, e.g. loss of access

Specific provisions and arrangements have been put in place to ensure feasibility of the firefighting strategies in situations caused by extreme external events such as those analyzed in the post-Fukushima “Stress Tests”.

3.3.A Passive fire protection

3.3.1.A Prevention of fire spreading (barriers)

3.3.1.1.A Design approach

Fire barriers are provided as required by the approved standards and the fire safety analyses. Barriers are designed and installed to provide the required fire resistance rating and meet the licensing basis fire protection standards.

Openings in required fire barriers for doors, hatches, windows, and ventilation ducts are protected with closures with a fire resistance rating not less than that for the barrier and installed in accordance with the approved standard.

Electrical cable and mechanical penetrations in fire barriers are provided with firestops with a fire resistance rating not less than that for the barrier and installed in accordance with the approved fire protection standard.

Cables required for fire safe shutdown may be protected by suitably designed and qualified cable fire barrier systems. This system shall protect the function of the protected cables for a sufficient duration as determined in the fire safety analyses. The system should have a Flame, Temperature and Hose stream (FTH) rating. Qualification of the cable fire barrier system shall be by tests conducted in accordance with the approved standard.

3.3.1.2.A Description of fire compartments and/or cells design and key features

Spatial separation, in combination with additional compensatory measures, are used instead of fire barriers to protect against the common failure of fire safe shutdown components and cables, where the installation of a fire barrier:

- is impractical due to the design of the space or the presence of process equipment and services; or
- would interfere with nuclear operation or pose a risk to nuclear safety.

The additional compensatory measures used with spatial separation, are as follows:

- elimination of intervening combustible materials, including combustible materials that might be present due to component failure, that can spread a fire across the spatial separation;
- the damage to more than one group of FSSSs located within the same fire compartment that is due to the effects of fire or products of combustion across the spatial separation (e.g., high room temperature, hot air plume or radiant heat) shall be assessed and prevented; one group of fire safe shutdown components or cables may be protected by fire barrier enclosures or use of fire resistive cables;
- fire detection and suppression and/or other fire protection measures shall be provided in accordance with the fire safety analyses.

The fire protection barriers must fulfill their function in the event of a fire, maintaining their stability, tightness and thermal insulation capacity for the prescribed time, depending on the density of the thermal load. Therefore, any penetration of the barriers must not affect their fire resistance. The penetrations of the barriers for the passage of cables and pipes must be sealed, and the degree of fire resistance of the sealing must be equivalent to that of the respective barrier, and the functional gaps must be closed with fire-resistant doors.

3.3.1.3.A Performance assurance through lifetime

Through the configuration control process, all design changes are analyzed by the personnel responsible for fire protection to ensure that the change has no impact on the passive fire protection of the building and the need to update the FHA will be determined.

Monitoring of passive fire barriers is done by:

- inspections conducted by the responsible engineers;
- routines conducted by the maintenance personnel;
- specialized inspectiors performed by external contractors as part of the surveillance program for the safety-related concrete structures.

In case of damage to some fire protection barriers, a Fire Protection Systems Unavailability Permit (PI) is initiated. This permit is submitted to the responsible system engineer for approval following assessment and verification. If necessary, remedial measures are established and compensatory measure are implemented in accordance with plant procedures (surveillance routines / fire watch).

3.3.2.A Ventilation systems

3.3.2.1.A Ventilation system design: segregation and isolation provisions (as applicable)

Ventilation systems are provided for all buildings where safety-related SSC are located. The flow of the ventilation is such that air circulates from areas where there is no possibility of radioactive contamination towards areas where radioactive contamination could occur.

Ventilation will stop in case of fire.

The ventilation systems are provided with dampers that will close in case of fire to prevent fire spread.

For the cases where filters are used in the ventilation systems, temperature detection and monitoring devices are installed, which also give a signal for the fire dampers to close.

3.3.2.2.A Performance and management requirements under fire conditions

The fire dampers close when the temperature in the ventilation ducts reaches the temperature of 71^{o}C. The fire dampers have a fire resistance rating of 90 minutes.

3.4.A Licensee's experience of the implementation of the fire protection concept

The licensee has continuously improved the fire protection of Cernavoda NPP and has maintained update the fire safety analyses.

The licensee reviews the relevant international standards on fire protection, including the new / revised editions and documents the gap analyses. Examples of such standards for which a compliance review has been conducted in the last years include:

- CSA N293-12 (R2017) - Fire protection for nuclear power plants; a new review and assessment is being performed for the newest edition, issued in 2023;

- IAEA SSG-77 - Protection Against Internal and External Hazards in the Operation of Nuclear Power Plants;
- IAEA SSG-64 - Protection against Internal Hazards in the Design of NPPs;
- WANO 2019-1 - WANO Performance Objectives and Criteria, Fire Safety (FS.1).

Several improvement measures are under implementation or planned, as presented in section 2.1.5.2. Implementation status of modifications/changes.

3.5.A Regulator's assessment of the fire protection concept and conclusions

CNCAN implements a regulatory oversight process that consists of review, assessment and inspections.

In the area of Fire Protection, CNCAN reviews and inspects the following:

- Compliance with regulations (NSN-09 on Fire Protection for NPPs) and relevant license conditions
- Compliance with the applicable industrial codes and standards (CSA N293, Fire protection for nuclear power plants, 2012 - the latest edition accepted by CNCAN)
- Fire Hazard Analyses
- Fire Safe Shutdown Analyses
- Fire Probabilistic Safety Assessments
- Fire detection systems
- Passive and active fire protection SSCE
- Control of ignition sources
- Control of combustible materials and prevention of explosive atmospheres
- Organizational and technical capabilities for fire fighting
- Records of surveillance, testing, inspection and maintenance activities for the fire detection and fire protection systems
- The reports from the monitoring implemented by the licensee's responsible system engineers and component engineers
- Training and qualification of the personnel with responsibilities in the fire protection program
- Conduct of fire drills and exercises (including in the context of more complex emergency response exercises)
- The availability, adequacy, accessibility, integrity (e.g. fire resistant penetrations/fire stops; fire retardant coating), configuration / position (e.g. fire dampers, fire doors), indications of current inspection (last check) and parameters (e.g. pressure of the fire suppression systems) of fire protection SSCE during plant walkdowns
- Compliance with the licensees' procedures and documents approved by CNCAN
- Quality of the process documentation (from general reference documents to detailed work instructions)

- Control of modifications to fire protection systems
- Implementation of the preventive and corrective maintenance activities for safey-related fire protection SSCs.
- Ageing management for the piping and structures of fire protection systems
- Progress in the implementation of the upgrades/improvements
- Licensees' self-assessment reports, audit reports, independent oversight reports, peer review reports (e.g. from WANO, IAEA/OSART), insurance pool inspection reports
- Relevant internal operating experience and abnormal condition reports
- Use of external operating experience, including benchmarks
- Indicators used for measuring the effectiveness of the process

The inspections performed by CNCAN include:

- scheduled inspections;
- 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 for Cernavoda NPP.

A series of routine inspections is used by the Cernavoda 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.

All the above-mentioned routine inspections also cover fire protection aspects.

Areas for improvement of the regulatory oversight in the area of fire protection:

- Further development of the inspection procedures, including the development of a plant specific detailed checklist for the fire protection inspection walkdowns in all plant areas;

- Revision and update of the NSN-09 regulation (in progress);
- More specific technical training to be provided for the reviewers and inspectors;
- Further improvements are expected to be identified from the EU Topical Peer Review on Fire Protection.

In addition to its regular oversight activities aimed at verifying compliance with the fire protection requirements, CNCAN performed reviews and inspections to verify the self-assessment reports prepared by the licensees in accordance with the WENRA / ENSREG specifications for the TPR.

Based on the regulatory reviews and inspections performed so far, CNCAN is satisfied with the adequacy of the licensees' fire protection programs and with their overall implementation. No major issues have been identified.

3.6.A Conclusions on the adequacy of the fire protection concept and its implementation

The Fire Safety Process is developed by the licensee for Cernavoda NPP to ensure appropriate planning, implementation and control of those activities which are related to fire safety. The ownership of the fire safety process is assigned to the Health Physics Department through the Industrial Safety Section.

The governing reference document (process procedure) RD-01364-RP15 establishes the requirements to effectively address the attributes of the fire safety management, as required by the specific nuclear regulations issued by CNCAN and by the national general regulations of fire protection for industrial facilities. Subsequently, the reference document is supported by specific procedures and the normal plant processes such as work management, maintenance programme, design control, observation and coaching programme, corrective action programme.

Based on the concept and principles of defence in depth, the Fire Safety Process built up a series of consistent and coherent barriers designated to prevent fire from occurring and, should a fire start, to extinguish it rapidly with minimal damages. The barriers include both administrative measures and physical means, which aim together to:

- Prevent fire;
- Limit and control fire;
- Extinguish fire.

These objectives divide the Fire Protection Program in three subprograms:

- Fire Prevention;
- Fire Control;
- Fire Response.

The Fire Prevention Program comprises of the following main elements:

- The prevention of fires is based on the premise that fires occur when the ignition source and combustibles interact in an undesirable manner due to human errors. One of the key elements of the fire prevention program consists of high standards that enables the plant personnel to perform the work in a safe manner preventing the likelihood of fire situations. Adherence to the fire prevention standards is continuously reinforced through the Human Performance tools.

- Training is another major element of the fire prevention, providing the plant personnel with the appropriate knowledge, skills and attitudes. In this respect, the plant personnel shall attend a basic fire training as part of Job-Related Training Requirements (JRTR). Refreshment of fire safety rules is provided via monthly safety meetings.
- Contractors are provided also with a generic training course which reinforces the fire safety expectations while performing the work within the plant.
- Through the appropriate procedures, the activities and the work site are routinely inspected in order to assess plant conditions for fire hazards and unsafe work practices. Hot work is always subject to a fire permit delivered after the assessment of the Industrial Safety Section.
- Another key element of the fire prevention is good housekeeping. Multi-level walk-down inspections are performed in order to identify and correct unsatisfactory material condition.

The effectiveness of the fire prevention program has been proven by the operating experience.

The Fire Control Program comprises of the following main elements:

- Among administrative measures implemented to prevent fire from starting, the Fire Safety Process includes passive and active means which are designated to limit the fire growth and to mitigate its effects.
- The fire barriers provide fire zoning of the plant based on the fire load density. The fire barriers have been coded and are subject to annual inspections.
- All the plant areas are covered by detection systems which provide early warning in the Main Control Room. From the Main Control Room, a generic signal is retranslated to the Fire Brigade Communication Center, which generates the assembling of the shift firefighters. Fire suppression systems are installed in essential locations where immediate response is necessary. Most of the systems are water based (sprinklers and deluge) but Inergen extinguishing systems are also installed.
- The capability of the detection and suppression systems is maintained through preventive maintenance and testing programs. Whenever impairments occur in the fire detection or suppression systems, or in the passive fire systems, compensatory measures are provided.
- For manual firefighting, a variety of extinguishers, fire hose cabinets, external hydrants and foam equipment are available throughout the plant. The response to extensive fires is provided by the Fire Brigade equipped with three fire trucks.

The Fire Response Program comprises of the following main elements:

- The Fire Response in Cernavoda NPP is organized in two levels according to the stage of fire development.
- The first line response requires that any person discovering a fire shall notify the Main Control Room. If the fire is in the incipient stage and there is no risk of injury, the

person shall use the extinguisher nearby. In order to achieve this requirement, the basic fire training includes knowledge and skills on how to use portable extinguishers.

- The second line response as part of the Contingency Plan is supported by Emergency Response Team. For fire incidents, at least 15 professional firefighters per shift are available to be deployed in the incident area to fight any fire which develops beyond the incipient stage and requires coordinated actions to be carried out and specific equipment to be used.

The performance of Cernavoda NPP is the area of fire protection is satisfactory. The licensee has implemented several design and operational improvements in the area of fire protection and further enhancements are planned for implementation.

3.B TRIGA Research Reactor

3.1.B. Fire prevention

The prevention of fires at the research reactor of the Institute for Nuclear Research is carried out in compliance with the general national regulations on fire protection, utilizing prevention means (fixed and mobile fire extinguishing equipment, hydrants) and permanent training of employees.

In order to increase fire prevention at the research reactor, a fire protection organization plan has been developed which is displayed on each floor of the main reactor building and in each reactor annex building. The first step of this plan is fire prevention, which includes a list of potential sources of ignition.

Combustible and flammable materials include:

- Furniture (tables, chairs, cabinets, flooring);
- Textile materials;
- Electrical equipment.

Potential sources of ignition are:

- of an electrical nature (the electrical installation for lighting and supplying consumers);
- of a thermal nature (open fire matches, welding, radiators, ovens).

Equipment and means of work that can generate fires are:

- the electrical installation for lighting and supplying consumers with energy;
- electrical consumers used without compliance with the rules or with improvisations and defects;
- electric bulbs and reflectors for special effects;
- failure to comply with the rules regarding smoking and open flame.

General measures for fire prevention include the following provisions:

- the operation of electrical installations will be carried out without improvisations or fences;
- the rules regarding smoking will be respected (smoking is prohibited in the closed spaces of the workplaces and on the circulation/access roads within the RATEN ICN premises);
- the means of heating shall be located at a safe distance from combustible materials (curtains, curtains, panels).

Specific measures for fire prevention:

- according to the schedule, the electrical consumers will be removed from the power supply and the potential sources of ignition will be removed;
- the installations supplied outside the normal working hours will be supervised by the staff of the Emergency, Prevention and Protection Service.

3.1.1.B Design considerations and preventions means

The design of the construction for the reactor hall was in compliance with the national general regulations on fire protection

Other constructions related to the reactor are:

- the station of the secondary circuit pumps, combined with the compressed air station, the 6 kV electrical station and the 0.4 kV electrical station;
- ventilation tower;
- cooling towers with forced draft (7 cells);
- diesel power station building.

The design of the SSC has taken into account the environmental conditions both in normal operating situations and in accident conditions, including the accident of loss of the cooling agent.

Structures important for nuclear safety have been designed to withstand the effects due to internal and external hazards, including fire events.

There is no danger of explosion in the rooms where the systems and components of the installation are located. Fire resistant materials were used for the construction and installations (concrete, reinforced concrete, steel sheet, etc.).

For fire protection, a fire detection system is provided, that is composed of:

- automatic detection and signaling center;
- fire detectors;
- manual alarm buttons.

The building is provided with a fixed installation for extinguishing fires (hydrants).

Mobile equipment (portable fire extinguishers, etc.) has been provided for extinguishing fires in accordance with the regulations and prescriptions in force.

In 1996, a "Fire risk analysis for the TRIGA ICN Pitesti reactor building" was performed. Taking into account the conclusions and recommendations, the fire detection and signaling system for the reactor building was developed, with the following components installed:

- fire detection and warning panel;
- addressable optical smoke detectors;
- manual fire warning buttons;
- 4 sound warning units.

In 2012, supplementary addressable optical smoke detectors and two manual fire alarm buttons were installed in the buildings of the Diesel plant, the 6 kV electrical station, the 0.4kV station and the secondary circuit pump station.

These detectors and buttons are connected to the fire detection and warning panel, located in the hall at the main entrance to the reactor building.

In 2014, as a result of the findings of the INSARR 2013 mission report, the following components were additionally installed in the fire alarm system:

- an analog optical smoke detector in the reactor hall;

- the smoke sampling component for the ventilation piping, in the reactor hall;
- a hydrogen detector, in the battery room; meantime, the old batteries were replaced with gel type batteries.

These detectors are also connected to the fire detection and warning panel, located in the hall at the main entrance to the reactor building.

3.1.2.B Overview of arrangements for management and control of fire load and ignition sources

In order to increase fire prevention at the research reactor, a fire protection organization plan has been developed which is displayed on each floor of the main reactor building and in each reactor annex building. Control of fire load and ignition sources has been described in section 3.1.B. Fire prevention. Procedures are in place to prevent the accumulation of combustible materials in areas where SSC important to safety are located. Also, procedures are enforced for the control of work and equipment that could constitute ignition sources.

3.1.3B Licensee's experience of the implementation of the fire prevention

Strict rules for the prevention of fires have been observed since the construction of the research reactor. The use of combustible material has been avoided to the extent practicable.

Since the start of the research reactor operation, the emergency, prevention and protection unit from the research institute was provided with adequate specific tools and equipment (fire vehicle, portable fire extinguishers, breathing devices, protective suits, etc.); also there are available alternative routes for evacuation of goods and personnel, hydrants inside and outside the reactor building, water supplies, fire detection and alarm units.

The emergency, prevention and protection unit personnel is trained and licensed for emergency situations and take part in firefighting drills and contests organized by the regional Emergency Situations Inspectorate.

No particular strengths and weaknesses have been identified.

As regards the lessons learned from events, reviews fire safety related missions, significant safety improvements have been identified and implemented following the INSARR mission received in 2013.

3.1.3.3.B Overview of actions and implementation status

No specific actions for improvement have been identified, in addition to the current actions resulting from regular inspections, audits and emergency exercises and drills. One of such specific actions is to increase the number of increase the amount of licensed volunteer firefighters at the research institute.

The FHA will need to be updated.

3.1.4.B Regulator's assessment of the fire prevention

Based on the regulatory reviews and inspections performed so far, CNCAN has not identified any major issues with regard to the fire protection of the research reactor.

CNCAN is updating its specific nuclear safety regulation on fire protection and will extend its scope to cover all nuclear installations, including research reactors and more detailed inspections will be performed to ensure compliance with the new regulatory requirements.

3.2.B Active fire protection

Active fire protection is an integral part of fire protection. This is characterized by elements and/or systems, installations that are put into operation in the event of a fire. In the main building of the reactor as well as in the annex buildings, the fire can be controlled and extinguished manually.

The installations and systems, devices and devices for preventing and extinguishing fires that are in the building include:

- internal hydrants;
- external hydrants;
- portable fire extinguishers - Foam Spray, ABC powder, Carbon dioxide.

3.2.1.B Fire detection and alarm provisions

The fire detection and signaling system allows the automatic detection of early stages of fire, through optical, addressable smoke detectors or by pressing the addressable fire warning buttons, mounted on the hallways and on the stairs of the building.

3.2.1.1.B Design approach

The design and implementation of the detection system has been performed in compliance with the general national regulations on fire protection, in order to provide adequate coverage for all the areas where SSC important to nuclear safety are located.

3.2.1.2.B Types, main characteristics and performance expectations

The fire detection and signaling system consists in fire control panel, addressable optical smoke detectors, addressable fire alarm buttons and conventional warning horns.

The fire control panel surveys the reactor building, the Diesel building and the 6kV station building.

The configuration of the fire detection and signaling system includes:

- addressable central unit, with microprocessor; its buffer batteries ensure autonomy for
- at least 15 hours;
- addressable optical smoke detectors;
- addressable manual buttons for fire signaling;
- outdoor acoustic horns.

Detectors may have different levels of sensitivity depending on their location.

The message displayed on control panel unit shows for each zone:

- the place of the event;
- event type: pre alarm, alarm or fault;
- the code and address of the device that located the incident;
- the date, time and minute of the event.

The panel can store up to 1000 events.

3.2.1.3.B Alternative/temporary provisions

Shift personnel permanently monitor or periodically survey the systems that are part of

the nuclear installation. When faults are detected in the SSC, that could lead to the start of fires, the operator in the control room is alerted and acts according to specific procedures (manual actuation of the addressable buttons for fire signaling, immediate communication of the event through the means of communication, etc.).

3.2.2.B Fire suppression provisions

3.2.2.1.B Design approach

During the design and execution of the hydrant system, the licensee respected the provisions of the firefighting and labor protection regulations in force at that time.

The reactor building is provided with a fixed installation for extinguishing fires, with hydrants, 2 jets of 2.5 l/s each in simultaneous operation, according to the national general regulations on fire protection, based on the classification of the building in fire hazard category and the requirements for constructive solutions with fire resistance, and the constant volume exceeds 25000 m^3.

Mobile equipment (portable fire extinguishers, etc.) has been provided for extinguishing fires according to the national regulations.

3.2.2.2.B Types, main characteristics and performance expectations

The water supply for the hydrant system in the reactor building is made with potable water from the well area and with industrial water from the pretreatment station in the nearby town.

All the consumers in the reactor building as well as the internal/external hydrants are connected to the internal network of the research institute, being fed from buffer tanks.

The flows and pressures of potable and fire water at the feeding points are ensured by the pumps from the external network of the reactor building. In laboratories, fire hydrants are provided.

The internal fire hydrants are type C, simple hand discharge pipe. Water flow and the pressure values at the feeding points were established based on national general fire protection standards.

3.2.2.3.B Management of harmful effects and consequential hazards

In the event that radioactive waste flows into the industrial sewer, following the extinguishing of a fire, from the places that may be radiologically contaminated, the control of quality water before and after the treatment station, by taking samples from the waste water collection tanks, was foreseen. The purpose is to ensure the impossibility of discharging the water that may be radioactive, directly into the environment without ensuring the necessary dilution.

If the sum of the ratio between the measured concentration and the maximum allowed concentration for each nuclide present in the water is above unity, the liquid waste will be transferred to the Radioactive Waste Treatment Station for conditioning for final storage. Solid materials resulting from extinguishing the fire, which may be contaminated, will be collected in special containers and transferred to the same Radioactive Waste Treatment Station.

3.2.2.4.B Alternative/temporary provisions

The supplementary means include:

- the intervention with the mobile intervention means consisting of a special vehicle with 4 extinguishing agents that will ensure the protection of the intervention personnel at the workplaces as well as the limitation of the spread of the fire until the arrival of the support forces from the Mioveni Fire Department and / or the Inspectorate for Emergency Situations Arges;
- the intervention with the portable extinguishing means provided for limiting, isolating and extinguishing fires in the initial phase;
- ventilation system shutdown in the affected area by the fire to reduce the level of oxygen that maintains the combustion.

3.2.3.B Administrative and organisational fire protection issues

The organization of the Reactor Section personnel for intervention in the case of response measures to transients and emergency situations for the postulated event "fire in the reactor building" is done following the "Fire Response Plan", the emergency organization plans and the procedures applicable to the situation.

3.2.3.1.B Overview of firefighting strategies, administrative arrangements and assurance

In order to increase fire prevention at the research reactor, a fire protection organization plan has been developed which is displayed on each floor of the main reactor building and in each reactor annex building. Control of fire load and ignition sources has been described in section 3.1.B. Fire prevention.

The second step of the plan is the organization of the first firefighting intervention, which presents the equipment and personnel that ensure the first intervention, the evacuation and telephone numbers used to alert the fire service.

The organization of the first firefighting intervention:

1. Means of alarm/alert:

- RATEN ICN fire department telephone number:
- Dispatch phone number RATEN ICN:
- Alarm button:

2. Fire limiting and extinguishing installations and devices:
   - Fire resistant doors
   - Smoke and gas exhaust hatches
   - Extinguishing installations
3. Means of protection for employees
   - Breathing devices with compressed air
   - Masks against smoke and gases
   - Protective suits (anti-caloric)

The intervention of the staff of the Reactor section, in case of fire started in the reactor building, can be carried out following two aspects: the response to transients and the response to the emergency situation.

Response to transients:

- the reactor shift manager takes act of fire location, assesses the event spreading and risk level,
- if the reactor is in operation during event occurrence, then the reactor shift manager requests to the reactor operator to shut down the reactor,
- the reactor shift manager requests the presence of shift personnel in reactor control room,
- the reactor shift manager requests the ventilation system shutdown,
- the reactor shift manager announces the fire event to research institute firefighters team through phone or through fire alarm buttons from reactor control room,
- the reactor shift manager requests shutdown of the equipment/systems/circuits from affected area,
- reactor shift manager requests power supply shutdown for the equipment/systems/circuits from affected area,
- the reactor shift manager informs the reactor manager/reactor operation manager on event occurrence and action taken; also, outside normal working hours, inform the research institute dispatch on event occurrence if is necessary to alert the reactor intervention team.

Response to the emergency:

- the reactor manager orders the alarm/alert, during working hours, to the shift leader and calls the intervention team,
- the reactor manager requests the evacuation of the personnel, other than intervention team,
- the reactor manager requests the gas supply feed closure,

- the reactor manager requests the removal of flammable or toxic materials from affected area,
- the reactor manager requests the dose rate measurements and dosimetry installation surveillance in affected areas,
- the reactor manager requests the intervention of the reactor team until the arrival of the research institute firefighters,
- the reactor manager requests to operators the installation surveillance results,
- the reactor manager requests the dose rate measurements in affected areas as the event is stopped,
- the reactor manager requests access restriction in areas with high irradiation and/or contamination levels,
- the reactor manager requests radiological monitoring for the intervention team,
- the radiation protection manager evaluates the doses received by the intervention personnel or those affected by the fire and transmits them to the reactor manager,
- the reactor manager, in cooperation with radiation protection manager, assess the radiological consequences of the event,
- the reactor manager announces the event to the research institute management and notify them of the actions taken,
- the reactor manager suggests the emergency type classification to research institute management,
- the reactor shift performs written records in “Shift Operators Report” the unplanned reactor shutdown and all performed actions/maneuvers,
- the reactor shift manager performs event classification and files the appropriate form,
- the reactor shift manager initiates the Event Report and files the corresponding fields,
- the reactor shift manager files the forms for reactor unplanned shutdown,
- the operators of reactor-related installations/systems record in the registers "shift report of reactor-related systems installations", in chronological order, all the activities and maneuvers performed,
- the reactor operation manager directs and confirms the corrective actions, and assess the efficiency of the activities,
- the reactor manager, depending of radiation level, requests disposal of the event consequences to the reactor personnel.

3.2.3.2.B Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

Firefighting capabilities include:

- early detection means – fire detectors, alarm buttons, fire alarm panel, horns
- communication means – intercom, telephone, walkie-talkie,
- extinguishing means – portable extinguishers, firefighting vehicle,

- reactor team for early intervention and spreading prevention,
- research institute firefighting team,
- local Emergency Situation Inspectorate firefighting team,

Responsibilities are specified for all the managers and for all the shift staff members.

The documentation includes:

- Emergency situation notification forms,
- Event Report forms
- Unplanned reactor shutdown form,
- Shift reports for each SSC.

3.2.3.3.B Specific provisions

Among the specific provision, the following are included:

- announcing the fire event to research institute firefighters team through phone or through fire alarm buttons from reactor control room; they also receive a signal from the fire control center,
- shutting down the reactor, if it is operating, according to the procedure for the unscheduled shutdown of the reactor,
- shutting down the ventilation system,
- marking and restricting access to areas with high levels of irradiation or contamination (if necessary),
- until the arrival of the firefighters, the intervention team acts to extinguish the fire with the intervention means (fire extinguishers, hydrants),
- evacuation of the workers that are not involved in firefighting, according to fire evacuation plan,
- performing dosimetric measurements and monitoring the dosimetry installation in the fire area and the possibly affected areas,
- radiological monitoring of personnel participating in the intervention or affected by the fire.

Other provisions:

- respect the work procedures related to open fire permit approval and firefighter surveillance of the activity;
- intervention in case of forest fire, based on a specific instruction for the research institute firefighting service;
- prevention of flammable materials storage inside reactor building and limitation of potential combustible materials;
- access pathways maintenance (illumination, indicators, unblocked).

3.3.B Passive fire protection

Passive fire protection aims to complement other forms of fire safety by preserving the structure of a building to give workers time to react, and at the same time, increasing the fire resistance of the structure. Passive fire protection greatly restricts fire, smoke and heat from spreading in different areas of the building, limiting the fire outbreak area compared to other adjacent areas. This allows the workers to address the situation and evacuate the building. Limiting the spread of the fire to a single area, the escape routes are left open and accessible. This allows those inside the building to escape safely through the nearest fire door.

3.3.1.B Prevention of fire spreading (barriers)

Prevention of fire spreading has been performed by the fireproofing (placing layers upon layers of materials over an object or area to give it high resistance to heat and flame).

3.3.1.1.B Design approach

The cable passages through the floors and walls at the entrance to the panels, cabinets and cells were sealed with protective pipes, metal tubes and seals to avoid the spread of possible fires. Also, where the free length of the route exceeds 25 m, fireproof separations (fireproof plugs) have been provided.

3.3.1.2.B Description of fire compartments and/or cells design and key features

The building resistance structure is made up of prefabricated reinforced concrete elements, plain concrete and reinforced concrete. The initial arrangements did not follow a strict fire compartment approach, therefore the fire cell approach has been used in the subsequent improvements of the fire protection design features.

3.3.1.3.B Performance assurance through lifetime

The performance of the passive fire protection features is subject to surveillace and inspection and includes the following activities:

- building resistance structure inspection, including fire barriers (walls, doors, etc.)
- SSC monitoring;
- SSCE maintenance;
- ageing programme accomplishment for SSCE.

3.3.2.B Ventilation systems

The following ventilation/air conditioning systems were provided for the reactor building:

- The ventilation/air conditioning installation related to the reactor hall, CV1;
- The mechanical ventilation installation related to the solid radioactive waste storage and purification installation, CV2;
- The air ventilation system related to the radioactive liquid waste storage, CV3;

- The ventilation/air conditioning installation related to the control room and the server room;
- The ventilation installation related to the laboratories, CV5;
- The air ventilation system related to the storage room, CV6.

Taking into account the nuclear safety conditions, the design of the ventilation/air conditioning system took into account:

- grouping of rooms according to nuclear zoning;
- ensuring the circulation of air, within the same ventilation system, from the rooms with a lower risk of contamination to the rooms with a higher risk of contamination by ensuring the negative pressure in the rooms, depending on the nuclear zoning, thus avoiding the leakage of contaminated air from rooms to outside;
- ensuring air evacuation through active charcoal filters in the event of an accident in the reactor hall;
- ensuring the automatic switching of the ventilation system of the reactor hall from normal mode to emergency mode;
- ensuring the automatic switching from the equipment in operation to the spare equipment, in case of failure of the equipment in operation;

the adoption of open circuit schemes in order to avoid the recirculation of contaminated air.

The following technological requirements were also considered:

- ensuring optimal temperature and humidity in the reactor hall;
- removal of excess heat from technological equipment, in order to ensure the operating conditions of technological installations and equipment

Thus, ventilation schemes were adopted for:

- the reactor hall, the irradiation capsule room, the heat exchanger room;
- the radioactive waste storage circuit.

The project was drawn up in accordance with the provisions of the nuclear safety regulations in force.

The ventilation installation attains negative pressure in:

- reactor hall;
- neutron experiments;
- neutronography laboratory;
- irradiation capsule room;
- heat exchanger room.

3.3.2.1.B Ventilation system design: segregation and isolation provisions (as applicable)

The air conditioning installation related to the CV1 reactor hall was designed to ensure the requirements imposed by the the nuclear safety regulations in force in 1975.

The system meets the following requirements:

- ensures adequate air flows in all accessible areas in the reactor building, in order to maintain air parameters within normal limits;
- maintains the pressure in the reactor hall at a slightly lower level compared to atmospheric pressure to prevent the release of air through the enclosures of airlocks or other leaks;
- ensures air distribution and maintain a pressure balance in accessible areas so that any air transfer is made from areas with clean air to areas with potentially contaminated air;
- in the normal operating regime, the flow of air circulated in the reactor hall is high enough to ensure an air exchange rate of 1-2 reactor hall air volumes per hour;
- automatic switching of the CV1 ventilation system from any operating mode to emergency mode, when it receives the command from the dosimetry system;
- automatically stops the ventilation installations in case of fire with the isolation of the hall piping through the isolation dampers;
- automatically switches the redundant equipment when the one in service has stopped due to a technical failure;
- the emergency line is electrically powered class II;
- the materials from which the installation components are made are chemically and mechanically resistant and easy to decontaminate;
- the control-command system is electrically powered class I;
- the construction of the ventilation chimney ensures homogeneous dispersion of the air forced towards atmospheric currents;
- maintain air temperature in the reactor hall;
- maintain air humidity in the reactor hall;
- air filtration is carried out by high-efficiency HEPA 13 filters, intended for use in the nuclear field; the filters are mounted in sealed devices (caissons), provided with upstream and downstream isolation flaps; easy access to all system equipment is ensured so that periodic tests can be performed without the risk of contamination;
- the control room is protected from the reactor hall by the air tight doors. In the room, an overpressure is created compared to the reactor hall.

The ventilation system is a support system, safety-related, which ensures the supply of filtered and conditioned air in terms of humidity and temperature in the technological rooms of the reactor. The system is also provided with a nuclear safety emergency component, to limit the consequences of a radiological accident inside the reactor building by retaining the fission products and the controlled evacuation of the effluents into the environment.

3.3.2.2.B Performance and management requirements under fire conditions

The air conditioning circuit CV1 has three 3 operating regimes, necessary to ensure the operation of the reactor in maximum safety conditions and is composed of:

Normal/economy regime (Steps 1+2+3)

Step 1

- 2 centrifugal fans (redundant) for introducing air into the reactor hall,

Step 2

- 2 centrifugal air suction fans (redundant) from the reactor hall
- dry material filters for coarse filtering of the sucked air, mounted in CV1, made up of panels in which 16 filter elements with bags are mounted
- absolute filters for filtering the exhaust air from the reactor hall, the neutron experiments room, the neutronography laboratory, consisting of HEPA13 filter elements and F7 corrugated filter elements
- air-air heat exchanger;
- air heating/cooling batteries from the air conditioning units;
- air preheating batteries,
- silencers;
- air flow regulation flaps with electric actuation;
- shutter type flaps (dampers) with manual actuation from the control room;
- shutter type flaps (dampers) with electric actuation;
- humidifier;
- chiller - water cooling unit for supplying the air conditioning aggregates, mounted on the reactor building terrace;

Step 3

- centrifugal air suction fans from technological spaces
- caisson-type absolute filters for filtering the air after leaving the technological spaces, consisting of HEPA13 filter elements and F7 filter elements, mounted in CV1.

Emergency regime (Steps 1+4)

The radiological parameters in the reactor hall (gamma radiation, aerosols and radioactive iodine) are continuously monitored by the reactor dosimetry system. In the event of reaching the threshold values, the dosimetry system goes into alarm and automatically sends the command to operate in emergency mode to the ventilation system. The ventilation system automatically switches to emergency mode composed of ventilation stages 1 and 4.

Step 1 - centrifugal fans for introducing air into the reactor hall,

Step 4:

- centrifugal fans for air intake from the reactor hall and chimney exhaust,
- bunker with active charcoal filters composed of three shelters with active charcoal for the retention of radioactive iodine with an efficiency of 99.99%;
- caisson-type absolute filters for air filtration, consisting of HEPA13 filter elements and F7 filter elements, mounted in CV1.

3.3.2.3.B System configurations for different operating states

a) Off state: In this state, all ventilation stages 1, 2, 3 are stopped and the technological spaces are not ventilated except for the reactor hall which is ventilated by the emergency ventilation (stage 4). The limits and conditions for operation of the reactor require that the ventilation system of the reactor hall has not be completely stopped for a period of more than three hours, and during this shutdown period the reactor hall must be ventilated in emergency regime.

b) Normal regime: In this state, all ventilation steps 1, 2, 3 are turned on at normal fan ventilation speed and the technological rooms are ventilated at maximum flow. The fresh air is sucked in CV1 through the air intake located above the 0.4 KV electrical station and led into the ventilation plant, through a concrete channel. The air is initially filtered by the dry material filter, preheated (if necessary) by the preheating battery then passed through the heat exchanger and filtered again before entering in the air conditioning unit. From these aggregates, the air is introduced in a distributed manner into the reactor hall, in the neutron experiments room and the neutronography laboratory. The flow rate of fresh air introduced into the reactor hall ensures the ventilation of the reactor hall with two exchanges of air volumes per hour.

From the reactor hall, the air is sucked in by the 2-nd ventilation stage, with a slightly higher flow rate than the input, so that a depression is attained. This stage consists of the two fans, mounted in CV1, that expel the air in the irradiation devices room, the heat exchangers room and the rooms of the CV1 circuit.

The last stage of the normal ventilation system -stage 3 -consisting of centrifugal fans mounted in CV7 sucks the air from the irradiation devices room, the heat exchanger room, the CV1 circuit rooms, the neutron experiments and the laboratory of neutronography room and evacuates it to the exhaust pipe through the absolute caisson filters. With the help of the adjustment flaps related to each fan, the air flow rate discharged from the building is controlled.

The air conditioning circuit CV1 related to the reactor hall has to maintain the air quality parameters at the set values. These parameters are temperature, negative pressure and humidity. Maintaining these parameters within the set limits is achieved automatically.

The ventilation system related to the main building of the reactor stops in case of fire, to prevent the spread of smoke and fire and to increase passive fire protection.

3.4.B Licensee’s experience of the implementation of the fire protection concept

Since the construction stage, the emergency, prevention and protection unit from INR Pitesti was provided with adequate specific tools and equipments (fire vehicle, portable fire extinguishers, breathing devices, protective suits, etc.); also there are available alternative routes for evacuation of goods and personnel, hydrants inside and outside the reactor building, water supplies, fire detection and alarm units,

Emergency, prevention and protection unit personnel is trained and licensed for emergency situations and take part in firefighting drills and contests organised by Emergency Situations Inspectorate. Emergency situation drills are planned and performed on-site every year.

In over 40 years of existence, the research institute has not experienced a single fire event.

Improvements have been implemented based on the recommendations of the INSARR mission received in 2013.

3.5. B Regulator's assessment of the fire protection concept and conclusions

No major findings in the area of fire protection have been identified from the regulatory reviews and inspections up to date. The general arrangements for fire protection implemented in the Nuclear Research Institute in Pitesti are considered satisfactory.

3.6.B Conclusions on the adequacy of the fire protection concept and its implementation

The implementation of the fire protection concept is considered acceptable. In order to prevent fires, procedures are established to control and minimize the amount of combustible materials and minimize the potential ignition sources that may affect SSC important to safety.

In order to ensure the operability of the fire protection measures, procedures are established and implemented. These include inspection, maintenance and testing of fire barriers, fire detection and extinguishing systems.

The operation, verification, maintenance of the reactor and related systems is based on a set of procedures approved by the regulatory body.

The fixed and mobile means of extinguishing fires are properly placed in the reactor building. Both inside and outside there is a network of fire hydrants for water supply.

The ventilation system in the area affected by the fire is also interrupted to reduce the oxygen level and the affected installations are stopped/de-energized.

For the limitation, isolation and extinguishing of fires, the personnel will intervene with the portable extinguishing means provided (in the early phase) or with the mobile intervention device (firefighters of the research institute) which will ensure the protection of the intervention personnel at the workplaces, as well as limiting the spread of the fire until the arrival of the support forces from the Mioveni Fire Department and/or the Emergency Situations Inspectorate.

3.C Nuclear Fuel Manufacturing Plant

3.1.C Fire prevention

3.1.1.C Design considerations and preventions means

In the Nuclear Fuel Manufacturing Plant, the prention of fires and explosions involves:

- Specific design features of the nuclear fuel manufacturing facilities and equipment that minimize fire risks;
- Identification and control of the potential sources of ignition and control of fire load density by keeping thermal loads below the designed values;
- Instructions containing general and specific preventive rules for fire / explosion prevention activities. The procedures are periodically updated to take into account the legislative amendments and the operating experience;
- Training of the employees on fire prevention in accordance with the procedures (specific procedures on the training of the NFP personnel in the field of emergency situations that integrates the legislative and regulatory requirements, in force);
- Periodic inspections regarding the compliance with fire/explosion prevention requirements by plant employees according to the procedure for supervising compliance with requirements in the field of emergency situations;
- Implementation of measures to prevent fires/explosions (example: methane and hydrogen gas detection in Hall II – sintering operation, hydrogen detection in the electrolysis room, ventilation system in the battery charging room, lightning protection systems, respectively the arrangement of smoking areas);
- Detection systems for accidental explosive gas leaks (example: methane and hydrogen gas detection system in Hall II - sintering, hydrogen detection system in the electrolysis chamber, hydrogen detection system in the room for charging batteries);
- Ventilation systems to avoid creating an explosive atmosphere caused by flammable gases and flammable vapors (example: Hall II - Sintering, Electrolysis Chamber, Battery Charging Chamber, rooms of the Chemical Analysis Laboratory, in which flammable liquids are used);
- Lightning protection systems to avoid fires / explosions, due to lightning (example: hydrogen storage tanks, Hydrogen Production Station, manufacturing halls);
- Earthing installations for all constructions, installations and equipment in the plant;
- Equipment and components under anti-explosion construction, such as installations operating in potentially explosive atmospheres (example: hydrogen electrolysis plant);
- Lighting and electrical components under construction, such as potentially explosive atmospheres (example: Battery Charger Room, Hydrogen Electrolysis Chamber).

3.1.2.C Overview of arrangements for management and control of fire load and ignition sources

The fire load is controlled and kept lower than the maximum allowed load. A set of rules are applied in order to reduce the probability of fire initiation, as follows:

- Combustible materials are stored based on storage plans, taking into account the storage method, the quantities of stored materials and their compatibility, in adequate places; it is forbidden to store combustible materials (even temporarily) in inappropriate places,
- The combustible wastes are regularly discharged from buildings and site.

Periodic checks, electrical installation and maintenance, ensure the control of the ignition sources. The plant building has lightning protection and electrical grounding systems. The potentially explosive installations have equipotential bonding.

Qualified personnel authorized for performing fire work carry out and supervise works involving fire, in accordance with specific internal procedures and national applicable legislation.

In areas with risk of explosion (e.g. production, storage and use of hydrogen), appropriate equipment is provided (equipment classified as safe for use in such environments).

Qualified personnel of the licensee performs regular plant inspections in order to verify the compliance with the rules regarding the management of the fire load and the control of the ignition sources.

3.1.3.C Licensee's experience of the implementation of the fire prevention

3.1.3.1.C Overview of strengths and weaknesses

Prevention is the most important aspect of fire protection. In the Nuclear Fuel Manufacturing Plant, installations are designed to ensure the prevention of fire / explosion. If preventive measures cannot prevent the fire from occurring, measures are taken to limit its effects.

In order to achieve the two purposes of preventing and limiting the effects of fire, general and specific measures are taken, as follows:

- Separation of areas where non-radioactive hazardous materials are stored from process areas;
- Minimizing the thermal load in the individual rooms;
- Choice of materials for structures and partitioning walls, for penetrations and cables associated with structures, systems and components important for nuclear safety in accordance with the functional criteria and fire- resistance assessments;
- Partitioning of buildings and isolation of the ventilation ducts, in order to prevent the fire propagation;
- Limitation the number of possible sources of ignition, such as open flames, or electric sparks.

To ensure that the fire protection measures are implemented in a controlled, coordinated and effective manner in order to achieve fire protection objectives, the licensee developed and implemented a fire protection program (FPP).

Specific fire protection procedures, which incorporate legislative and regulatory requirements, ensure the efficiency, verification and rapid application of corrective measures in the event of abnormal situations. The licensee has specific measures for fire prevention, documented through specific internal procedures that integrate the applicable national and international requirements from legislation and regulation. Permanent updates of the procedures ensure the integration of the latest legislative and regulatory requirements, operational experience, and changes in the manufacturing process.

Specific measures for fire prevention are established and implemented in accordance with the applicable national legislation and international standards and guides, by specific internal procedures. The constant updating of the procedures ensures the introduction of the operating experience, legislative and/or manufacturing changes.

Fire intervention is gradually ensured, by rapid emergency response team of the licensee (own staff) and professional firefighters from both private (Emergency Service of the Nuclear Research Institute in Pitesti) and public service (County Inspectorate for Emergency Situations), respectively.

The licensee ensures proper-trained personnel to monitor fire hazards, storage of combustibles and ignition sources responsibilities. Training and annual exercises are conducted with the rapid intervention team (own staff) in order to practice the response to potential fires. Monthly joint exercises between the licensee’s emergency response team and external fire intervention organizations, the private Emergency Service of Nuclear Research Institute in Pitesti and the public fire intervention service, the County Inspectorate for Emergency Situations, verify the efficiency of the procedures and fire intervention plans.

Weaknesses identified from drills and exercises, findings from inspections, audits and independent oversight assessments are regarded as opportunities for improvement and actions are implemented to strengthen fire protection systems, procedures and practices.

3.1.3.2.C Lessons learned from events, reviews fire safety related missions, etc.

After the IAEA SEDO mission of 2011, the licensee has made numerous improvements to prevent and protect against fires, as follows:

- Development of procedures for general housekeeping and control of flammable/combustible materials, inspections and improvements of fire walls and fire separation, records associated with individual fire extinguishers and hydrants have been introduced to indicate the last testing and maintenance;
- Development and implementation of a Fire Protection Program that defines the management responsibilities, programme objectives, programme elements and controls in order to minimize the potential for fire, which could result in radiological and chemical health effects for workers, population and environment.

3.1.3.3.C Overview of actions and implementation status

The recommendations resulting from the fire risk identification and assessment analyses were implemented through specific fire prevention measures and actions such as:

- Separation of non-radioactive hazardous materials storage areas from fabrication processes areas, fire-resistant compartments, minimizing the thermal load in individual rooms and limiting or even eliminating possible sources of ignition;
- Structural materials, partitioning walls, penetrations and cables associated with structures, for systems and components important for nuclear safety, chosen in accordance with functional criteria and the results of the fire risk assessment;

- Maintaining clear the emergency response personnel access and exit routes for evacuation in case of fire;
- Completing/improving the fire detection and alarm system;
- Developing specific procedures that include specific instructions for fire protection and updating existing procedures to include the requirements set forth in current legislation and international standards, as well as procedures for operation in abnormal conditions that may generate fires and / or explosions.

3.1.4.C Regulator’s assessment of the fire prevention

CNCAN performs periodic inspections for verifying compliance with the regulatory provisions. No major issues have been identified with regard to the fire protection of the plant.

CNCAN is updating its specific nuclear safety regulation on fire protection and will extend its scope to cover all nuclear installations, including nuclear fuel manufacturing plants and more detailed inspections will be performed to ensure compliance with the new regulatory requirements.

3.2.C Active fire protection

3.2.1.C. Fire detection and alarm provisions

3.2.1.1. C Design approach

Fire hazard control and monitoring

Plant spaces are equipped with fire detection and alarm systems that include smoke detectors, fire alarm buttons and sirens, located throughout the buildings, connected to a main alarm panel, permanently monitored, indicating the exact location of the fire to facilitate the coordination of the evacuation process.

Fire detection, signaling and alarming systems include: Inteligent Addressable Control Panel equipment, fire detectors (optical smoke detectors, combined smoke/temperature detectors, aspiration smoke detectors, linear smoke detectors), manual alarm triggers, acoustic alarm devices, optical alarm signaling devices, input/output modules.

Fire prevention involves the limiting of combustibles materials and ignition sources throughout the facility, to reduce the likelihood of fires occurrence. The licensee also has detection systems of explosive gas accumulations (hydrogen, methane gas) in technological areas that use such gases, respectively: control and signaling equipment, hydrogen detectors and methane gas detectors.

3.2.1.2.C Types, main characteristics and performance expectations

The main characteristics and performance aspects identified in the Nuclear Fuel Manufacturing Plant include:

- Optimization of the suppression provisions to protect a variety of spaces ranging from machinery enclosures to computer server;

- Remote shutdown of the ventilation system in case of fire to ensure the shutdown in case it cannot be done from the local control panel (as a result of smoke/fire) or when quick shutdown is necessary to avoid the spread of smoke and fire;
- Training and instructions of the own personnel with the stipulations and provisions of fire intervention procedures and the Fire Intervention Plan that describes the method of intervention in case of fire and the location of fire extinguishing equipment;
- Gradually fire intervention with rapid intervention teams (own staff, professional firefighters from the private and public services)) and joint exercises with all fire intervention teams.

3.2.2.C Fire suppression provisions

Fire suppression involves the following features, activities to control, and extinguish fires:

Fire protection loop

Fire suppression provisions consist in fixed systems (e.g. Argon fire extinguishing system ensures fire protection of the Zy-4 compacting machine and an automatic Inergen Fire Suppression System protects the server room), portable fire extinguishers, indoor and outdoor hydrants, pipeline networks, water tank to provide water to fire fighter use.

Interior fire hydrants ensure the protection of each point with at least one jet of water having a flow rate of 2.5 l/s; the fire hydrants are equipped with three-position hoses and pipes for water discharge.

An annular network of firewater with seven external hydrants ensures the external extinguishing of building fires. An annular network of firewater with five external hydrants ensures the external extinguishing of fires at the General Warehouse of Goods / Materials.

Two tanks for drinking water supply, domestic water and firewater, with a capacity of 500 m^3 each, provide firewater storage. The intangible reserve of firewater is of 500 m^3.

Periodic maintenance of fire extinguishing equipment, carried out by specialized external contractors, prevent breakdowns and ensure safety and reliability of the fire suppression provisions, in accordance with the requirements provided by the national legislation in force.

Onsite Fire Brigade and own response team

Emergency response team (for fires) of the licensee (own staff) and professional firefighters of the Department for Emergency Situations of Nuclear Research Institute in Pitesti (private service based on a contract) ensure the fire intervention. The Emergency Service of Nuclear Research Institute is located at a distance of approximately 800 m from the Nuclear Fuel Manufacturing Plant site, being equipped with water-foam-powder-CO_2 firefighting vehicle.

The licensee conducts planned fire intervention drills that provide training and practical exercises to understand the facility layout and associated hazards.

Off-site Fire Brigade

Professional firefighters of the regional (county) Inspectorate for Emergency Situations - ISU Arges (public structure) ensure the fire intervention to support firefighting operations if needed.

The regional Inspectorate for Emergency Situations is located at a distance of approximately 3 km from the site of the plant.

3.2.3.C Administrative and organisational fire protection issues

3.2.3.1.C Overview of firefighting strategies, administrative arrangements and assurance

The activities related to fire protection are applied in accordance with national law and regulations, respectively Law no. 307/2006 on fire protection and CNCAN regulation NSN-09. The licensee has implemented technical and administrative fire and explosion prevention measures, fire detection and protection systems, emergency fire response plans and procedures and an annual fire response exercises program.

3.2.3.2.C Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

The licensee has the following firefighting capabilities:

- Portable fire extinguishers, internal and external hydrants, pipe networks;
- Internal hydrants that ensure the protection of each point with at least one jet of water with a flow rate of 2.5 l/s;
- Annular network of firewater with 12 external hydrants to provide the fire extinguishing from the outside;
- Two tanks with a capacity of 500 m^3 each provide the water reserve for the fire, 500 m^3 representing the intangible firewater reserve.

A specialized department, including fire protection trained and certified personnel, ensures the management of fire protection.

Licensee's personnel is periodically trained (monthly for operators and members of the intervention teams and quarterly or every 6 months for the rest of the employees, depending on their responsibilities), with the participation professional firefighters of the private contract based service and public service.

3.3.C Passive fire protection

3.3.1.C Prevention of fire spreading (barriers)

3.3.1.1.C Design approach

Passive protection isolates and limits the fire spreading and reduces the consequences of the fire. Measures taken to prevent the spread of fires include:

- Safety distances between buildings and installations;
- Fire-resistant walls, fire-resistant doors equipped with automatic closing system, fire dampers on the ventilation ducts when the ducts pass through the fire-resistant walls, fire-resistant materials used to seal wall gaps around cable ducts, etc., ensure the prevention of fire spreading;
- Specific internal procedures containing fire protection instructions as well as procedures for operation in abnormal conditions that may generate fires and / or explosions.

3.3.1.2.C Description of fire compartments and/or cells design and key features

Constructive elements to limit the spread of fire and smoke provide for the separation of rooms / spaces with high and very high risk of fire from other spaces with medium and low risk of fire, as:

- Archive and the Library from the Administrative Pavilion are separated from the building by using 6 hours fire-resistant walls and 2 hours fire-resistant doors, both of them being equipped with self-closing devices;
- Electrolysis Chamber in the Hydrogen Production Plant is separated from the neighboring spaces by *anti-Ex* walls;
- General Goods / materials Warehouse, Fuel Cell Warehouse and the Zy-4 Warehouse are separated by 4 hours fire-resistant walls (at least) and 2 hours fire-resistant door, equipped with self-closing device.

Fire-resistant elements, equipped with smoke evacuation devices, separate the spaces for the storage of combustible materials having an area more than 36 m^2 from the adjacent spaces. The most important such spaces are the Archive inside Administrative Pavilion, General Warehouse of Goods / Materials, Central Fuel Bundle Warehouse and New Nuclear Fuel Warehouse.

3.3.1.3.C Performance assurance through lifetime

A program for periodic inspections is implemented to verify the integrity of the passive fire protection measures.

3.3.2.C Ventilation systems

The ventilation system consists of ventilation units and the piping system. The rooms where the ventilation units are located are made of fire-resistant walls and doors. The pipes of the ventilation system pass through the fire-resistant walls, 90 minutes fire-resistant, air-dampers are provided, triggered by fuses with a trigger temperature of 73°C (for example: Hall IV, Chemical Analysis Laboratory).

A remote shutdown system of the ventilation system ensures the remote shutdown of the ventilation system in case of fire in the plant. The remote shutdown system ensures the shutdown of the ventilation system in case of fire, if it cannot be done from the local control panel (as a result of smoke/fire) or when rapid shutdown is required to avoid the spread of smoke and fire.

3.4.C Licensee’s experience of the implementation of the fire protection concept

For the Nuclear Fuel Manufacturing Plant, the implementation of the fire protection concept involves the application of the Defense-In-Depth (DID) concept, which supports the general safety objectives for the facility, being applied to all levels of the facility and associated administrative, organizational and operational safety activities, from establishing high-level fire safety objectives to the detailed procedures and equipment required to meet the objectives of fire safety.

The objective of DID is to support timely detection and control of fire and limit or mitigate the consequences of a fire. For the Nuclear Fuel Manufacturing Plant, DID is achieved through a combination of physical barriers, safety distances, fire detection and extinguishing systems, management of fire protection (operational procedures), periodic verification and preventive maintenance, quality assurance and emergency arrangements.

The Fire Protection Program (FPP) ensures the fulfilment of the levels of the DID as following:

- Level 1 - Fire prevention by:
    - Operational procedures;
    - Training and instruction;
    - Periodic verification and preventive maintenance of structures, systems, components and equipment associated with the nuclear fuel manufacturing processes;
    - Appropriate equipment (equipment classified as safe for use) for areas with risk of explosion (e.g. production, storage and use of hydrogen);
    - Systems to ensure the lower explosive level (LEL) in specific areas (battery charging room is provided with a system for hydrogen sulfide extraction);
    - Lightning arrester provisions.
- Level 2 - Detection, suppression and extinguishing of fire through:
    - Fire detection and alarm systems;
    - Fire intervention through specialized teams and fire trucks.
    - Procedures for intervention in emergency situations, in accordance with the legal provisions in force;
    - Alarm drills / evacuation / fire-fighting, practical demonstrations;
    - Fire evacuation plans;
    - Technical means for prevention and extinguishing fires (fire hydrants and extinguishers, fire-fighting facilities, accessories and other means of fire protection).
    - Fire extinguishing systems.
- Level 3 - Minimizing the consequences of fire by:
    - Fire resistant compartments (walls, doors) to limit the spread of fire and fire penetration;
    - Safety distances between buildings and equipment;
    - Ventilation systems separated for the different fabrication processes, equipped with fire dampers on the piping, to limit the spread of smoke and fire penetration.

3.5.C Regulator's assessment of the fire protection concept and conclusions

No major findings in the area of fire protection have been identified from the regulatory reviews and inspections up to date. The general arrangements for fire protection implemented in the Nuclear Fuel Manufacturing Plant in Pitesti are considered satisfactory.

As the PSR is ongoing and activities have been initiated to perform a FHA, it is expected that improvement opportunities will be identified. The PSR and FHA will be subject to regulatory review.

3.6.C Conclusions on the adequacy of the fire protection concept and its implementation

The level of fire protection implemented in the Nuclear Fuel Manufacturing Plant in Pitesti is generally considered adequate, the fire protection activity being consistent with the applicable legislative requirements in force.

The licensee has technical and administrative measures to prevent fires and explosions, adequate fire detection and protection systems, has emergency fire response plans and procedures and maintains an annual fire response program. Also, the licensee demonstrates permanent concern for fire protection activities, including the prompt resolution of findings resulting from its own audit and oversight activities and from the inspections performed by the national authorities.

3D Cernavoda Intermediate Dry Spent Fuel Storage Facility

3.1.D Fire prevention

3.1.1.D Design considerations and preventions means

All the materials used in the construction of the dry spent fuel storage facility are not combustible.

3.1.2.D Overview of arrangements for management and control of fire load and ignition sources

The main arrangements for fire prevention are the same that are applicable to all the installations on the site of Cernavoda NPP.

3.1.3D Licensee's experience of the implementation of the fire prevention

No particular problems have been encountered in the fire prevention of this type of facility.

3.1.4.D Regulator's assessment of the fire prevention

Based on the regulatory review and inspections performed up to date, the fire prevention for the Cernavoda Intermediate Dry Spent Fuel Storage Facility is considered adequate.

3.2.D Active fire protection

3.2.1.D Fire detection and alarm provisions

Fire detection provisions have not been considered necessary for the dry spent fuel storage facility. Fire detectors are installed only in the administrative building in the vicinity of the dry spent fuel storage. Alarm buttons are installed in the administrative building and alarms are displayed in the Main Control Room of the Unit 1 of the NPP.

3.2.2.D Fire suppression provisions

No automatic fire suppression systems are installed the dry spent fuel storage facility for the storage modules.

3.2.3.D Administrative and organisational fire protection issues

The applicable administrative and organisational fire protection issues are the same for all nuclear installations and facilities on the Cernavoda NPP site.

Within the Cernavoda NPP Special Fire Department, a sufficient number of military firefighters personnel are active, working on shifts and having available fire trucks and CBRN trucks. The same firefighting personnel, as described in the section 3.2.3.2.A, is responsible for the response to a fire event that may occur on any of the installations and facilities on the Cernavoda NPP site.

3.3.D Passive fire protection

Passive fire protection is ensured by the design of the facility. All the materials used in the construction of the dry spent fuel storage facility are not combustible.

Natural ventilation has been considered sufficient for this facility, based on design and operational specific aspects, therefore there is no engineered ventilation system installed.

A set of air inlets and outlets, laid as a labyrinth to reduce radiation streams, provides a path so that the cooling air, driven by its natural buoyancy, enters at the bottom air inlets and exits at the top air outlets. The air circuit is designed for redundancy and diversity, as several interconnected openings on the both sides of the module are available to maintain adequate cooling even if some air paths would be blocked.

3.4.D Licensee’s experience of the implementation of the fire protection concept

No particular problems have been encountered in the fire protection for this type of facility.

3.5.D Regulator’s assessment of the fire protection concept and conclusions

Based on the regulatory reviews and inspections performed so far, CNCAN is satisfied with the adequacy of the licensees’ fire protection programs and with their overall implementation. No major issues have been identified.

3.6.D Conclusions on the adequacy of the fire protection concept and its implementation

No major findings in the area of fire protection have been identified from the regulatory reviews and inspections up to date. The general arrangements for fire protection implemented by the licensee are considered adequate.

3.E Cernavoda Solid Radioactive Waste Interim Storage Facility

The fire protection measures implemented for the general waste storage are:

- passive protection measures, namely the protection of the metal structure of the storage, with a layer of intumescent paint, which ensures a minimum limit of fire resistance for 30 minutes;
- installation of a fire detection and alarm system, consisting of 15 detectors, placed above the barrel stack and an alarm circuit connected to the Main Control Room of the Unit 1 of the NPP; also, alarm buttons and sirens are installed in the storage facility;
- a ring of external hydrants for fire water;
- fire fighting equipment, including portable fire extinguishers.

3.1.E Fire prevention

The storage of filter cartridges (structure no. 2) and the cellular storage (structure no. 3) are classified in category of low hazard of fire and do not include specific fire protection measures.

As regards the structure no. 1, which is a concrete building warehouse in which are located stainless steel drums of 220L, containing compactable and noncompactable solid radioactive waste, some of the general waste (paper, textiles, plastics, rubber, wood, etc.) are combustible materials, so that special measures were taken for the general waste deposit, for the prevention, detection and extinguishing of fires. The most important measure to prevent an extensive fire is the containerization of waste in closed metal barrels with lids and gaskets.

The fire resistance tests of barrels with combustible waste demonstrated that a fire at the exterior of the barrels determines only the partial carbonization of the contents of the barrels directly exposed to the external flame and the fire does not spread to other barrels.

3.1.1.E Design considerations and preventions means

The most important measure to prevent an extensive fire is the containerization of waste in fire resistant closed metal barrels with lids and gaskets.

3.1.2.E Overview of arrangements for management and control of fire load and ignition sources

The main arrangements are the same that are applicable to all the installations on the site of Cernavoda NPP:

- Rigorous assessment and planning of the work, which includes risk assment, work authorization and supervision. Strict policies and requirements are applied to fire works, in order to prevent such works from causing fires.
- Assurance of the availability and operability of the passive and active fire protection measures, in accordance with the design intent and requirements.
- Adequate training and qualification of the personnel, to ensure that the fire protection rules and measures are properly understood and implemented.

3.1.3E Licensee's experience of the implementation of the fire prevention

The licensee has continuously improved fire prevention, using inpus from operating experience and from internal and external inspections, audits and review missions.

3.1.3.1.E Overview of strengths and weaknesses

The strengths and weaknesses identified ar the same as listed in section 3.1.3.1.A, as those apply to all the nuclear installations and facilities on the Cernavoda NPP site.

3.1.3.2.E Lessons learned from events, reviews fire safety related missions, etc.

Several improvements have been implemented in the area of fire work preparation and authorization, applicable for all the the nuclear installations and facilities on the Cernavoda NPP site.

3.1.3.3.E Overview of actions and implementation status

Opportunities for improvement are identified on a current basis, taking into account the internal and external operating experience and the performance of the emergency drills and exercises. Based on these opportunities for improvement, the licensee devises improvement actions and implementation plans. These are also subject to the periodic regulatory review.

3.1.4.E Regulator's assessment of the fire prevention

Based on the regulatory review and inspections performed up to date, the fire prevention for the Cernavoda Solid Radioactive Waste Interim Storage Facility is considered adequate.

3.2.E Active fire protection

3.2.1.E Fire detection and alarm provisions

The facility has a fire detection and alarm system, consisting of 15 detectors, placed above the barrel stack and an alarm circuit connected to the Main Control Room of the Unit 1 of the NPP; also, alarm buttons and sirens are installed in the storage facility.

3.2.2.D Fire suppression provisions

Fire suppression means and equipment for this facilty consist of:

- a ring of external hydrants for fire water;
- fire fighting equipment, including portable fire extinguishers.

3.2.3.D Administrative and organisational fire protection issues

The applicable administrative and organisational fire protection issues are the same for all nuclear installations and facilities on the Cernavoda NPP site.

Within the Cernavoda NPP Special Fire Department, a sufficient number of military firefighters personnel are active, working on shifts and having available fire trucks and CBRN trucks. The same firefighting personnel, as described in the section 3.2.3.2.A, is responsible for the response to a fire event that may occur on any of the installations and facilities on the Cernavoda NPP site.

3.3.E Passive fire protection

3.3.1.E Prevention of fire spreading

Prevention of fire spreading is ensured through the use of fire resistant barrels for the storage of the radioactive waste and through the protection of the metal structure of the storage with a layer of intumescent paint.

3.3.2.E Ventilation systems

Natural ventilation has been considered sufficient for this facility, based on design and operational specific aspects, therefore there is no engineered ventilation system installed.

3.4.E Licensee's experience of the implementation of the fire protection concept

As for all the facilities and installations on the Cernavoda NPP site, the licensee has implemented the concept of defence-in-depth also for fire protection. There has been no significant problems in the implementation of fire protection measures for the Cernavoda Solid Radioactive Waste Interim Storage Facility.

3.5.E Regulator's assessment of the fire protection concept and conclusions

Based on the regulatory reviews and inspections performed so far, CNCAN is satisfied with the adequacy of the licensees' fire protection programs and with their overall implementation. No major issues have been identified.

3.6.E Conclusions on the adequacy of the fire protection concept and its implementation

No major findings in the area of fire protection have been identified from the regulatory reviews and inspections up to date. The general arrangements for fire protection implemented by the licensee are considered adequate.

4. OVERALL ASSESSMENT AND GENERAL CONCLUSIONS

The performance of the licensees in the area of fire protection has been found adequate. Nevertheless, several opportunities for improvement have been identified, which will be included in the national action plan.

Improvements to the regulatory requirements and oversight processes have been also identied and will be included in the national action plan.

One of the actions identified is already in progress and relates to the revision of the nuclear safety regulations on fire protection.

5. REFERENCES

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LIST OF ACRONYMS

CANDU - Canadian Deuterium Uranium Reactor

CNCAN - National Commission for Nuclear Activities Control

CSA – Canadian Standards Association

DBF – Design Basis Fire

EOOS – Equipment our of Service

EPRI – Electric Power Research Institute

ENSREG – European Nuclear Safety Regulators Group

FHA – Fire Hazard Analysis

FSAR - Final Safety Analysis Report

FSSA – Fire Safe Shutdown Analysis

IAEA - International Atomic Energy Agency

ISO – International Organization for Standardization

NMC - Norms on Quality Management

NPP - Nuclear Power Plant

NSRB – Nuclear Safety Review Board

OSART - Operational Safety Review Team

PM – Preventive Maintenance

PHT – Primary Heat Transport (System)

PHWR - Pressurised Heavy Water Reactor

PSA - Probabilistic Safety Assessment

PSR - Periodic Safety Review

QMS - Quality Management System

RATEN - Technologies for Nuclear Energy State Owned Company

RATEN - CITON - Centre of Technology and Engineering for Nuclear Projects

RATEN - ICN – Institute for Nuclear Research

RB – Reactor Building

SDG – Standby Diesel Generators

SNN - National Company “NUCLEARELECTRICA”

SSC – Systems, Structures and Components

SSCE - Systems, Structures and Components and Equipment

TPR – Topical Peer Review

TRIGA - Training, Research, Isotopes, General Atomics

WANO - World Association of Nuclear Operators

WENRA - Western European Nuclear Regulators Association