EU TOPICAL PEER REVIEW 2023
FIRE SAFETY

NATIONAL REPORT REPUBLIC OF BULGARIA

NUCLEAR REGULATORY AGENCY
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Table of Contents

0. INTRODUCTION

According to the provisions of Council Directive 2014/87/Euratom of July 8, 2014, amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations (hereinafter the Nuclear Safety Directive), member states should undertake, on a coordinated basis, topical peer reviews (TPRs) at least every 6 years, with the first starting in 2017.

For each review the directive requires the following:

(a) a national assessment is performed, based on a specific topic related to nuclear safety of the relevant nuclear installations on their territory,

(b) all other member states, and the Commission as observer, are invited to peer review the national assessment referred to in point (a),

(c) appropriate follow-up measures are taken of relevant findings resulting from the peer review process,

(d) relevant reports are published on the above-mentioned process and its main outcome when results are available.

The member states, acting through the European Nuclear Safety Regulators Group (ENSREG), have decided that the topic for the second TPR is fire protection.

The structure and content of the National Report of the Republic of Bulgaria on the assessment of fire protection of nuclear installations corresponds to the WENRA Technical Specification for the National Assessment Reports [1].

All nuclear installations that are within the scope of the Directive are included in the National Report as "candidates". There are no installations "excluded" from consideration in the National Report.

The selection of the installations was carried out in accordance with the recommendations given in Appendix 4 to the Technical Specification [1] and includes the following candidate installations presented in the individual groups as follows:

- Power units in operation - unit 5 of the Kozloduy NPP was selected, unit 6 is represented;
- Power units in the process of decommissioning - unit 4 of the Kozloduy NPP was selected, units 1, 2 and 3 are represented;
- Wet storage facility for Spent Nuclear Fuel (SNF) at the Kozloduy NPP site - included in the report;
- Dry storage facility for SNF - included in the report;
- Storage facility for conditioned radioactive waste (RAW) at the Kozloduy NPP site - included in the report.

For the purposes of the second peer review, the National Report consistently presents:

- National fire safety requirements and guidelines, safety objectives and how the principle of defence in depth has been applied in relation to fire safety in nuclear installations.
- The fire safety analysis performed for the selected nuclear installations and facilities.
- The fire protection concept of the installations in the scope of the second peer review and its implementation, including the different aspects of defence in depth for fire safety: fire prevention, active fire protection and passive fire protection.

The national report also presents the overall assessment and general conclusions resulting from the topical review carried out at a national level, including the conclusions on the adequacy of the licensees' overall approach to fire safety.

1. GENERAL INFORMATION

1.1. Nuclear installations identification

1.1.1. Qualifying nuclear installations

In accordance with Article 2 of the Nuclear Safety Directive, the Directive applies to all civil nuclear installations for which a license is required. According to Article 3, item 1, a nuclear installation means:

“a) nuclear power plant, enrichment plant, nuclear fuel manufacturing plant, reprocessing facility, research reactor, spent fuel storage facility; and

b) radioactive waste storage facilities that are located on the same site and are directly connected to the nuclear installations listed in letter a).“

In this sense, the scope of the Directive includes the following qualifying nuclear installations on the territory of the Republic of Bulgaria:

- 2 power units in operation – units 5 and 6 of Kozloduy NPP;
- 4 power units under decommissioning – units 1 to 4 of Kozloduy NPP;
- 2 SNF storage facilities at the Kozloduy NPP site with different storage technologies;
- 1 conditioned RAW storage facility at the Kozloduy NPP site.

1.1.2. National Selection of the facilities for the TPR II and justification

The selection of the installations was carried out in accordance with the recommendations given in Appendix 4 to the Technical Specification [1] and includes the following candidate installations presented in the individual groups as follows:

- Power units in operation - unit 5 of the Kozloduy NPP was selected, unit 6 is represented;
- Power units under decommissioning - unit 4 of the Kozloduy NPP was selected, units 1, 2, and 3 are represented;
- Wet storage facility for SNF at the Kozloduy NPP site (pool-type) - included in the report;
- Dry storage facility for SNF - included in the report;
- Storage facility for conditioned RAW at the Kozloduy NPP site - included in the report.

All nuclear installations that are within the scope of the Directive are included in the National Report as "candidates". There are no installations "excluded" from the National Report. More information on the selection process and rationale for the selection of installations for the national report is presented in Annex 1 to the report.

Although unit 6 of the Kozloduy NPP is listed above as "represented", the report includes information on its systems and equipment, and on the measures implemented to improve fire safety. This is because the two units share many of the resources in the field of fire protection as well as due to the fact that the majority of analyses and modifications are carried out for both units.

The nuclear power plant "Kozloduy" is located in northwest Bulgaria, on the right bank of the Danube River near the town of Kozloduy. It is located in a straight line 120 km

and by road 200 km from the city of Sofia. The approximate geographical coordinates of the site are: 43º 44' 48.4" north latitude and 23º 46' 9.2" east longitude (coordinates of the center of the preventive protection zone). A zone with a radius of 30 km around the site includes municipalities with centers: Kozloduy, Valchedrum, Hairedin, Mizia (entirely) and Lom, Byala Slatina, Oryahovo (partially). The 30-kilometer zone of the site also includes a sparsely populated part of the territory of Romania - 12 villages.

The country's nuclear power is concentrated at the Kozloduy NPP site, where six nuclear units, a RAW storage facility, a RAW processing facility, a conditioned RAW storage facility and two SNF storage facilities (SNF) – using dry and under water methods are located. The area of the entire site is about 3.2 km^2, and together with the channels for cooling and service water supply, a bank pumping station, and the open switch yard, as well as auxiliary facilities, it reaches 5.2 km^2.

"Kozloduy NPP" EAD is a joint-stock company with its registered office and management address: Kozloduy 3321, Kozloduy municipality and is the licensee of the following facilities included in the report:

- power units in operation – units 5 and 6 of Kozloduy NPP;
- SNF storage at the Kozloduy NPP site with underwater storage technology;
- repository for dry storage of SNF.

The subject of activity of "Kozloduy NPP" EAD includes the use of nuclear energy for production of electricity. This activity is carried out under the conditions of valid licenses for the operation of nuclear facilities and a license to produce electricity and thermal energy, issued respectively by the Nuclear Regulatory Agency (NRA) and the Energy and Water Regulatory Commission.

State Enterprise "Radioactive Waste" (SE RAW) is a legal entity within the meaning of Art. 62, para. 3 of the Commercial Law, established based on Art. 78, para. 1 of the Act on the Safe Use of Nuclear Energy, with headquarters in Sofia and specialized divisions in the country. SE RAW is the licensee of the following facilities included in the report:

- power units 1-4 of Kozloduy NPP under decommissioning;
- repository for storage of conditioned RAW at the Kozloduy NPP site.

The subject of the activity of SE RAW is:

- radioactive waste management, which includes all activities related to the handling, pre-treatment, processing, conditioning, storage and/or disposal of radioactive waste, including the decommissioning of a radioactive waste management facility;
- construction, operation, rehabilitation and reconstruction of radioactive waste management facilities;
- carrying out the transportation of radioactive waste outside the site of the relevant nuclear facility;
- decommissioning of nuclear facilities.

The nuclear facilities at the site use common shared resources - power supply, external fire ring, professional fire brigade at the site, etc. More details on the use of shared resources are presented in Section 3 of this report.

In the immediate vicinity of the Kozloduy NPP site, at a distance of at least 6.7 km, there is a main gas pipeline with the following characteristics: pipe diameter DN1400 and

working pressure 9.8MPa. The consequences of possible accidents of the gas pipeline have been assessed.

1.1.3. Key parameters per installation

1.1.3.1. Kozloduy NPP units 1-4

Kozloduy NPP units 1-4 with reactors VVER-440 were shut down in 2002 (units 1 and 2) and in 2006 (units 3 and 4). By Decision of the Council of Ministers No. 839 of December 20, 2008, for units 1 and 2 of the Kozloduy NPP and No. 1038 of December 19, 2012, for units 3 and 4 of the Kozloduy NPP, they were declared as facilities for management of radioactive waste.

According to the licenses of SE RAW issued in 2014 and 2016, these units are nuclear facilities for decommissioning. The decommissioning activities are carried out by the SE RAW Specialized Division Decommissioning of Kozloduy units 1-4 (SDD Kozloduy 1-4). The low- and medium-level waste of category 2a generated by the decommissioning activities is handed over for subsequent management to the Specialized Division Radioactive Waste – Kozloduy (SDRAW Kozloduy) at SE RAW.

Solid radioactive waste is generated as a result of the maintenance and repair of the units and of the planned dismantling related to the decommissioning of the units. They represent parts of dismantled equipment, fittings, filters, tools, special clothing for work in the controlled area, construction waste, etc. Solid radioactive waste, depending on its characteristics, is directed to the plasma incineration system, to the Size Reduction and Decontamination Workshop or to SDRAW Kozloduy.

Liquid radioactive waste is aqueous solutions, suspensions, concentrates, oils generated during the operation of units 1÷4, as well as radioactive waste generated during decommissioning. Part of this waste is transported and processed in SDRAW Kozloduy. Others are stored in tanks designated for the purpose of the Special Radwaste Storage Building – (SRSB-2), and some of them are processed by the Contaminated Water Treatment System.

Storage facilities for liquid RAW

The storage facilities for liquid RAW are stainless steel tanks, each located in a separate room of reinforced concrete, which are located in a building with a reinforced concrete structure, a separate part of SRSB-2. They consist of:

- Storage for liquid radioactive concentrate - 5 tanks with a total net volume of 2500 m^3;
- Storage for spent sorbents - 4 tanks with a total net volume of 1440 m^3.

These storages are not considered separately in the report as they are part of the unit's fire protection concept.

The decommissioning activities of unit 4 of NPP Kozloduy according to the license include:

- decontamination of the Systems, Structures and Components (SSCs);
- dismantling of SSCs;
- management of decommissioning materials;
- management of radioactive materials from decommissioning;

- management of the nuclear power plant site, as well as activities supporting the main activities.

There is no nuclear fuel for storage on the territory of unit 4 as well as on the territory of units 1-3. The planned date for completion of the decommissioning activities is 2030 and the planned final state is brown field.

Compliance with the fire protection requirements and criteria for a fire-safe condition applies to all premises, facilities, and places in which unit 4 electrical equipment, auxiliary and common systems are located in the turbine building (TB) and the controlled area.

1.1.3.2. Kozloduy NPP units 5 and 6

Units 5 and 6 of the Kozloduy NPP are pressurized water reactors type VVER-1000 model V-320, located in a hermetic protective reinforced concrete structure. In 2017 and 2019, respectively, the Nuclear Regulatory Agency (NRA) renewed the licenses for the operation of the units for a period of 10 years. Units 5 and 6 operate at an increased level of thermal output - 104% (3120 MW) from 2019 and 2018 respectively.

The key characteristics of units 5 and 6 are presented in Table **1.**

Table 1. Key characteristics of Kozloduy NPP units 5 and 6

Item	Unit 5	Unit 6
Licensee	"Kozloduy NPP" EAD	"Kozloduy NPP" EAD
Reactor type	VVER-1000, model V-320	VVER-1000, model V-320
Thermal power	3120	3120
Electrical power (net)	1100	1100
Year of commissioning	1987	1991
Planned decommissioning date	none	none

The system for temporary storage of spent fuel under water in the reactor pools is located in the containment of units 5 and 6. It is a set of systems, devices and facilities intended for carrying out the transport and technological operations, control, storage and cooling of spent nuclear fuel that includes:

- Refuelling and storage pool;
- Equipment for fuel transport and handling;
- Cooling system.

The refuelling pool is designed to perform the loading and unloading operations of the fuel assemblies in the reactor core and for operations with the reactor internals.

The main specific risks that arose as a result of a fire in SSCs are related to personnel exposure, release of harmful emissions into the environment and loss of integrity of building structures, which have been analysed and evaluated in the Safety Analysis Report (SAR).

The temporary storage of RAW generated during the operation of units 5 and 6 of the Kozloduy NPP is carried out in temporary storage facilities, which are part of the units' design. These storages are not considered separately in the report as they are part of the units' fire protection concept.

Solid RAW storage facilities

The design storage facilities for solid RAW are bunker-type with an upper service hatch and are located in a building with a reinforced concrete structure, a separate part of SRSB-3.

They consist of:

- Repository for low-level solid waste - 18 units with a total net volume of 3,2486 m^3;
- Storage for intermediate-level solid waste - 3 bunker-type cells with a geometric volume of 213 m^3.

Liquid RAW storage facilities

The design storage facilities for liquid RAW are stainless steel tanks, each located in a separate reinforced concrete room, which are located in a building with a reinforced concrete structure, a separate part of SRSB-3. They consist of:

- Storage for liquid radioactive concentrate - 7 tanks with a total net volume of 3600 m^3;
- Storage for spent sorbents - 2 tanks with a net volume of 200 m^3 each.

1.1.3.3. Wet SNF storage facility

On the site of the Kozloduy NPP there is a pool-type spent fuel storage facility (PSFSF) for under water storage of spent nuclear fuel (SNF) from reactors of the VVER-440 and VVER-1000, put into operation according to the NRA permit of 15.03. 2001. The current license for PSFSF operation is until 2024 and the licensee is "NPP-Kozloduy" EAD. "NPP-Kozloduy" EAD has submitted an application to the NRA with a request to extend the term of the current license until 2034. There is no planned decommissioning date.

The spent fuel storage facility is a self-contained seismically resistant structure that was originally designed for temporary underwater storage of nuclear fuel from units 1-4 of the Kozloduy NPP with VVER-440 reactors. Subsequently, the PSFSF was retrofitted to store SNF from units 5 and 6 with VVER-1000 reactors. The storage facility is equipped with equipment and systems ensuring the reception, storage and removal of SNF.

The storage facility accepts SNF with the following characteristics:

- for VVER-440 fuel:

  - initial U-235 enrichment not greater than 3.6%;
  - maximum fuel burnup not greater than 42 MW.d/kg.U.

- for VVER-1000 fuel:

  - initial U-235 enrichment not greater than 4,4%;
  - maximum fuel burnup not greater than 55 MW.d/kg.U.

The main specific risks as a result of a fire in a PSFSF are related to exposure of personnel, release of harmful emissions into the environment and loss of integrity of building structures, which are analysed and evaluated in the SAR.

1.1.3.4. Facility for dry storage of SNF (DSFSF)

On the site of the Kozloduy NPP there is a "dry type" spent fuel storage facility with a current license for operation until 2026 and the licensee "NPP-Kozloduy" EAD. The repository was commissioned in 2011. There is no planned decommissioning date.

The dry storage facility for spent fuel is a self-contained seismically resistant structure consisting of a one-story hall divided into two main operating areas - a receiving/removal area and a container storage hall and additional administrative and command rooms.

The repository provides long-term storage of nuclear fuel from VVER-440 type reactors in special CONSTOR-440/84 containers. In this regard, additional devices for handling these containers and moving them to the DSFSF have been installed in the PSFSF.

SNF with the following characteristics is accepted in the dry storage facility:

- initial U-235 enrichment not greater than 3.6%;
- maximum fuel burnup not greater than 42 MW.d/kg.U.

The main specific risks as a result of a fire in a DSFSF are related to exposure of personnel, release of harmful emissions into the environment and loss of integrity of building structures, which are analysed and evaluated in the SAR.

1.1.3.5. Storage facility for conditioned RAW (SFCRAW)

The storage facility for conditioned RAW (SFCRAW) is intended for temporary storage of conditioned RAW in reinforced concrete containers (RCC) and was put into operation on 22.08.2003.

The operation of SFCRAW ensures that the reception, warehousing and temporary storage of conditioned RW in reinforced concrete containers (RCC), testing, maintenance and repair operations are achieved in a safe manner.

Two main SFCRAW states can be defined:

- RCC acceptance/release mode;
- Storage mode.

All operations in acceptance/release mode are carried out remotely, by an operator in a control room, with control carried out by television cameras and visually on site.

In storage mode, no operations are performed. Monitoring is carried out - periodic external inspection and radiation monitoring. In the event of equipment failure, an emergency, or on a planned schedule, SFCRAW systems are taken out for repair.

The main specific risks potentially affected by a fire in a storage facility for conditioned RAW are related to exposure of personnel, release of harmful emissions into the environment and loss of integrity of building structures, which have been analysed and evaluated in the updated SAR.

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

The current National Assessment Report (NAR) was prepared by the NRA, based on a self-assessment by the Licensees, and was adopted by a decision of the Council of Ministers. The report was prepared taking into account the requirements of the Technical Specification developed by WENRA and adopted by ENSREG [1]. The NAR takes into account the recommendations from the report of the board of TPP II "Board's review of the national selections of nuclear installations to be reported on in the national assessment reports" from October 2022 and the scope of the review additionally includes the storage facility for conditioned RAW.

The structure of the report corresponds to Annex 2 of the specification. The presented information refers to the number of nuclear installations to be covered in the NAR, as specified in point 00.3, as well as to the regulatory requirements and activity and the activity of the licensees in the field of fire safety.

1.2. National regulatory framework

1.2.1. National regulatory requirements and standards

The requirements of the national legislation related to ensuring the fire safety of the NPP are regulated in:

- Act on the Safe Use of Nuclear Energy;
- Regulation on Ensuring the Safety of Nuclear Power Plants, NRA, 2016;
- Regulation on Ensuring the Safety in Spent Fuel Management, 2004;
- Regulation on Safety During Decommissioning of Nuclear Facilities, 2004;
- Regulation on Safe Management of Radioactive Waste,2013;
- Regulatory Guide “Protection against internal fires in nuclear power plants“, RG 1/2023;
- Regulation No. Iz-1971 of 29.10.2009 on Construction and Technical Rules and Regulations for Ensuring Fire Safety;
- Regulation No. 8121z-647 on the Rules and Norms for Fire Safety during Operation of the facilities;
- Other legislative documents and standards regulating fire safety.

The main requirements for fire protection in nuclear power plants resulting from the application of the concept of defence-in-depth (DiD) are included in the Regulation on ensuring the safety of nuclear power plants [2]. According to the Regulation, a deterministic analysis of the fire hazard shall be carried out to demonstrate the effectiveness and sufficiency of the fire protection measures. The analysis shall be performed for all steady states and transients under normal operation with consideration of:

- occurrence of a single fire and its spread in any zone with flammable materials;
- assumption for dependent failures in the affected areas, as a consequence of the fire;
- assumption for a combined effect of the fire and another initiating event that is likely to occur independently of the fire.

The deterministic analysis shall be carried out according to preliminary developed methodologies that include the assumptions of the analysis and their basis, the individual steps of implementation and justified criteria for the acceptability of the results.

The results of the fire hazard analysis shall indicate the possible consequences of the fire and of the operation of the fire detection and extinguishing systems, including potential failures and false activation.

Analysis methodologies, safety analysis results, and acceptance criteria implementation shall be documented in a verifiable and traceable manner, paying particular attention to cases where engineering judgment is used. More detailed information on conducting the deterministic fire hazard analysis is contained in the Regulatory Guide RG 1 “Protection against internal fires in nuclear power plants“.

The Regulation on ensuring the safety of nuclear power plants requires that all significant internal hazards, such as internal fires, shall be included in the scope of the probabilistic safety analysis (PSA). More detailed information on conducting the fire PSA is included in the Regulatory Guide RG 7 "Probabilistic safety analyses of " [4].

According to the Regulation [2], structures, systems, and components (SSCs) important to safety shall be designed, located, and protected in a way that leads to a reduction in the frequency and consequences of fires. Design solutions shall ensure the implementation and maintenance of the fundamental safety functions and control of the state of the reactor installation.

The measures for fire safety shall ensure the implementation of the DiD by preventing the occurrence of fire, quickly detecting, and extinguishing any fire that occurs, ensuring the resistance of the structure in case of fire, limiting the spread of fire and smoke and the consequences of a fire, creating conditions for evacuation of the personnel and for the safety of the emergency teams. To achieve these goals:

1. building structures shall be designed conservatively as fire-resistant, taking into account internal and external fires;

2. internal structures and components shall be of reaction to fire class A1 or A2;

3. the combustible load shall be kept to the practical minimum;

4. the power unit shall be divided into fire protection sectors by means of fire protection barriers with the necessary fire resistance to prevent the spread of smoke and heat in case of fires considered in the design;

5. the characteristics of the fire alarm and fire extinguishing systems (reliability, independence, capacity and qualification) shall be selected taking into account the results of the fire hazard analysis;

6. the necessary protected areas, safe areas, evacuation routes and evacuation exits shall be provided;

7. conditions for emergency firefighting shall be provided: external and internal water supply for firefighting, roads for firefighting purposes and access for the rescue teams.

During plant operation it is required to apply the fire safety measures defined in the fire hazard analysis. These measures include requirements for the management of activities that have an impact on fire safety - maintenance, control of combustible materials, personnel training, tests and emergency drills, changes to the location and configuration of fire extinguishing systems, fire alarm systems, ventilation systems, power supply systems and control systems for safety systems and technological processes.

For prevention of internal fires the development of procedures is required to manage and minimize the amounts of combustible materials and possible potential sources of ignition that may affect safety related SSCs. Procedures shall ensure the operability of technical fire safety equipment through inspections, maintenance and testing of fire barriers, fire extinguishing and fire alarm systems and manual fire extinguishing equipment.

To determine the responsibilities and actions of personnel in the event of fire, a firefighting strategy and emergency instructions shall be developed and exercised by emergency drills. The strategy shall cover any area where an internal fire may affect SSCs important to safety, as well as the protection of radioactive materials. When national or regional fire protection forces are used to fight fires, coordination between NPP personnel

and these forces shall be established, and they shall be made aware of plant risks. When NPP personnel are involved in firefighting, their organization and quantity, eligibility and training requirements must be documented and confirmed by a competent person in fire protection. Periodic joint emergency drills shall be conducted to assess the effectiveness of firefighting.

The application of the DiD concept is elaborated in the Regulatory Guide RG-1 on Protection against Internal Fire in Nuclear Power Plants [3]. According to this guide, for the application of the concept in relation to the protection against internal fire, the plant design should include measures to prevent the occurrence of fires, to detect them and in the event that they occur, to control and to mitigate their consequences.

Since fire is a hazard that has the potential to create conditions for common cause failures, the following basic objectives need to be met when applying the DiD concept:

- Preventing the occurrence of fires;
- Quick detection and extinguishing of fires, limiting the consequences;
- Preventing the spread of unextinguished fires, thereby minimizing impacts on essential safety functions.

In order to fulfil the above objectives, the plant design should provide for:

- Measures to reduce the likelihood of fire, including containment and separation of combustible and flammable materials;
- Active systems for early detection and extinguishing of fires (combination of automatic and/or manual fire extinguishers);
- Physical and spatial separation of fire zones to minimize impacts on systems performing essential safety functions.

In accordance with the DiD concept, fire protection requires ensuring high quality and reliability of SSCs, qualification for environmental conditions, application of the principles of redundancy, diversity, physical separation and design of appropriate barriers and protective means.

Fire protection requirements should be implemented in the design by combining different solutions, such as spatial separation of buildings and premises, equipment placement, active and passive measures for the various systems (technology systems, ventilation, heating and air conditioning systems, electrical systems, and civil construction solutions).

The design of a nuclear power plant should include measures to reduce the risk of fire. Measures to prevent the spread of fire should be applied as a priority mainly by use of passive systems, thus the protection of safety systems does not depend on the operation of fire extinguishing systems.

When active fire alarm or fire extinguishing systems are provided as elements of a fire zone, it is necessary to ensure their constant operability through increased requirements to the design, delivery, installation, inspection, and periodic testing. In this case, the systems should be designed applying the single failure criterion for the safety function they protect.

Structures should be designed conservatively with an appropriate degree of fire resistance in terms of internal and external fires. The degree of fire resistance of the building elements of a structure located in a fire zone or forming the border of a fire zone should be

defined to be no less than the degree of fire resistance of the fire zone itself, taking into account the fire load in it.

The design should provide means for successful firefighting (such as internal and external water supply), adequate access routes to and evacuation from the relevant buildings and structures.

The requirements for fire protection in activities with spent nuclear fuel are defined in the Regulation on Ensuring the Safety in Spent Fuel Management [5]. According to this regulation, the design of the SNF management facilities shall ensure the fire safety and explosion safety of the facilities and the used technologies.

The fire zones, the fire characteristics of the building structures and equipment and the maximum permissible fire loads shall be specified in the design. It is required the premises to be equipped with fire alarm systems, fire extinguishing systems, operational and emergency lighting, and the ventilation systems shall be compatible with the requirements for ensuring the fire safety of the facilities and automatically shut down in the event of a fire.

The design shall provide for measures to ensure sub-criticality and reliable cooling of SNF in case of fires and mitigating the consequences of fires that have occurred, and the organization of operation shall exclude the possibility of using fire extinguishing agents that can increase the effective neutron multiplication factor, and the storage of combustible and explosive materials in the facilities.

With regard to decommissioning activities, the safety requirements are determined in the Regulation on Safety During Decommissioning of Nuclear Facilities [6]. The regulation requires the licensee during all stages of decommissioning of a nuclear facility to ensure that the physical barriers and protection levels are maintained in a condition that ensures the safety of the nuclear facility.

The technical condition, reliability and operating modes of the systems and facilities important for safety shall ensure the safe performance of all activities and the safe condition of the decommissioned nuclear facility in accordance with and in fulfilment of the technological specification for the given stage. This shall be ensured by appropriate analyses and justifications, which are presented as part of the content of the safety analysis reports and which consider and justify the availability, technical condition, operational resource, and readiness to perform the functions of the existing systems and facilities important to safety.

The analyses shall determine and justify the need for additional measures, such as repairs and reconstructions and/or the construction of additional safety systems given the specific technologies and decommissioning activities planned for the respective stage.

With regard to RAW management facilities, according to the Regulation on Safe Management of Radioactive Waste [7], the design shall define the initiating events for the expected operational states and design basis accidents, and the list of these events shall cover probable internal and external events for all operational states of the facility, including total or partial failure of SSC, human errors and external natural and human induced events. The internal events that shall be considered in the design include fire and/or explosion.

The technical rules and regulations for ensuring fire safety are contained in Regulation No. Iz-1971 on Construction and Technical Rules and Regulations for Ensuring Fire Safety [8]. The Regulation specifies the requirements for the design and implementation of constructions in compliance with the provisions of the Spatial Planning Act, as well as for reconstruction, major renovation, major repair or change of purpose of an object or part of

it, as well as for carrying out construction and installation works, for which a building permit is required.

The Regulation No. Iz-1971 specifies the requirements for all passive and active fire safety measures, including fire resistance and reaction to fire of structures, systems and components; fire barriers; minimum distances between buildings and separation of premises of different fire hazard classes and categories; ensuring safe evacuation; degree of protection of electrical equipment; fire extinguishing, fire alarm and warning installations; installations for removal of smoke/heat; water supply for firefighting; portable extinguishers and equipment for initial fire extinguishing; evacuation and emergency lighting and others.

Regulation No. 8121z-647 on the Rules and Norms for Fire Safety during Operation of the facilities (RRNFSO) [9] defines the rules and norms for fire safety during the operation of the facilities.

The implementation of the regulations and standards is carried out through the internal documents - instructions, procedures, rules, programs, and orders issued according to the established order in the respective entity.

1.2.2. Implementation and application of international standards and guidance

Fire safety at the site of the Kozloduy NPP, including all facilities under item 1.1.3. is provided in accordance with the requirements of the legal documents of the Republic of Bulgaria on fire safety issues and the current standards of the IAEA, taking into account the reference levels of WENRA and many years of accumulated operational experience in the field of development and upgrading of the concept for fire protection, as well as the specific requirements for ensuring fire prevention strategies to avoid the development of failures leading to a potential risk of their occurrence and likely to occur in emergency scenarios.

The main international standards, guidance and other documents that are included in the regulatory framework and are applied in relation to ensuring fire safety in nuclear facilities are the following:

- IAEA, Safety Assessment for Facilities and Activities, Safety Standards Series, General Safety Requirements No. GSR Part 4 (Rev. 1), IAEA, Vienna (2016);
- Safety of Nuclear Power Plants: Design, Specific Safety Requirements SSR-2/1 (Rev.1), IAEA, 2016;
- IAEA, Safety of Nuclear Power Plants: Commissioning and Operation, Safety Standards Series, Specific Safety Requirements No. SSR-2/2 (Rev. 1), IAEA, Vienna (2016);
- IAEA, Protection Against Internal and External Hazards in the Operation of Nuclear Power Plants, Safety Standards Series, Specific Safety Guide No. SSG-77, IAEA, Vienna (2022);
- IAEA, Design of Nuclear Installations Against External Events Excluding Earthquakes, Safety Standards Series, Specific Safety Guide No. SSG-68, IAEA, Vienna (2021);
- IAEA, Maintenance, Testing, Surveillance and Inspection in Nuclear Power Plants, Safety Standards Series, Specific Safety Guide No. SSG-74, IAEA, Vienna (2022);
- IAEA, Protection against Internal Hazards in the Design of Nuclear Power Plants, Safety Standards Series, Specific Safety Guide No. SSG-64, IAEA, Vienna (2021);

- IAEA, Format and Content of the Safety Analysis Report for Nuclear Power Plants, Safety Standards Series, Specific Safety Guide No. SSG-61, IAEA, Vienna (2021);
- IAEA, Conduct of Operations at Nuclear Power Plants, Safety Standards Series, Specific Safety Guide No. SSG-76, IAEA, Vienna (2022);
- IAEA, The Operating Organization for Nuclear Power Plants, Safety Standards Series, Specific Safety Guide No. SSG-72, IAEA, Vienna (2022);
- IAEA, Deterministic Safety Analysis for Nuclear Power Plant, Safety Standards Series, Specific Safety Guide No. SSG-2 (Rev. 1), IAEA, Vienna (2019);
- WENRA Safety Reference Levels for Existing Reactors, 2021;
- WENRA: Report Waste and Spent Fuel Storage Safety Reference Levels, Report of Working Group on Waste and Decommissioning (WGWD), April 2014;
- WENRA WGWD: Report Decommissioning Safety Reference Levels - Version 2.2, 22 April 2015.

2. FIRE SAFETY ANALYSIS

2.1. Kozloduy NPP unit 5 and 6

The operating power units 5 and 6 of the Kozloduy NPP have a high level of fire protection, as a result of the implementation of a wide range of design solutions related to preventing the occurrence of fires, limiting the spread of fires and affecting the functionality of structures, systems and components (SSCs) related to safety, normal operation as well as the normal operation of the rest of the general plant and other adjacent equipment.

The state of the physical configuration, the facilities on the site and the constant upgrading of the systems related to the provision of fire protection (FP) according to the results of the performed complex analytical assessments, show a measurable progress in the performed deterministic analyses and a distinct trend for the improvement of fire protection according to the results of the performed update of the probabilistic safety analysis in the fire hazard assessment part.

2.1.1. Types and scope of fire safety analyses

Fire hazard analyses (FHA) are an essential part of demonstrating the safety of nuclear installations. The safety assessments of power units 5 and 6 include fire hazard analysis, which consists of a complex of various quantitative analyses to determine and assess hazards using deterministic and probabilistic methods. The scope and level of depth of the FHA are determined using a graded approach.

The complex approach implemented in the development of the deterministic analyses in the field of fire protection for NPP "Kozloduy" EAD follows the design goals, tied to ensuring the appropriate defence in depth, depending on the applicability, through a combination of several levels of protection, i.e. assessments related to the provision of physical barriers, application of passive and active protection principles, zoning, monitoring, upgrading of barrier protection systems, administration and implementation of a set of fire protection strategies and instructions.

The analyses carried out in the FHA take into account the possible external events that can lead to fire and its spread, determining an appropriate level of protection in order to prevent their consequences in the states defined by the design. This includes both natural external events such as extreme weather conditions and human-induced events depending on the possible potential fire risks associated with the facility or activity.

FHA, considering internal events, demonstrates whether structures, systems, and components can perform their safety functions under the loads during normal operation and under anticipated operational events and emergency conditions explicitly considered in the design of the facility. Specific attention when performing the FHA is given to operational events related to failures leading to:

- Fires as a result of seismic events;
- Possible common cause failures/failures related to loss of cable routes;
- Loss of a safety system channel as a result of a fire;
- Initiating events related to fire in combination with single failures of active components, which are necessary to safely shut down the reactor;
- Conditions of simultaneous occurrence of independent fires;
- Simultaneous occurrence of fires and other independent internal events.

Depending on the specific risks associated with the facilities and activities, this may include consideration of combinations of environmental conditions affecting structures and components as a result of internal events, deviations, internal explosions and fires.

The deterministic analyses of the factors determining the fire protection of the SSCs and the personnel at the NPP site relate to the following aspects in terms of assessment of the conditions and modifications:

- the fire-extinguishing means used and the corresponding types of firefighting equipment used;
- available fire detection and signalling systems and automatic fire extinguishing systems, time and impact characteristics;
- the use of non-flammable structural elements and materials with standardized characteristics in terms of ensuring fire safety;
- the used technical solutions, barriers, equipment, element base and devices limiting the spread of fire;
- the design measures used to divide the SSCs and the facilities into firefighting sections and zones;
- the physical securing of the fire barriers and insulating/fire-blocking elements of the equipment and SSCs;
- the implemented design means for notification and evacuation of personnel;
- the means used for individual and collective protection of personnel (including the personnel of the professional fire brigade) from the hazards of fire and effects of radiation.

Fire safety analyses include both deterministic FHA and probabilistic fire risk analysis.

The FHA is reviewed and, if necessary, periodically updated over a period of 5 to 10 years, following the basic modernization plan. FHA are also updated when the regulatory framework in the Republic of Bulgaria changes, in order to prove that the degree of implementation of the fire safety design objectives meets the requirements of the modern applicable standards and guidelines.

Deterministic fire hazard analyses

The fire hazard analysis at the “Kozloduy NPP” EAD was prepared on the basis of a deterministic approach according to the requirements of the applicable national regulations in the field of fire protection, harmonized with the IAEA specific guides and the WENRA reference levels in the field, covering:

- all operational states of the plant - normal operation, shut down reactor, single fire and subsequent spread, fires whose potential spread is determined by the occurrence of dependent and multiple failures in the SSCs and the protection facilities;
- activities associated with an increased risk of fire generation as a result of human actions, including those undertaken during emergency conditions;
- conditions in which the impact of the fire threatens the SSCs and the safety functions they perform and an assessment of the possible threats to these safety functions due to the development of a fire;
- defined places on the NPP site where there is stationary or mobile combustible material;

- possible combinations of fire and other events (including external hazards).

The deterministic analysis is complemented by a probabilistic safety analysis (PSA) to determine the effect of fire protection measures and to assess the risks caused by fire.

Probabilistic fire safety analyses

The initial fire risk analysis was prepared and documented in 2003/2004. The document contains a fire risk assessment for each plant building. The purpose of the analysis is to assess the risks arising from fire so that appropriate and sufficient preventive and protective measures can be implemented. Periodically, the fire risk analysis is updated as part of the Periodic Safety Review (PSR).

The probability of a fire event resulting in core damage has been defined by PSA Level 1 in 2010. PSA Level 2 was completed in 2013.

The analysis covers fire cells and areas, including cable and switchgear rooms, safety-related equipment rooms and the turbine hall. The frequencies of initiating events were determined, and analysis was used to identify vulnerable areas in the power plant and deficiencies in operating instructions.

An update of the existing PSA level 1 in case of fire was carried out in 2020-2022. It took into account all technical modifications carried out between 2007 and 2020, including the fire protection modernization program of units 5 and 6.

2.1.2. Key assumptions and methodologies

Deterministic fire hazard analyses

The purpose of the performed deterministic FHA is to show that the protective measures are sufficient to prevent failures of equipment and safety-related SSCs located in separate fire cells within the same fire zone and to bring and maintain the unit in a safe condition.

To achieve the above objectives, the following is performed when performing deterministic assessment:

- Identification of the equipment important to safety and determination of the location of individual components in fire zones;
- Determination of the fire and explosive properties of the substances used, quantities and conditions of use, analysis of the probable sources of ignition;
- Analysis of expected fire development and possible consequences on equipment important to safety;
- Determination of the required degree of fire resistance of fire barriers, especially the fire resistance of the boundaries of fire zones;
- Determination of passive and active fire protection measures;
- Identification of cases where additional separation or additional protection is required, particularly for common cause failures, so as to ensure the operation of safety systems during and after an anticipated fire;
- Assessment of the indirect secondary consequences of the development of fires.

Deterministic assessments and studies take into account the actual physical configuration and sufficiency of SSCs with functions to provide fire protection, design margins and margins related to the response and reaction time of fire alarm systems (FAS)

and fire extinguishing systems (FES), the effectiveness of human actions and implemented external and internal procedures.

Deterministic analysis is performed for all steady states and transients under normal operation, accounting for:

- Occurrence of a single fire and its development in any area with combustible materials;
- Assumption for dependent failures in the affected areas, as a consequence of the fire;
- Assumption for combined effect of fire and other initiating event or external hazard likely to occur independently of the fire.

The methodological approach reflects the applicable regulatory framework in the field and the constant upgrading of the plant design (implementation of measures and implementation of technical solutions related to the modernization of active/passive fire protection and minimizing the risk of the spread of fire), taking into account the supervision exercised, the performed inspections and checks, the operational experience reporting system including foreign operational experience and the results of studies which aim to provide the basis for in-depth assessments and identification of weaknesses or interrelated problems affecting the field of fire protection.

The scope of implementation of FHA includes:

- Assessment of the construction and layout of buildings and equipment (including electrical cables) within fire zones and fire cells;
- Available combustible materials, taking into account the maximum amount of temporarily stored combustible materials in a fire zone or in a fire cell;
- The fire protection measures, including the fire alarm and fire extinguishing systems in each fire zone and fire cell;
- Analysis to verify the possibility that a single fire (in any fire zone or cell) could disrupt the safe shutdown and cooling functions of the reactor or lead to an uncontrolled release of radioactive substances into the environment;
- Analysis of spent fuel storage areas.

A Deterministic FHA of Units 5 and 6 of the Kozloduy NPP was conducted in the period 1998-2000, within the framework of Measure 21111 of the Modernization Program of Units 5 and 6. This analysis was performed following the IAEA Guides in effect at the time.

The scope of the Deterministic FHA includes the main buildings of the Kozloduy NPP, units 5 and 6:

- Reactor compartment (RC), reactor building – inside and outside the hermetic structure of the reactor installation, respectively controlled zone and supervised zone;
- Diesel Generating Station (DGS);
- Turbine building including the electrical equipment rack (TB, EER);
- Circulation water pumping station (CWPS);
- Special Radwaste Storage Building (SRSB).

The prepared data inventories contain information about the general situation on the premises. This includes data on the premises, basic equipment and redundancy, type

and amount of combustible materials/thermal load, fire protection in terms of building structures and equipment.

The information on the provided fire protection from the point of view of building structures includes data on the boundaries of the premises, the type of walls and the type of installed doors, the ventilation (supply and suction ventilation systems) and the installed fire dampers, as well as the transit air ducts passing through the premises. The presence of large openings in the room, their location, the type of opening and its dimensions are also part of this data.

The results of the study are used in documenting the degree of development of the existing fire protection system of the Kozloduy NPP, units 5 and 6 and ensuring the design goals for nuclear safety at the site, including when considering conditions such as shutting down the reactor, maintaining it in the subcritical state and removal of the residual heat.

Analytical methods, safety standards and information used in the scope of the performed deterministic FHA are updated and validated, taking into account the available information related to the design features and characteristics of the site, the state of the SSCs and the data of the performed studies for determination of the main fire hazard properties of the materials used. The prevailing climate, the likelihood of a combination of environmental factors, transport and/or industrial activities near the site that have the potential to endanger safety are also taken into account.

The methodology includes an assessment of buildings, premises, elements, and facilities, SSCs, which are related to the occurrence and development of a potential fire, taking into account the degree of activity, capacity and coverage of firefighting equipment and the fire-extinguishing means used in accordance with the predefined fire-resistance zones. The functional design of the fire detection and alarm systems, time and impact characteristics are considered.

The conditions that can lead to a fire and the degree of fire resistance of structural elements and materials are analysed for compliance with the requirements regarding fire safety. The amount of released heat and combustible load at individual points in the event of an anticipated large fire, as well as the ventilation characteristics (forced, natural ventilation, amount of removed heat, hot gas layer temperatures, etc.) are determined. A structured approach to selecting scenarios includes the use of analytical methods, such as failure mode and effect analysis, for failures leading to the development of a fire.

Along with the evaluated operational events, failures of the SSCs with potential impact on safety, the physical securing of the fire barriers and the isolating/fire-resistant elements of the equipment are also evaluated. The FHA model is a detailed, integrated and realistic model of the plant, including the procedures and actions of the operational and professional fire service personnel for a wide range of output events and hazards, external and internal fires, the combination of extreme weather conditions and the consideration of seismic hazards specific to the NPP site.

The results of the fire hazard analysis are used directly as part of the decision-making process to assess the level of safety. The implemented improvements and modifications related to the protection of SSCs from fires, as well as the means for individual and collective protection of the operational staff, including the staff of the professional fire service, are also subject to evaluation.

FHA is performed on the basis of complete and accurate design data for the geometric, material and technological characteristics of the SSCs.

Probabilistic analyses of the fire safety

The scope of the updated PSA level 1 includes an analysis of the current configuration of units 5 and 6 of Kozloduy NPP, taking into account all internal and external events and hazards specific to the site (in accordance with the requirements of the Safety Regulation [2] and the IAEA and WENRA recommendations) that individually or in combination could lead to nuclear fuel damage at the Kozloduy NPP units 5 and 6 (including the reactors and spent fuel pools). The scope of this PSA Level 1 update is defined as follows:

- Only the nuclear fuel contained in reactor or spent fuel pool is considered a radioactive source;
- The analysis covers all possible operating states – full power, low power and shut down unit;
- The study covers the full spectrum of internal initiating events (including internal fires, internal floods) and possible external hazards (natural and anthropogenic).

The model of PSA level 1 is developed for the defined operational states of the unit. This allows each operating condition to be analysed separately, thus ensuring completeness of the analysis and adequate consideration of changes in unit configuration and parameters.

In accordance with para 7.16 of SSG-3 Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants, IAEA 2010, the deterministic FHA performed during the design or operation of the plant is used as input data for PSA level 1 for internal fires, for example, the list of components and cables and their location, the division of the plant into fire zones, taking into account the functional and detailed fire impact analyses carried out to provide fire barriers and fire protection.

Internal Fire PSA is a probabilistic analysis of fire events caused by sources that are within the site boundaries and their potential impact on the nuclear safety of the plant. Using probabilistic models, this PSA examines:

- the possibility of fire in specific locations of the unit;
- the detection, extinguishing and spread of the fire;
- the effect of fire on safety-related equipment (components, as well as associated instrumentation and control, and power cables);
- the possibility of damage to this equipment, and in case of severe fires, to the integrity of the structures (walls, ceilings, columns, etc.);
- the impact of accidental equipment failures and human error.

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

Deterministic fire hazard analyses

For the implementation of the FHA in a deterministic plan, a comprehensive set of events is compiled that covers all plausible failures of the SSCs and reflects the current fire and emergency procedures including the actions of the operational personnel and the personnel of the professional fire service in the implementation of the procedures. The analysis covers steady states, transients, expected operational events and emergency states related to or initiated by fire and its spread. An important aspect in performing deterministic analyses is the identification of the safety functions and the associated safety features that must be protected from fire.

The list of events for units 5 and 6 of the Kozloduy NPP is defined at the design stage, reflecting the design objectives and design basis, as well as the goals of the fire protection. This list has subsequently been updated to reflect the applicable new regulatory framework using a structured approach that covers the following steps:

- Identification of all barrier failure mechanisms;
- Definition of all physical fire hazard processes that can initiate the mechanisms for sequential failure of fire barriers;
- Definition of all premises and areas in which combustible material is permanently or temporarily located and the scope of the introduced internal rules used to prevent the development of fire in specific situations;
- Grouping these processes by phenomenology;
- Definition of critical scenarios for each of the characteristic groups of scenarios leading to large extremes and temperature gradients during fire development;
- Identification of a sufficient number of scenarios that are encompassing in terms of meeting the relevant FHA eligibility criteria;
- Postulation of all the initiating events and scenarios that can, with high probability, lead to these characteristic scenarios;
- Definition of the initiator of a fire with initiating internal events and/or external events.

The FHA development stages follow a thorough process of accumulating and structuring data for the purposes of performing analytical tasks, followed by systematic assessments related to the structure of fire protection - boundaries, approach, intrinsic properties and capacity possibilities, ventilation, passages (openings), equipment related to the state of fire protection (for detecting and locating the fire, fighting the fire, removing smoke, heat, etc.).

In the next stage, the deterministic assessment is carried out, the basis of which is the defined specific fire hazard, arising from the existing characteristics of the fire loads, and the analysis covers:

- engineering assessment with the use of additional means to calculate the characteristic fire resistance taking into account the existing boundary conditions;
- use of appropriate fire simulation models;
- assessment of the adequacy of fire safety.

The systematic analysis of fire protection includes identification of the premises and fire cells, inventory of combustible materials and assessment of the characteristics of the installed equipment for diagnostics and detection of fires, the cable routes and backup channels for providing fire protection. A deterministic analysis is performed on:

- the fire resistance of the installed fire barriers and passages to limit and impact the fire;
- analysis of the individual fire-resistant zones (premises and their elements, such as walls, fire doors, fire dampers, passages, etc.) in order to check whether the fire will not lead to common cause failures of the backup systems;

- assessment (confirmation) of the existing separation and definition, if necessary, of new firefighting cells and zones;
- assessment of the level and quality of construction and equipment related to fire protection measures;
- assessment of indirect secondary consequences of fires;
- analysis of fire detection systems - speed, coverage, capacity, security;
- complex analyses of firefighting systems, including analysis of the possibilities of different extinguishing gases;
- evaluation of the effect of the agent used to extinguish the fire on the safety-related equipment;
- analysis of ventilation systems in terms of smoke distribution;
- assessment of consequences in case of false start of fire extinguishing systems.

The analysis is accompanied by a global assessment and identification of weak points and deviations from fire protection requirements and factors contributing to the spread of fire to defined fire zones/cells in which equipment performing specific safety-important functions is located.

For applying conservative approach in the FHA, the initial and boundary conditions are defined using the values of the parameters and characteristics that lead to unfavourable results with respect to the acceptance criteria. The approach is to define conservative deviations and specific assumptions for each initial and boundary condition depending on the nature of the initiator and the relevant acceptance criteria.

When the uncertainties cannot be avoided in the FHA due to the nature of fire development and the multiple failures that it initiates, empirical formulas and/or engineering coefficients are applied in the modelling. Uncertainties in fire hazard analysis are characterized by factors in terms of their source, nature and degree of influence and are reported in the analysis results.

Uncertainties that may affect the results of the FHA are assessed by sensitivity analysis. Uncertainty analysis refers to statistical combinations of the input data and accounting for the uncertainties in the data on a parameter that results from the calculation.

Probabilistic fire safety analyses

The assessment of the risk of internal fires in the operation of the power unit includes the result of the analysis of 40 fire zones and cells and fire scenarios from eight groups of initiating events identified for them.

The estimate for reactor core damage frequency in power unit operation, obtained as the sum of the results of individual fire zones and cells, is insignificantly different for the two units and is defined as:

- 4.54E-07 1/y for unit 5
- 4.49E-07 1/y for unit 6.

As a result of the quantitative calculation, 26789 minimal cut sets for unit 5 core damage and 26844 minimal cut sets for unit 6 core damage were obtained. In both units, the

result is relatively evenly distributed, with only the first five sections contributing more than 1%.

In both units, there is no cut set that exceeds 4.0E-08 1/y, which indicates a high level of fire safety reached at units 5 and 6 of the Kozloduy NPP and satisfies all current requirements in the area.

The estimated fire occurrence frequencies in individual rooms of units 5 and 6 differ. This difference (albeit minimal) leads to a different percentage of contribution of the identical cut sets in the evaluations of the two units. Therefore, in the case of a difference, the results for unit 5 are given in parentheses.

The first cut set has the frequency of occurrence 3.5E-08 1/y and 7.81% (7.73% for unit 5) of the contribution to the risk of internal fires. This cut set is determined by a fire in the Turbine Hall elevation -3.60, the occurrence of a transient process without the possibility of removing the residual heat through the turbine condensers and a common cause failure (CCF) of the Steam Dump to the Atmosphere Valves (SD-AV) to close.

The next four cut sets, from the second to the fifth, carry a total of about 22.6% and are practically of the same type. The contribution of each cut set in this group is 5.66% for unit 6 (5.60% for unit 5).

With a contribution of 0.95% (0.92% for unit 5), is the sixth cut set, which is determined by a fire in the engine room of CWPS with the failure of the fire brigade to extinguish it and the CCF of SD-AV to close. Additionally, other four cut sets of the same fire scenario, from the ninth to the twelfth, determine a contribution of 0.69% in case of CCF of SD-A of three Steam Generators (SG) to close. These cut sets for unit 5 are from the tenth to the thirteenth and have a contribution of 0.67%).

The seventh cut set has a contribution of 0.72% (0.71% for unit 5) and is from the Turbine Hall fire scenario elevation -3.60. CCF of Sections 6kV type NXAir to function results in damage to the reactor core.

The eighth cut set has a contribution of 0.70% (0.71 for unit 5) and is from a fire in cable floor section 2, elevation 0.00 of EER, and scenario "Opening with subsequent non-closure of more than one Steam Dump to the Condenser Valves (SD-CV)". CCF of Fast Acting Main Steam Isolation Valves (FAMSIV) to close results in damage to the reactor core.

The thirteenth cut set has a contribution of 0.67% (the cut set is the fourteenth for unit 5 and has a contribution of 0.63%) and is from a generalized scenario of a CWPS building premises fire and a CWPS cable mezzanine. This contribution is determined by the failure of the fire brigade to extinguish the fire and the CCF of SD-AV to close.

2.1.4. Main results/dominant events

Deterministic fire hazard analyses

The results of the FHA and their update led to the implementation of recommendations related to the provision of additional fire prevention measures in order to minimize the hazard associated with the occurrence of fire and its spread. In the course of applying many years of experience in performing analytical assessments for FHA and determining the basic design requirements, numerous active and passive fire prevention measures have been implemented, affecting:

- Gas fire extinguishing systems;

- Fire alarm systems;
- Increasing the redundancy of cables and equipment, physical and other separation;
- The measures for smoke suppression, removal of heat and smoke, optimization of the air exchange rate, overpressure in the stairwells and other specific cost characteristics;
- Fire dampers and fire doors.

The fire hazard analysis was performed in accordance with the principles set forth in the IAEA Safety Report Series No. 8 "Preparation of Fire Hazard Analyses for Nuclear Power Plants". FHA was also performed in consideration of the Fire Containment Approach relying on the placement of backup elements in different fire zones surrounded by fire barriers that are resistant to the complete burning of potentially combustible equipment without allowing the fire to spread outside the zone/ the room, as well as the Fire Impact Approach which assumes that redundant elements are located in different fire cells within the same fire zone, and that the possibility of fire destroying equipment in different fire cells simultaneously is controlled by measures such as separation, local passive protection and active fire protection.

During the performance of the FHA, events such as the consequences of an earthquake were considered for the purposes of assessing the possibility of CCF of the SSCs. The protection of the reactor installation in case of spread of fires due to the ignition of fuel tanks has been assessed as well and measures have been determined to limit and prevent the spread of the fire.

During the performance of the analytical activities, the elements and SSCs important to safety, which must be reliably protected, were determined. The existing fire hazard and the consequences of the development of the fire in relation to SSCs important to safety have been assessed. Verification was carried out with the requirements of the IAEA guidelines in force at the time. The functionalities of the necessary means for early fire detection have been determined.

The measures related to the necessary physical separation and isolation necessary for avoidance of common cause failure (CCF) related to equipment location (for example, CCF of cables, mechanical equipment, electrical/electronic equipment) are defined.

Probabilistic fire safety analyses

Main Results

The total core damage frequency during operation of each of the units is determined as follows:

- 8.14E-7 1/y for unit 5;
- 8.03E-7 1/y for unit 6.

The analysis of the results shows that, for both units, the contribution of the internal initiating events constitutes about 60% of the total frequency, with the next contribution being the seismic effects with about 22%. Internal fire risk accounts for 10% of the total core damage frequency per unit, with turbine hall fires being the dominant factor. External hazards account for 8% of the total core damage rate per unit, and internal flooding accounts for 2%. The share of other internal events is negligibly small.

The results show that the risk of internal fires during the operation of units 5 and 6 of the Kozloduy NPP is mainly determined by the occurrence of internal fires during the unit power operation (about 56% contribution to the final result). The contribution of the low-power state and shut down states is determined to be about 13%.

The contribution of fuel damage in the spent fuel pool is about 31%, which shows that it should not be underestimated.

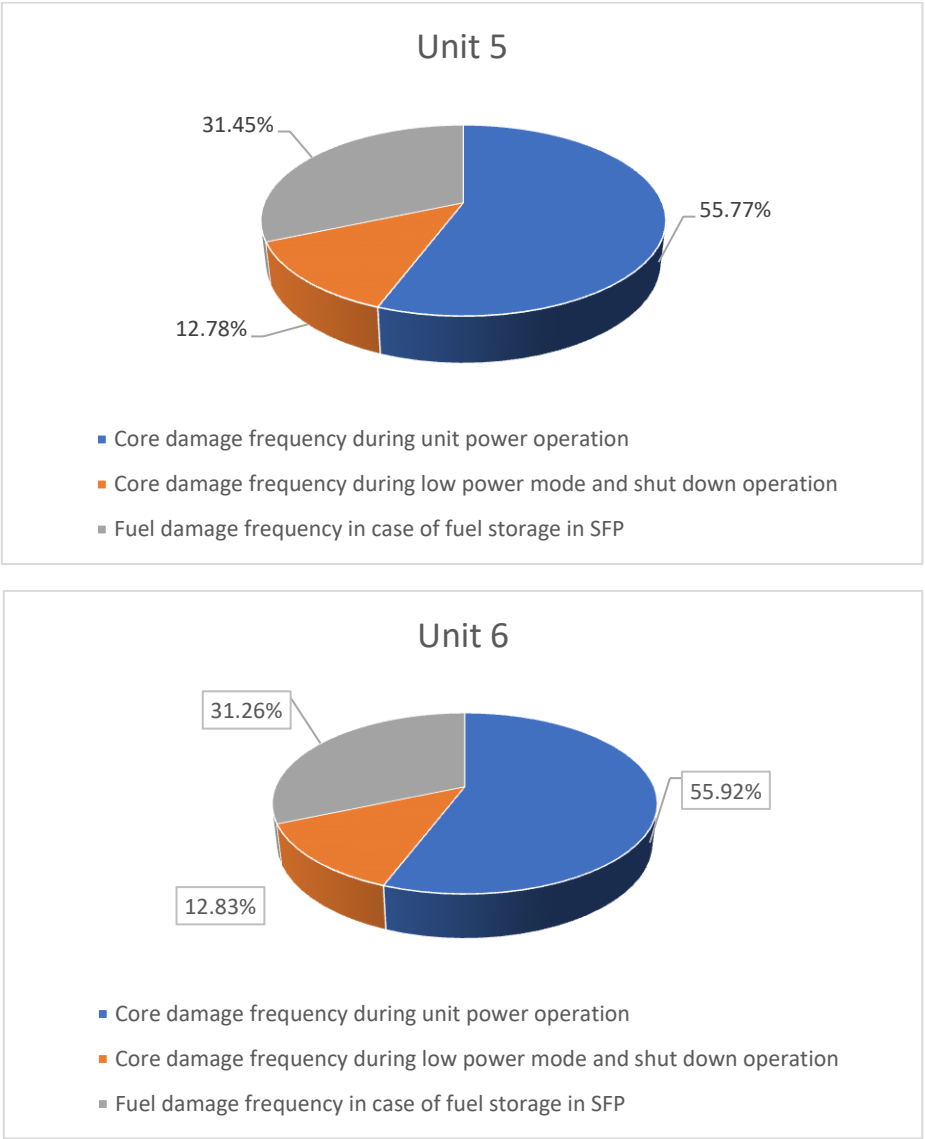

Fig 1. Main results from internal fires PSA unit 5 and 6

It should be noted that the presented result shows the occurrence of fuel damage in the core and in the spent fuel pool simultaneously. This is possible given that some fire scenarios are common to both the fuel storage in the pool and in the reactor. Examples of such scenarios are "Loss of external power supply" and "Loss of essential service water", "Loss of one house load bus bar 6 kV ", " Loss of one house load bus bar 6 kV during unit operation at low power during shut down".

A comparison of the results of this PSA level 1 update with the previous probabilistic analysis shows that the overall risk in terms of the fuel damage frequency, has been reduced by 66% (approximately 2.9 times). This also shows a reduction in the overall frequency of fuel damage from internal fires by about 76%, i.e., just over 4 times.

The analysis of the cumulative effect within the framework of the performed PSR shows that the innovations in the plant and the implementation of investment projects related to the minimization of fire risks, as well as the control of fire sources, directly affect the level of safety of the NPP.

Main Contributors

Based on the method for evaluating the significance indicators on the results for the Fussel-Vessely coefficient, it can be summarized that the final result for the core damage frequency from internal fires during power operation is determined by the following failures:

- Common cause failure of SD-AV to close with a contribution of 14.9%. This failure is dominant by the scenarios that lead to a transient without the possibility to remove the residual heat through the turbine condensers.
- Common cause failure of all FAMSIV to close - this failure determines 5.8% of the contribution. The dominance is determined by the impossibility of preventing the sharp cooling of the primary circuit in scenarios and emergency sequences with non-closure of SD-CV, SD-AV or SG safety valves.

The core damage frequency due to internal fires at low power and shut down conditions is determined by the following failures:

- The contribution of the outage and maintenance of one train of the safety systems is the largest, with a contribution of just over 18%. The significance of this scenario is based on the results of fire zones assessment with a loss of one channel of the safety systems due to fire.
- Another dominant failure is the event with a diesel generator failure, contributing 8%. The dominance of this failure is determined in the event of a fire in the house load section category III cable floor and the subsequent loss of signals.

Operator actions that have a significant impact on overall results when the unit is operating at low power or the reactor is shut down are:

- Failure of the operator during diagnostics and decision-making to leave the Main Control Room (MCR) and to pass to the Emergency Control Room (ECR) in the event of a fire in the cable routes to the MCR and to the RC control systems. The failure accounts for 6.2% when the unit is shut down and an additional 4.3% when the unit is running at low power.
- Failures of the operator to diagnose and make a decision to provide spent fuel pool cooling, as well as to supply coolant, are decisive for the SFP fuel failure rate result.

2.1.5. Periodic review and management of changes

The FHA periodic review is performed as part of the periodic safety review during license renewal of units 5 and 6.

The following are applied to define the elements and criteria for evaluation of factors related to fire safety evaluation:

- Current national and international requirements, norms and standards for the performance of analytical assessments;

- Applicable standards for assessment in the field of fire safety and assessment of nuclear and radiation safety;
- Operational experience of nuclear power plants in the area;
- Documents, design data and design basis, specific data for the plant and SSCs ensuring the protection of from fires;
- Procedures for preventing hazards and mitigating the consequences of fire development.

Within the scope of the three consecutive periodic safety reviews of units 5 and 6 performed by the Kozloduy NPP, a review of the volume of performed analyses related to the assessments of fire hazards for the site and its adjacent facilities was carried out. The results of the PSR show that the available deterministic analyses are carried out systematically in a structured approach, according to the regulatory criteria and requirements, as well as considering the accumulated operational experience.

The FHA review included assessment of the up-to-date status of the information related to the initiating events involving fires, including:

- the current state of all systems, structures and facilities at the Kozloduy NPP site;
- the current status of both active fire protection systems and passive fire protection measures;
- the accumulated considerable experience and implemented modifications in the field of fire safety provision.

The consideration of the defined new vulnerabilities and treats at the design level is also supported when revising the design basis during the implementation of technical solutions, commissioning, changes in the characteristics of the site reflecting on the fire protection, results of research activities, new scientific knowledge and lessons and best practices from foreign operational experience.

2.1.5.1. Overview of actions

The approach of the Kozloduy NPP in ensuring the activities related to guaranteeing the fire safety of the site is based on the implementation of measures to prevent the occurrence of fires, to detect and quickly extinguish fires that have occurred and to prevent the spread of fires and their effects in or to any area that may have a safety impact. When substantiating the sufficiency of the fire prevention measures taken at "Kozloduy NPP" EAD, a fire safety analysis was carried out, by conducting a deterministic and probabilistic analysis of the fire hazard.

The following analyses were additionally made:

- "Analysis of the oil fire in the containment - RC unit 5 and 6 ". The main objective of this analysis was to assess the impact of an oil fire during depressurization of the oil system of the Main Coolant Pumps (MCP) on the condition and behaviour of the metal structures and technological equipment in the containment.
- Analysis of a large fire in turbine hall - unit 5 and 6 and its impact on main steam lines (MSL) compartment, in which t safety related equipment is located. An analysis was made of the impact of a large fire in the turbine hall on the building structures and technological equipment in the compartment.

A solution has been proposed to prevent the penetration of heated combustion products from the turbine hall into that compartment.

In order to maintain an up-to-date FHA, the "Fire Hazard Analysis of units 5 and 6 with consideration of changes from modernization measures and changes in the regulatory framework of the Republic of Bulgaria" was prepared in 2013. The activities of ensuring the DiD concept of the NPP from fires were analysed, and assessments of the expected effect of the implementation of changes in the design of the facilities were carried out. The following assessments fall within the scope of analytical activities and review:

- Assessment of adequacy of separation of fire zones/cells for facilities important to nuclear safety;
- Analyses of the expected development of fires and their consequences in relation to SSCs important to safety;
- Determination of the functional fire hazard class and the fire hazard category of buildings, main process and storage premises;
- Assessment of the degree of fire resistance of fire barriers;
- Analyses to determine the need to build a ventilation system to remove smoke and heat from main process and storage rooms;
- Analysis and evaluation of the requirements of the existing emergency ventilation systems;
- Specification of the dimensions of explosive zones in accordance with the requirements of the applicable standards;
- Evaluation of the FAS and FES and their automation in the management of the elements ensuring the non-spreading of the fire and its extinguishing;
- Analysis of the safe evacuation of personnel according to the requirements of the current regulations.

As a result of the implemented measures and recommendations resulting from the update of the FHA, a higher degree of protection of the NPP against the occurrence of fire has been achieved through the implementation of a complex of organizational and technical measures:

- Protection against the occurrence of fire, carried out through the implementation of a complex of organizational and technical measures, such as:
  - Improving the effective control of identified flammable substances and materials;
  - Constant control of ignition sources;
  - Analysis and control of innovations in the plant and the implementation of investment projects related to the assessment of potential hazards and sources of fire;
  - The provision of operating conditions in the identified fire zones and cells.
- For the purposes of quick detection and extinguishing of fire and achieving effective protection, addressable automatic fire alarm systems, with self-diagnostics ability, having high reliability in timely detection of fire, to take adequate extinguishing actions, have been installed.
  - In order to protect the facilities important for safety in the NPP, effective control over potential fires is provided through a combination of automatic extinguishing systems and creation of conditions for manual fire extinguishing actions.

- In the safety systems, volumetric gas fire extinguishing systems based on FM200 extinguishing agent are built.

❖ The measures related to limiting the spread of fires have been implemented by preferentially using passive protection systems, thus the protection of safety systems does not depend on the operation of stationary fire extinguishing systems. Buildings that contain equipment important to safety are designed to be fire resistant, divided into fire zones and fire cells. The fire resistance of passages such as doors, air ducts, manholes, fire dampers and cable routes, ventilation pipes and pipelines that form part of a fire barrier and the boundary of a fire zone are provided with a degree of fire resistance that is at least equal to the fire resistance of the fire barrier itself.

❖ The separation of fire zones and fire cells is carried out not only in the presence of electrical equipment important to safety, but also depending on the amount of combustible load per m², in accordance with current national standards.

2.1.5.2. Implementation status of modifications/changes

At the Kozloduy NPP, numerous technical modifications and measures related to ensuring and upgrading fire protection and minimizing the risk of fires have been implemented. Each of the implemented measures and introduced new modifications related to SSCs is analysed based on technical data and an assessment of the expected effect of the implementation.

In order to ensure that all aspects of fire protection are taken into account, the implementation of changes in the SSCs and provisions for fire protection is analysed through the application of deterministic and probabilistic safety analysis. The effectiveness of the design modifications/changes related to the fire protection is evaluated in the following aspects:

- Evaluation of increasing the level of safety according to the defined conditions of operation;
- Analysis of the operational condition of the FHA in relation to the provision of fire barriers, the failure of which could call into question the assumptions made in the FHA hazard analysis;
- Analysis of new possibilities for the use of firefighting means and the type of extinguishing medium;
- Improvement of conditions for access, efficiency and timely extinguishing of potential fires;
- Prevention of failures related to the induction of fire;
- Minimization of human error and errors in the use of firefighting equipment;
- Improvement of self-diagnostics of FAS and FES.

The necessary improvements in the design and the new fire protection measures are included in specific analyses performed during the modernization process and when the regulatory framework is updated. In the conditions of a constantly upgraded design, the following analytical activities are performed:

- Assessment of the conformity of the implemented fire prevention measures with the requirements of the applicable regulatory framework;
- Evaluation of the functional design and the sufficiency of the zoning and separation of fire cells for the protection of the facilities performing a safety function in view of the design configuration of the equipment;

- Evaluation of the effectiveness of the automatic water fire extinguishing system of RC and EER of units 5 and 6;
- Analyses of FAS and the expected development of fires and their consequences in relation to facilities important to safety;
- Assessments of premises containing combustible materials (oils, etc.), assessment of airtightness, degree of insulation and effects related to the implementation of fire prevention measures and impact of FES;
- Review and assessment of the requirements related to the provision of emergency ventilation in case of fire, and of the provision of safe evacuation of personnel in case of fire;
- Analysis of the degree of fire resistance of fire barriers and determination of the functional fire hazard class and fire hazard category.

As a result of the FHA, the measures related to the modernization of the systems ensuring fire safety was determined, such as:

- Improving the fire resistance of fire doors;
- Limiting the spread of fire through ventilation ducts;
- Modification of the gas fire extinguishing system;
- Qualification of fire alarm devices according to the required seismic level.

In connection with the FHA a detailed design was developed on "Ensuring the necessary quality of fire zones and cells, according to the requirements of Fire Hazard Analysis in the buildings of reactor compartment of units 5 and 6, TB-EER of unit 5 and 6, CWPS-3 and 4, DGS unit 5 and 6 and SRSB-3“.

The recommendations of the analysis have been addressed with the implementation of the design modifications packages listed below:

- Ensuring the necessary quality of fire zones and cells, according to the requirements of the "Fire Hazard Analysis" in the DGS building – unit 5;
- Ensuring the necessary quality of fire zones and cells, according to the requirements of the "Fire Hazard Analysis" in the DGS building – unit 6;
- Ensuring the necessary quality of fire zones and cells, according to the requirements of the "Fire Hazard Analysis" in the building of SRSB- 3;
- Ensuring the necessary quality of fire zones and cells, according to the requirements of "Fire Hazard Analysis" in the building of power unit 5 - TB and EER;
- Ensuring the necessary quality of fire zones and cells, according to the requirements of "Fire Hazard Analysis" in the building of power unit 6 - TB and EER;
- Ensuring the required quality of fire zones and cells, according to the requirements of "Fire Hazard Analysis" in RC – unit 5;
- Ensuring the necessary quality of fire zones and cells, according to the requirements of "Fire analysis in the buildings of RC units 5 and 6, TB-EER and 3 and 4 DGS units 5 and 6, and SRSB-3;
- Implementation of fire prevention measures according to the recommendations of the "Analysis of the fire hazard in 5 and 6 buildings, taking into account the changes from the modernization measures and the amendments to the regulations of the Republic of Bulgaria.

2.1.6. Licensee's experience in fire safety analyses

The experience of “Kozloduy NPP” EAD in the implementation of analyses related to fire safety dates back to the design stage and is related to the assessment of fire risks from external and internal hazards, taking into account the stages of construction of facilities and implementation of FAS and FES.

The following complex analytical assessments of fire safety at the NPP were carried out during the course of the licensee's development activities:

- Analyses and assessment of fire hazards at the NPP site at the design stage, with part of the expertise focusing on assessments of local events with external and internal initiator.

  Development of a full-scale FHA performed within the scope of the Modernization Program in order to analyse and document whether the existing fire protection of the Kozloduy NPP, units 5 and 6, is sufficient to ensure the achievement of the nuclear safety objectives of the NPP in the defined operating conditions for the nuclear installation. The analysis was performed in accordance with the IAEA Safety Guide in force at the time and the measure also focuses on the division of fire zones and fire cells, with the consideration of:

  - the existing location of redundant equipment important to safety;
  - the amount and type of combustible materials by assessing fire loads, passive fire protection measures and separation measures;
  - architectural features and building type connections, wall openings, ceilings and connected rooms also in areas where safety systems are not located;
  - the access routes to the affected premises, necessary for manual fire extinguishing;
  - fire alarm systems, fixed fire extinguishing systems and manual fire extinguishing devices (hydrants, fire extinguishers);
  - the existing fire-resistant separated rooms and zones.
- Analyses related to updates of regulatory documents. In 2010, there were changes in the regulatory framework in the field of fire safety. The most important of them is the entry into force of Regulation No. Iz-1971 [8]. The goal is to synchronize the requirements in force in the Republic of Bulgaria with those in the EU. With the entry into force of the Regulation, new requirements are imposed on main process and non-process premises - laboratory buildings, warehouses and storage areas, administrative buildings, general layouts, and others. This necessitated additional in-depth analyses in order to perform sufficiency screening of the fire prevention measures implemented so far at units 5 and 6 of the Kozloduy NPP, considering the updated, stricter requirements for the technical rules and norms for ensuring fire safety defined in this Regulation.
- Analytical evaluations within the scope of the performed periodic safety reviews - cover a review of the existing fire protection analyses and additional analyses performed during modification of the FAS and FES carried out with extended volume, with the application of conservative assumptions in accordance with internationally accepted requirements and IAEA standards.

- An analysis of the implementation of the full set of measures to increase safety and fire protection was carried out in 2022, through the development of an updated probabilistic safety analysis. The PSA is completed for all reactor states (full power operation, low power operation and shut down reactor) and for unit and site specific hazards (including internal events, internal fires, internal floods and seismic impacts).

2.1.6.1. Overview of strengths and weaknesses identified

Taking into account the fire safety analysis activities carried out, the following strengths can be formulated:

- An in-depth deterministic analysis of units 5 and 6 of the Kozloduy NPP was carried out, which also includes the RAW storage facilities associated with these units;
- An analysis of a large fire in turbine hall – units 5 and 6 and its impact on MSL compartment, was carried out;
- An analysis of the oil fire in the Containment - RC of units 5 and 6 was carried out;
- An update of the level 1 probabilistic safety analysis of units 5 and 6 of the Kozloduy NPP was carried out, taking into account the fire risk, reflecting all changes in the design until mid-2020.

The results of the probabilistic analysis of fire events and their potential impact on the plant's nuclear safety were also used in the assessment of the cumulative effect of modifications at the Kozloduy NPP performed within the scope of the Periodic Safety Reviews.

The comparison of the results of the PSA level 1 update shows that the total risk for the power units, expressed by the frequency of fuel damage, is reduced by 66% compared to the previous assessment model. This also shows a reduction in the overall frequency of fuel damage from internal fires by about 76%.

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

At the Kozloduy NPP EAD, a system has been introduced for evaluation of events related to fire initiators and the identification of events related to the determination of potential sources of fire. In the specified database for fire events, information from each initiating event is archived according to characteristic assessment data (place of fire, duration, operating conditions).

Using a graded approach, based on the identification of direct and indirect causes, the degree of spread and affected systems, an assessment of the event is performed, and measures are taken to address the cause and prevent recurrence. In addition to each of the events, the source, the probable cause, and the duration of the fire (the factors complicating extinguishing, the initiating combustible material and the time of impact and extinguishing) are analysed.

When planning measures to improve fire safety the recommendations formulated in the scope of insurance inspections at the “Kozloduy NPP” EAD and the conducted partner missions and inspections of the IAEA and WANO in the field of fire safety are reflected (detailed information is presented in section 3.1.3.2 of this report).

As a result of identified weaknesses in the performed inspections and missions at the NPP, corrective measures are implemented related to:

- Implementation of modernization of the existing fire alarm and fire extinguishing systems (FAS and FES);
- Replacement of diesel fire pumps;
- Improvement of the training program related to emergency response at the NPP site;
- Update of the evacuation schemes in the premises of units 5 and 6;
- Provision of indicators for the presence of hydrogen in the premises of units 5 and 6 batteries;
- Increase of inspections and control of passive and active fire protection equipment on site.

The deadline for the implementation of the planned corrective measures is determined by the configuration management system at Kozloduy NPP and the defined approaches in the implementation of technical measures in the scope of increasing fire protection.

Analysing the cumulative effect within the framework of the performed Periodic Safety Reviews shows that the modernizations in the plant and the implementation of investment projects related to the minimization of fire risks, as well as the control of fire sources directly affect the level of safety of the Kozloduy NPP.

As a result of the assessment of the safety factors that were included in the scope of the PSR performed on units 5 and 6 of the Kozloduy NPP in 2016 and 2018, respectively, an update was made and all internal and external fire-initiating events specific to the unit and site for all operating states of the unit were reassessed.

A thorough probabilistic assessment of the external and internal hazards identified in this way, which have the potential to simultaneously affect all facilities on the site in the event of an initiator fire, was carried out.

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 NRA reviews and evaluates the submitted fire safety analyses in accordance with the requirements of the Regulation for ensuring the safety of nuclear power plants [2] and the Regulatory Guide for protection against internal fires in nuclear power plants [3].

The regulatory review in the field of fire safety analyses and related activities, technical solutions, and corrective measures in the provision of fire safety focuses on the following aspects of control:

- Review of the FHA and the related analytical parts during the implementation of the projects with foreseen protective measures to ensure the fire protection;
- Assessment of the models, conservatism and results of the assessments made and recommendations for modifications and changes in the design of the facilities;

- Analysis of the measures that are subject to the quality assurance procedures in the field of fire protection and the programs for technical supervision and inspections in the NPP;
- Analysis of operational events and approaches to identify potential safety failures that are fire-initiated.

Topical inspections are carried out in implementation of the agency's annual inspection plans to check the effectiveness and adequacy of fire protection measures.

2.1.7.2. Lessons learned from inspections and assessments as part of the regulatory oversight

The focus of regulatory control in the area of activities and measures to ensure fire protection at “Kozloduy NPP” EAD is permanent and aimed at the following defined directions:

- Regulatory review and control of measures to prevent internal fires in the NPP (providing preventive protection);
- Plan for implementation of fire protection activities (active and passive protection);
- Modifications in the design related to changes in the applicable regulatory framework in the Republic of Bulgaria;
- Regulatory review of activities related to the assessment of fire safety at the site of the Kozloduy NPP within the scope of the conducted periodic safety reviews;
- Review of functional indicators related to the evaluation of the effectiveness of the implementation of fire safety programs;
- Monitoring of deadlines and verification of the implementation of activities and measures to ensure fire safety at the NPP;
- Conduct of topical inspections in the field of the activities related to the provision of fire protection at the Kozloduy NPP.

Within the framework of the last topical inspection in the field of fire protection, conducted in 2021, it was found that fire safety at the Kozloduy NPP is maintained in accordance with the current regulatory documents, and that independent control and coordination of activities to ensure fire safety is carried out. Fire alarm and fire extinguishing systems are checked, tested, and maintained and upgraded in accordance with the established internal rules and the safety standards.

The recommendations of the regulatory body formulated as a result of the topical inspections in the field of fire protection have led to the improvement of the control and coordination of activities to ensure fire safety in accordance with the requirements of national legislation, European and international standards. They address the improvement of operational procedures, the instructions for functional tests of FAS and FES, as well as the instructions for fire safety of the organizational units.

Based on the regulatory recommendations, “Kozloduy NPP” EAD has implemented numerous measures aimed at expanding the volume and scope of tests and inspections of automatic gas and water extinguishing systems, fire alarm systems and fire barriers. The degree of monitoring of firefighting equipment has been increased, which leads to the rapid detection of defects and their timely reporting, analysis, and elimination.

One of the essential aspects related to the provision of an increasingly high level of fire protection is the improvement of the control of the activities by the independent

organizational structures in the company including the activities related to inspection, maintenance, tests and modernization of the systems providing fire protection.

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

The initial fire hazard analysis was prepared in 2003/2004. In 2010, a Level 1 Probabilistic Safety Analysis (PSA) was carried out, including an internal fire hazard analysis. In 2013 the PSA level 2 has been completed. The analysis covers the fire areas and adjacent zones, including the cable and switchgear rooms, the safety equipment rooms and the turbine hall. Frequencies of initiating events were determined, and analysis was used to identify vulnerable areas in the power plant and deficiencies in operating instructions.

In the period 2020-2022, an update of the existing PSA level 1 was carried out, reflecting all technical modifications implemented between 2007 and 2020, including the program for the modernization of the fire protection of units 5 and 6.

The regulatory review of the fire hazard analysis, as well as the applied modern methodology for analytical assessment of design assurance and the introduced protective measures for fire safety at “Kozloduy NPP” EAD, show a high level of compliance with the requirements of the applicable standards in the field of implementation of deterministic assessments of the fire hazard. According to the analyses of the functional design of the fire protection at the NPP, an adequate level of protection is presented, which meets the requirements for maintaining sufficient safety margins and ensuring the concept of defence in depth in the area of the fire protection.

The following strengths were considered in the evaluation of the analysis methodology and the identification of the initiating events for fires:

- The set of initiating events for the development of the analyses has been defined adequately and exhaustively, as all the mechanisms and physical processes that can lead to the failure of a given barrier have been identified;
- Realistic assumptions, realistic data and models were used and uncertainties were assessed;
- Specific analyses of the possibility of fire in specific locations of the unit have been carried out with a full assessment of aspects related to the detection, extinguishing and spread of the fire;
- All aspects of the impact of fires on safety-related equipment and the possibility of damage to the SSCs in the event of severe fires in terms of structural integrity have been assessed.

In the assessment of the impact and consequences, the possibilities of interaction with all affected facilities located at the site of the Kozloduy NPP were taken into account. For the performance of the analyses, the applicable modern software, and codes (computational models) when considering the characteristics of the SSCs and the specific buildings and facilities were used.

The regulatory review confirms the adequacy of the completed FHA in terms of its scope, analysis methodology and periodic update.

2.2. Research reactors

Not applicable

2.3. Fuel cycle facilities

Not applicable

2.4. Dedicated spent fuel storage facilities

2.4.1. Pool-type Spent Fuel Storage Facility (PSFSF)

The PSFSF SAR determined that it was necessary to analyse only the consequences of a fire in the switchgear room, as representative to a fire in the electrical and I&C equipment rooms. The main consequences of a fire in this room are:

- Loss of power;
- Loss of control and remote control systems.

The vehicles used to transport the SNF containers to and from the PSFSF can be considered as the only source of fire at the PSFSF. These vehicles must be technically sound and equipped with verified fire extinguishing equipment.

In the transport corridor where the vehicle enters, there are no safety related SSCs.

The construction of the containers for transport within the site (TK-6 and TK-13/3), and the containers for transporting SNF (TK-13/1B) ensure their integrity and leak tightness within 30 minutes, if the container is in the center of a fire with an average temperature of the flame not less than 800°C.

In the event of a fire in the transport vehicle, the distance from the source of the fire to the container is about 12 m, which allows to create a fire protection zone with the available means located in the transport corridor and to separate the container from the source of the fire.

SNF CONSTOR 440/84 dry storage containers provide the safe hermetic containment of spent nuclear fuel under the hypothetical conditions of a constant fire temperature of 600°C and a fire duration of one hour.

Calculations for fire conditions were performed with the Finite Element Modelling and Analysis program ANSYS 7.1, which has been verified and validated for the specific application. The fire conditions were modelled with a constant fire temperature of 600°C and a fire duration of 1 hour, resulting in higher temperatures of the tested elements than the conditions required by the IAEA: a fire temperature of 800°C for 30 minutes. SNF Dry Storage Containers have been found to have the required fire resistance.

The deterministic analysis of the design-basis accident "Fire in the premises of the PSFSF", carried out within the framework of the safety analysis for the current state of the PSFSF in 2013, proves that for all the initiating events considered in the design, as well as for extended design conditions, the acceptance criteria are met in terms of radiological consequences for personnel, the population, and the environment. Within the framework of the deterministic analysis, it was identified that no new/additional prerequisites for the occurrence of fire were created in the PSFSF, compared to the design ones, and compared to those reported in the SAR from 2003, incl.:

- no new machinery or equipment is installed that changes the fire risk assessment;
- the function and use for the premises in the PSFSF have not been changed;
- no new or additional materials are intended to be used to change the fire load rating.

From an inspection of the insurance risk of "Kozloduy NPP" EAD in 2023, a Report on the study of nuclear insurance pools for "Civil liability for nuclear damage" insurance was received, in which a recommendation was made to revise the fire hazard analysis of PSFSF. The implementation of this recommendation is planned until 2025.

2.4.2. Dry Spent Fuel Storage Facility (DSFSF)

The DSFSF is divided into two main operational areas: a reception area and a storage hall. The storage hall is used for storing CONSTOR 440/84 containers and is surrounded by shielding walls. The adjacent reception area is separated from the storage hall by a screen wall with a sliding screen door.

Preventive fire protection is provided in the design by minimizing potential ignition sources and fire loads. Potential fire loads in the vicinity of the DSFSF are very small and the concrete building provides sufficient external fire protection for the storage containers.

Within the transport corridor, the design has minimized the loads from potential fires. These are limited to the winch electric motor of the reversing unit, shock absorbers and tires on the trailer, tires and fuel on the tractor towing the trailer, electrical cabinets and cable network, and limited quantities of oils in closed systems. Combustible materials are not permitted to be stored in the storage area.

Various measures to prevent the occurrence and spread of fires are discussed in the DSFSF SAR. In the building, fire sources are limited to a few areas where the construction allows fires to be extinguished without spreading.

Potential fire situations for the containers, for example, caused by initiating events such as internal and external fires, fires after earthquakes or gas cloud explosions, result in only small local fires with little load on the containers. A fire with a constant temperature of 600°C and a duration of 1 hour is adopted for the DSFSF as the limiting design fire.

Numerical temperature calculations are performed with finite element program ANSYS 7.1 using two-dimensional and three-dimensional finite element models. The results show that the design temperature limit of fuel elements cladding of 330°C is not exceeded.

The impact of a fire does not lead to the release of radioactive substances and, accordingly, there are no radiological consequences for the population and the environment. Increased radiation exposure to personnel is possible as a consequence of fire suppression and post-accident mitigation measures.

The equipment specification takes into account the early detection and signalling of fires. In both areas (for reception and storage), as well as in all closed rooms, a fire detection system is provided.

The electrical equipment is housed in a separate closed room. Similarly, rooms where any activity or equipment creates a potential fire hazard are segregated to prevent the spread of fires. The reception area is equipped with manual fire extinguishers, as all activities creating a fire risk are carried out only in the presence of operators.

2.5. Waste storage facilities

Storage Facility for Conditioned RAW (SFCRAW)

In the basis of the radioactive waste conditioning technology is the inclusion of the waste in a cement matrix in Reinforced Concrete Containers (RCC), which does not allow the spread of radionuclides in the environment. The chosen method for cementing the liquid and for pressing the solid RAW in barrels is a solution that allows them to be combined during their packaging. In this way, the matrix simultaneously includes solid and liquid RAW, and the RCC in which they are contained isolates them from the environment, creating a secondary barrier, protecting them also from fire.

The container is a reinforced concrete structure in the shape of a cube, with a side of 1.95 m, which consists of two parts - a body and a lid. The lid has a hole in the middle (the hole serves to refill the container with "clean" cement solution). The mass of the empty container is 6 t, and the calculated maximum mass of the full container is 20 t. The useful volume of the container is 5 m^3, accordingly the percentage of useful to the whole volume is 68%.

The RCC is a construction with four hooks in the upper four corners of the body for carrying out transport-handling activities with it, and accordingly there are four hollow points at the corresponding geometric positions on the bottom for the entry of the hooks. This allows the containers to be stacked on top of each other in four rows and to store a large volume of waste in a small area.

RCC has a special external and internal coating depending on the chemical properties of the waste to be stored in it. It is alkali-, acid- and corrosion resistant. The reinforcement is without welds, which provides the necessary corrosion resistance. The concrete is designed and executed with the combined use of active mineral admixtures, where the corresponding compressive strength increases from 25 to 75% (over 40 MPa on the 28th day) and the leak tightness increases from 2 to 7 times compared to ordinary concrete mixtures.

The design of the lid allows, after filling the internal volume with waste, to close hermetically (watertight) to the body. Thus, the waste remains reliably and safely isolated from the environment.

Each newly developed RCC or RCC with a modified design undergo a series of quality assurance tests in accordance with industry standard OH 0185755-92 "Reinforced concrete container for transportation and storage of processed RAW", which include:

- radiation protection;
- free fall;
- pressure (for height storage);
- penetration;
- waterproofing;
- mechanical damage test (three types of free fall on a target);
- heat test (fire resistance).

The organization, scope, and order for conducting the tests are carried out according to a specially developed program.

The fire resistance test is carried out in the following sequence:

The test samples are placed in a vessel measuring 2.5m x 2.5m x 0.2m, filled with 468 liters of hydrocarbon fuel (petroleum). The fuel is ignited, evenly covering the four walls and the bottom of the RCC for 40 minutes (minimum 30 minutes if required), with flames 1-3 meters high and a temperature not lower than 800°C. After cessation of combustion and natural cooling, all specimens were found to exhibit a negligible number of shallow wall concrete failures.

The results show that the experimental samples tested are fire resistant, do not spread combustion and prevent the spread of radioactive waste.

SFCRAW is intended for temporary storage of packaged RAW, "temporary" meaning a period of time that can reach tens (10-25 and more) of years. It consists of two sheds, which are served by a transport corridor located between axes 1 and 2. In each of the sheds, it is possible to store 960 containers arranged in 30 rows in length, 8 rows in width and 4 rows in height, or a total capacity of 1920 RCC.

SFCRAW is an engineering facility that provides a sufficient degree of protection for personnel and the environment. In this case, the concept of defence in depth to ensure safety, based on the simultaneous application of a system of physical barriers and administrative measures, provides:

- prevention of spread of radioactive substances in the environment;
- protective barriers and maintenance of their effectiveness;
- protection of the population and the environment.

The physical barrier system of each facility is defined in the facility design. The safety of a facility should not depend entirely on a barrier. With SFCRAW this is achieved by:

- immobilization of RAW in a cement matrix;
- inclusion of the matrix in a package having a certain resistance to external influences, including fire;
- building structure resistant to certain characteristic external influences and protecting RAW packages;
- organizing a system of physical protection around the facility, limiting access to it.

For SFCRAW, safety related systems are as follows:

- Buildingstructure;
- Lifting and transport mechanisms;
- Fire safety systems.

The fire safety analysis for the SFCRAW facility is conducted within the Updated Safety Analysis Report of SDRAW Kozloduy and includes:

- Initial study of the facility and data collection:
  - Definition of operational states;
  - Description of processes;
  - Description of the hazard;
  - Limits of safe operation;
  - Measures to ensure safety.
- Qualitative safety assessment:
  - Identification of hazards;
  - Deterministic (qualitative) analysis of emergency scenarios:
    - Selection of initiating events for analysis;

- Qualitative analysis of the initiating events;
- Grouping of initiating events by category;
- Identification of undesirable end states.

- Quantitative safety assessment;
- Documenting the results.

The main conclusion of the Updated SAR is that a fire in SFCRAW is possible from a short circuit in the electrical circuits of the transport-technological equipment and cranes, and it is assumed that such an event will not affect the protective barriers, especially since SFCRAW does not store combustible substances and materials that help spread the fire.

2.6. Installations under decommissioning

Kozloduy NPP units 1-4

The fire safety of units 1÷4 at the Kozloduy NPP site is ensured in accordance with the national regulatory requirements and standards on fire safety, as well as internal documents, as follows:

- Regulation No. RD07/8 on the minimum requirements for signs and signals for safety and/or health at work;
- BDS ISO 11602-2:2002 "Protection against fire";
- Regulation No. Iz-1971 on Construction and Technical Rules and Regulations for Ensuring Fire Safety [8];
- Regulation No. 8121z-647 of 01.10.2014 on the Rules and Norms for Fire Safety during Operation of the facilities [9];
- Rules for fire safety of the SE RAW;
- Instruction on Fire Safety of SDD Kozloduy 1-4;
- Instruction on Fire Safety when carrying out hot works in SDD Kozloduy 1-4;
- Action plan for extinguishing fires of SDD Kozloduy 1-4;
- Rules for ensuring healthy and safe working conditions in SE RAW;
- Risk assessment program in the SE RAW;
- Internal emergency plan of SDD Kozloduy 1-4.

Compliance with the fire protection requirements and criteria for a fire-safe condition applies to all premises, facilities, and places in turbine building and controlled area where unit 4 electrical equipment, auxiliary and common station systems are located.

The fire safety analysis methods are based on the “Report on safety analysis during the decommissioning of units 3 and 4 of the Kozloduy NPP”, developed in 2015 on the basis of the planned activities and in connection with obtaining a decommissioning license presented in the table below.

Table 2 List of activities for the period of validity of the licenses,

for which a hazard analysis has been performed

№	Activity
1.	Plasma melting and conditioning of solid radioactive waste with a high volume reduction factor
2.	Extraction and processing of spent ion exchange resins from respective tanks
3.	Extraction and processing of the solid phase from concentrated liquid RAW
4.	Decontamination of open pools/reservoirs
5.	Decontamination of indoor pools/reservoirs
6.	Removal of the thermal insulation of the primary circuit and connected equipment
7.	Dismantling of equipment at the border of the RC and outside the RC
8.	Measurement of dismantled materials for exemption from regulatory control
9.	Activities and events related to components in which significant radioactivity accumulates – falling or breaking of spent filters
10.	Decommissioning and downsizing of dismantled equipment

In the fire hazard assessment during the implementation of these activities, the following possibilities are taken into account:

- Exposure to toxic and other hazardous substances – for example, asbestos, combustible materials, carcinogens, chemicals used in the decontamination process, suffocating gases;
- Other hazardous effects – for example, high temperatures in a fire.

A large part of the hazards are also inherent in the operation of the nuclear units, therefore the design decisions, supplemented by the operating instructions and other administrative measures, ensure the first level of defence in depth – prevention of deviation from normal operating conditions and the second level of defence in depth – prevention of design accidents with the means of normal operation. Therefore, these hazards are excluded from the analysis for normal operating conditions.

For these conditions, only new processes, and possible new phenomena not inherent to a unit in operation are considered (for example, stagnation in places where there was previously a circulating medium, etc.).

The full list of potential hazards is given in the following table. It states whether and how they relate to normal operating conditions and to emergency situations during the performance of activities.

Table 3 Extended checklist for the purpose of identifying fire hazards and their relationship to the validity of licenses

Hazards	Possible during planned works from the list of activities	Possible during incidents related to the list of activities
INTERNAL HAZARDS		
• *Fire*		
Thermal cutting techniques (e.g. using zirconium alloys)	No - fire protection measures, fire alarm and fire extinguishing systems	7, 10
Decontamination processes (chemical, mechanical, electrical methods or combined methods to remove contamination from metals, concrete and other surfaces)	No - fire protection measures, fire alarm and fire extinguishing systems	10
Accumulation of combustible materials and RAW	It is not allowed to collect combustible materials and RAW in the vicinity of each other	They are not expected in the considered activities
Flammable gases and liquids.	No - fire safety rules, fire alarm and fire extinguishing systems	1
• *Explosion*		
Decontamination process	Design measures to prevent the formation of explosive mixtures	Not expected under the intended decontamination methods
Powder (e.g. graphite, zirconium alloy)	There are no such materials	There are no such materials
Radiolysis (e.g. in storage and transport of RAW)	No - RAW 1 and 2 categories are generated	No - RAW 1 and 2 categories are generated
Gases under pressure	Safety measures when cutting	1, 10
Explosives	Such substances are not stored on site. No demolition of buildings or use of explosives is foreseen during the validity period of the licenses	Not applicable

3. FIRE PROTECTION CONCEPT AND ITS IMPLEMENTATION

The concept of defence in depth under Art. 3 of the Regulation on ensuring the safety of nuclear power plants [2] applies to all activities related to safety. When applying the concept to internal fire protection, it is necessary in the design of the NPP to provide for measures to prevent the occurrence of fires, to detect them in the event that they occur, to control and to mitigate their consequences.

The prevention, control, and reduction of fire hazards in any installation requires to study the fires and their effects on safety-related elements that must be protected in order to achieve the safety objectives. In accordance with the principles of defence in depth, the relevant practical means of fire protection aim at:

- Minimizing the likelihood of fires through:
  - elimination of flammable materials and potential sources of ignition as far as practicable,
  - strict control of all such ignition sources by limiting their number and location, for example by separating ignition sources from combustible materials.
- Fire control and containment through:
  - timely detection and extinguishing of the fire,
  - preventing the spread of fires.
- Mitigating the secondary effects of the fire and maintaining the safety functions identified as necessary in the event of a fire, including the protection of relevant SSCs.

Therefore, the protective measures are implemented and organized in different sequential levels, which should be as independent as possible. Each level of fire protection must prevent the situation from worsening and moving to the next level, as well as mitigate the consequences of the failure of the previous level.

In accordance with the concept of defence in depth, fire protection is generally provided by ensuring high quality and reliability of SSCs, by qualifying these SSCs, by applying the principles of redundancy and diversity, as well as by physical separation, segregation and design of suitable barriers and other protective means.

3.1. Fire prevention

Priority in the field of fire safety is:

- Reduction of the likelihood of fire occurrence as far as is practicable;
- Ensuring protection of safety systems so that they perform their functions.

Measures to ensure fire safety include:

- application of defence in depth principles;
- creating an organization with clearly defined individual responsibilities;
- implementation of the fire prevention and protection program.

Fire prevention activities are carried out in the following main directions:

- Minimize fire loads by using, where practicable, suitable non-combustible materials. If this is impossible, materials that slow down the spread of combustion are used.

- Minimizing the number of ignition sources at the design stage.
- Each system of the power plant is designed and constructed to ensure, as far as possible, a minimum risk of fire in the event of a system failure.
- Measures for the safe storage of flammable materials are foreseen in the design, and during the construction - implemented, as they are located at a safe distance from the safety systems or are protected in another appropriate way.
- Substances and materials capable of forming flammable and/or explosive gas-, vapor- or dust-air mixtures are stored and used in a way that prevents the formation of such mixtures. If this is impossible, fire and explosion safety is ensured by removing sources of ignition.
- Safety-important systems, including fire and explosion safety systems, are protected from the impact of natural phenomena - earthquakes, lightning strikes, tornadoes, floods, etc.

3.1.1. Design considerations and prevention means

Control of combustible materials and ignition sources shall be implemented to minimize the hazard of fire occurrence and spread, and where possible alternative non-combustible materials shall be used.

Control of fire load is a process of measures starting from the design with the aim of foreseeing the use of flame retardant or non-flammable materials during construction.

The next stage is the incoming control, which is carried out by the relevant organizational unit according to the Instruction for conducting the incoming control of the materials, raw materials and components delivered to the NPP and the Instruction for the incoming control of chemical reagents, materials, and fresh engine oils.

The control is carried out by performing checks for the compliance of the input materials with those provided in the design documentation. Inspections are carried out by the inspectors from the Fire Safety department, according to the Instruction for control activities of the Fire Safety department.

When an implemented investment project or modification is put into operation, the compliance of the design documentation with the implemented change is checked through a state acceptance commission or an internal departmental commission. Declarations of conformity of the used materials are presented.

The regulations for the storage, use, movement of combustible materials and responsibilities are defined and documented in the Rules for Fire and Emergency Safety of “Kozloduy NPP” EAD.

The operating instructions regulate the inspections for the presence of leaks of flammable liquids, combustible liquids, and gases in the premises.

In 2012, the "Analysis and Quantitative Assessment of the Risk of Major Production Accidents Related to Hazardous Chemical Substances on the Kozloduy NPP" was prepared. An assessment was made of the method of storage and stored quantities in accordance with the regulatory requirements. It examines accident scenarios and probabilities involving diesel fuel, hydrazine, nitric acid, ammonia, and hydrogen.

Safe storage, use and release of transportable combustible materials are also recorded in the plans for ensuring fire safety during the execution of planned annual outage (PAO), in-service repairs and construction and installation works.

In order to reduce and control the sources that can cause ignition during hot works, an order of the executive director was issued, which regulates the procedure for fire-safe execution of hot works. In order to ensure fire safety when carrying out hot works in places with increased fire danger, the specially created Regional Service "Fire Safety and Protection of the Population" located at the NPP site (RSFSPP-NPP) provides a duty with a fire truck.

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

Buildings and productions on the territory of units 5 and 6

The regulation of the fire load in the premises is a process of measures starting from the design. For each investment project for changes, reconstruction and modernization in the plant, a Part "Fire Safety" is developed, in which the impacts on the passive and active protection measures and the adopted technical solutions to ensure fire safety are indicated.

The next stage is the control of the input materials, consisting of the implementation of incoming control. Incoming control is carried out by the relevant organizational unit according to the Instruction for conducting the incoming control of the materials, raw materials and components delivered to the NPP and the Instruction for the incoming control of chemical reagents, materials, and fresh engine oils.

Control during the implementation of the projects is carried out by performing checks for the compliance of the materials used with those provided for in the project documentation. Inspections are carried out by the inspectors from the Fire Safety department, according to the Instruction for the control activity of this department.

The control of the compliance of the products used in the constructions and sites includes the verification of the documents certifying the characteristics of the construction materials related to the implementation of fire safety requirements.

In order to reduce and control the sources that can cause ignition during hot works, the fire safety rules of "Kozloduy NPP" EAD have been approved by the executive director and the above-mentioned order of the executive director has been issued which regulates the procedure for fire-safe performance of hot works.

According to the legislation, hot works include the following activities: welding, brazing, soldering, and cutting of metals and their alloys using welding equipment, abrasive machines and tools, liquid fuels, as well as melting (heating) of bitumen, resins, and the like, with the use of solid, liquid and gaseous fuel.

It is forbidden to start hot works without issuance of an Act for carrying out hot works in temporary places (exception - the designated permanent places for hot works). The Act defines the place of work, the nature of the work, the manager of the fire work, the fire work executor, the measures to ensure the safe performance of the fire work (before, during and after work and additional fire prevention measures) and the person who monitors the fire work. It is not allowed to carry out fire work before all measures specified in the Act have been completed.

Before starting the fire work, the manager of the fire work and an employee from the RSFSPP-NPP check the implementation of measures to ensure fire safety. Such an

inspection is also carried out after the completion of the work by the manager and the executor of the fire work. Checks are reflected in the Act of fire work. In the presence of conditions for the formation of an explosive environment from vapours or gases, a sample and analysis of the environment is organized and carried out, for which a protocol is drawn up. The protocol is an integral part of the Act of performing fire work.

The regulations for the receipt, storage, use, movement of portable flammable materials and the responsibilities are defined and documented in the Instructions for conducting incoming control of delivered materials, raw materials and components at "Kozloduy NPP", Rules for fire and emergency safety of "Kozloduy NPP" ” EAD, Instruction on fire safety in the “Stock Logistics” department, Instruction on the control activity of the Fire Safety department, Procedure for controlling the status of passive fire protection measures and the spread of fire, Instruction on fire prevention rules and requirements for warehouses and storage rooms, Plans for ensuring fire protection during current repairs and construction and assembly works, Safety instruction Fire and emergency safety in fire-hazardous and explosion-hazardous premises and facilities on the territory of Electricity Production-2 (EP-2), Instructions for ensuring fire safety in productions, departments and sectors in the company, and Instructions for maintaining the operational order and operational condition of the equipment, premises and areas of the subdivisions of the Kozloduy NPP.

The specified instructions define the requirements for storage, use and responsibilities when working with flammable substances and materials. The following is checked:

- unregulated collection and storage of flammable materials on the territory of the site;
- unregulated storage of flammable and explosive materials, flammable liquids and combustible liquids in the corridors, fire-resistant vestibules, staircases, process rooms and elevations, offices and laboratories;
- method of storage and use of explosive and combustible raw materials for painting, self-levelling floors and other purposes;
- not allowing the joint storage in laboratories and other premises intended for working with explosive and fire-hazardous materials of compressed air and oxygen in one room with flammable and combustible liquids;
- coordination with the fire safety authorities of intermediate warehouses for one-day (24-hour) work with combustible materials and non-combustible materials in combustible packaging.

Flammable materials, flammable liquids, combustible liquids, and combustible gases are stored in warehouses built in accordance with the requirements of the national regulatory documents in force at the time of authorization for their use.

Premises (workshops, laboratories, and consumables warehouses) in which certain quantities of flammable liquids, combustible liquids, and combustible materials are stored in non-combustible cabinets are designated by fire hazard category F5C according to Ordinance No. Iz-1971 [8], if a higher category is not specified (F5A or F5B). The category is designated with signs according to the requirements of Art. 24 of Ordinance No. 8121z-647 [9] on the rules and norms for fire safety during operation of the facilities. For the materials that will be stored in the non-combustible cabinets, a list with their brief description is prepared. The substances are arranged in the cabinets by groups.

In the plans for ensuring fire safety during PAO, in-service repairs and construction and installation works, measures for safe storage, use and disposal of mobile flammable materials are also recorded.

If there is a need for temporary placement of combustible materials on the territory of the NPP, a placement scheme with the additional combustible load is drawn up, which is agreed with the state control bodies for fire safety.

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

3.1.3.1. Overview of strengths and weaknesses

Buildings and productions on the territory of units 5 and 6

Strengths

The Fire Safety Program includes maintenance, testing, monitoring, and inspections, including hazard management processes such as:

- control and administrative procedures for fire hazard control;
- inclusion of firefighting equipment in the scope of the aging management process - physical and technological;
- hazard mitigation and response equipment monitoring programs;
- fire risk management.

Fire hazards are taken into account when planning and conducting inspections.

Weaknesses

In accordance with the recommendations made from the program for extending the equipment lifetime of units 5 and 6 of the Kozloduy NPP, actions have been taken to implement measures to replace the existing detectors for the AlgoRex CS1140 Modular Fire Detection System with new FDOOT241- A5 type detectors (Interactive – Sinteso protocol). The replacement is planned to take place in the period until 2027.

A local automatic fire extinguishing system for the diesel fuel tanks in CWPS 3 and 4 is also planned to be built. The measure is planned for implementation by the end of 2025.

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

Buildings and productions on the territory of units 5 and 6, including PSFSF and DSFSF

According to the "Kozloduy NPP EAD Management System Manual", the main objective of the operational experience process is to ensure maintenance and improvement of the plant's safety and reliability through effective study and use of internal and external operational experience. In accordance with the requirements, the corrective measures described below have been analysed and implemented.

In connection with an event from April 2019 related to the activation of a "Fire" signal during the performance of hot works:

- Requirements are introduced in the relevant instructions: 1. In premises where construction, repair and hot works are carried out (with dismantled doors or air ducts), to take out of service the FAS and the FES in all connected premises. 2. The issuer of the order for construction activities to make sure that the planned preparation of the

workplace is in accordance with the actual conditions of the upcoming work through a personal inspection.

In relation to an October 2019 incident involving angle grinder cutting and sparking on equipment:

- Additional requirements for storage and transportation to and from the workplace in non-flammable containers with lids, which can only be removed from the non-flammable container when working with them, and for placing easily flammable waste and dismantled oiled pieces of equipment in non-combustible lidded containers.

- In addition, a requirement has been introduced in the fire safety instructions - after completion of the day's work, to remove all flammable liquids and combustible liquids from the workplace.

In connection with an event from November 2020 related to the activation of a fire alarm in a cable shaft, when working according to a work order and an Act of hot works:

- An amendment was made to the instructions to regulate the procedure for closing the Act for hot works, in case of non-compliance with the conditions entered in the Act.

- An inspection was carried out and the "Burgas" type fire doors were replaced in all fire areas and cells of units 5 and 6, CWPS-3,4 and SRSB -3.

- A commission inspection of cable ducts was conducted in all fire protection areas and cells of units 5 and 6, CWPS-3,4 and SRSB -3, to establish their condition (sealed/unsealed) and measures were taken to seal them.

In connection with a registered defect of a pipeline from an automatic fire extinguishing system of the safety systems and a conducted analysis, decisions were made to replace the pipelines with corrosion-resistant austenitic steel. The developed design is in the process of implementation. In this regard, a long-term schedule for operational control (thickness measurement) of the pipelines has been developed.

From the insurance inspection carried out in 2012-2023, weaknesses were identified and as a result the following measures to improve fire safety were implemented:

- Installed detectors for the presence of hydrogen in the rooms of the storage batteries and related annunciators for unit 5 and 6;
- Installed detectors for the presence of hydrogen on the ceiling in the batteries' room, sensors for the flow of exhaust ventilation and related annunciators;
- Replacement of the diesel fire pumps.

OSART – 2012 mission

Key conclusions of the fire prevention and protection program:

The Mission identifies the following practices as Good Performance

- The plant has a detailed testing and supervision schedule for the site's fire protection systems. This is complemented by a unique interaction with the national fire service, whose fire command is based close to the site and periodically trains at the site. This results in very good cooperation with the national fire service, which provides mitigation measures for decommissioned fire systems and supports activities such as hot works, including the authorization of these activities.

- As part of the emergency planning program, the plant maintains regular formal relationships with state and local authorities. Weekly coordination meetings are held with the Regional Office "Fire Safety and Protection of the Population" - NPP, the Regional Police Department - Kozloduy NPP and the municipal authorities. The operating organization notifies local authorities when an emergency situation is declared, even at the alert level.
- Plant managers participate in every exercise and actively support the emergency preparedness training program. Firefighters and emergency response teams at the plant receive prior training at the national center in Montana. This facility includes rooms simulating conditions that might exist during a plant accident: radiation environment, high noise level, presence of steam or poisonous gases, or total darkness.

Mission suggestions for possible areas of improvement:

Suggestion: The plant should consider creating a list of response functions that are appropriate for the on-site emergency response organization. It should consider using this list to create an exercise program that will cover all response objectives over a period of several years.

The suggestion is completed by the plant:

- In the new edition of the Emergency Plan of "Kozloduy NPP" EAD, Appendix "Procedure for determining the objectives during emergency drills and exercises" has been developed, including a table with all the objectives that can be covered during trainings and exercises at Kozloduy NPP EAD for 5 years, as well as the organizations responsible for their implementation.
- This amendment has also been introduced in the External Emergency Plan of “Kozloduy NPP” EAD (an Attachment to the National Emergency Plan).

WANO peer reviews

From the conducted WANO review missions 2013, 2017 and 2021, areas for improvement were identified as a result of which the following more important measures were derived and implemented:

- Inspections are regulated in the operating instructions on:
  - condition of active and passive fire safety equipment;
  - presence of leaks of flammable liquids, combustible liquids and gases in the premises.
- Changes have been made to the fire safety instructions of the structural units which include a description of:
  - what type and quantities of combustible, easily flammable substances and gases is used;
  - safety measures, labelling, conditions and place of storage and their maximum permissible quantity.
- Planning, organizing and conducting training of fire safety officers in the organizational units and the operational unit to carry out inspections of passive and active fire protection equipment.

- In the route maps for the tours of the operational personnel, checks of the condition of the available equipment for active and passive fire protection are included.
- Fire safety officers in organizational units prepare schedules for carrying out inspections of passive and active equipment and enter logs to reflect the results of inspections, according to an instruction.
- Barriers on the evacuation routes, built at a height of less than 2 meters, which create conditions threatening the safety of evacuating people in the event of an accident, are indicated.
- The evacuation plans in the sites of EP-2 have been updated.
- Marked locations of sanitary trolleys, during sanitization of buildings and premises, so that they do not create conditions to impede evacuation.
- The procedures for operation, functional tests and repairs for the evacuation and emergency lighting are brought in line with the requirements of BDS EN 60 598-2-22.
- According to detailed designs, modernizations (replacement) of the existing fire alarm and fire extinguishing systems (FAS and FES) were carried out in the TB of units 5 and 6, circulation pumping stations 3 and 4, the additional diesel generators and the new backup emergency power supply - unit 6, Water Treatment Plant (WTP) and United Auxiliary Building (UAB), SRSB-3 with new SIEMENS systems based on the SINTESO platform, model FC 20XX.
- The MM8000 Siemens visualization system has been upgraded to the latest generation Desigo CC.

Positive findings:

- The plant has implemented a sufficient number of fire protection measures, including automatic gas and water extinguishing systems, fire alarm systems and fire barriers, and has developed schedules and programs for checking the operation of these systems. The condition of these fire barriers is good.
- The plant has implemented a system for continuous monitoring of firefighting equipment through three operators on permanent duty. Defects are identified, reported to management and recorded in a database.

3.1.3.3. Overview of the actions and implementation status

The responsibility for the management, organization, and control of fire safety in the Company rests with the Executive Director. By delegating powers within the organizational-management structure, organization, management and planning of events maintaining a constant level of effective fire safety is carried out.

The activities of control and coordination of measures to ensure fire safety in accordance with the requirements of national legislation, European and international standards are delegated to the "Fire Safety" department. Employees from the department control the actual state of fire safety and compliance with the requirements of the current regulatory and technical documentation in the field of fire safety. The head of the "Fire Safety" department has been delegated the rights to create an organization and control compliance with the rules and norms for fire safety in the company. According to the organizational and management structure, the "Fire Safety" department is within the "Safety" division.

Within the Kozloduy NPP there is a separate organizational unit "Fire protection systems and equipment" (FPSE) department. In accordance with the requirements of national legislation, they carry out all maintenance and technical service activities of the fire alarm and fire extinguishing systems with their associated electrical and manual valves, fire doors and partitions, fire dampers of air ducts, fire engineered features and equipment for initial fire extinguishing.

In order to organize the maintenance of passive and active measures for fire protection and prevent the spread of fires, procedures and instructions have been drawn up, regulating the scope of control, maintenance, the frequency of inspections and functional tests, as well as the responsibilities of the staff, to guarantee their normal operating condition.

Control of the functional state of the fire alarm and fire extinguishing systems is carried out by shift personnel. There are three Fire Protection Systems operators on shift. The operational staff of the “Kozloduy NPP” EAD in the event of a fire act according to developed and approved fire extinguishing plans for each organizational unit, and their actions are coordinated with RSFSPP-NPP.

In the organizational units of the Company, by order of the relevant managers, officials are appointed who create an organization, carry out control for compliance with the rules and norms for fire safety and keep a file with documents related to ensuring fire safety.

By a Decision of the Council of Ministers of the Republic of Bulgaria from 1992, in order to ensure the security and fire protection at the site of "Kozloduy NPP" EAD, the Regional Service "Fire Safety and Protection of the Population" at the NPP site was established (RSFSPP-NPP).

The activities and duties of the RSFSPP-NPP are in accordance with the Act on the Ministry of the Interior and the Regulations for the Implementation of the Act on the Ministry of the Interior. The main duties are the performance of independent state fire control and fire emergency rescue activities.

To fulfill its duties, RSFSPP-NPP has been formed with a sufficient number of professional employees and specialized vehicles. The formed units for firefighting and emergency-rescue activities maintain 24 hour continuous duty at the site and have three teams on duty.

Control of compliance with the requirements in the field of fire safety is carried out by conducting formalized inspections according to the Instruction for control activities of the Fire Safety department. All detected deviations and violations of the current regulatory and technical requirements in the field of fire safety during the performance of the inspection activity are documented in order to:

- analyse the causes of deviations and violations;
- identify and take the necessary measures to eliminate the identified deviations and violations;
- analyse the activity of the organizational units and the measures taken by them to reach an adequate level of fire safety.

Depending on the frequency of the inspections, they are monthly, quarterly and semi-annual. The frequency of inspection of a site is determined depending on the importance to the safety of the plant.

All types of inspections are carried out in the form of tours and observations in order to determine all conditions that could worsen the fire safety of the sites at "Kozloduy NPP" EAD. The detected violations or deviations from the requirements for fire safety are filed in the plant information system "Organization of Operational Activities" (IS OOA). Monthly and annual reports of the Fire Safety department are prepared to report on the above-mentioned activities.

In accordance with the Quality Assurance Rules "Using a system of indicators for self-assessment of the effective management of the Kozloduy NPP EAD", specific indicators are analysed annually by the Fire Safety department, which show to what extent the declared goals for ensuring fire safety at the plant have been achieved. Based on the results of the achievement of the specific goals, the result of the functional indicator "Effectiveness of fire safety programs" is determined. For 2023, the trend towards performance of the indicator is positive.

The functional indicator "Effectiveness of fire safety programs" is part of the system of self-evaluation indicators at " Kozloduy NPP" EAD and is determined according to a special administrative instruction. It is monitored in order to timely assess the achievement of the declared goals for ensuring fire safety and to take corrective measures if necessary.

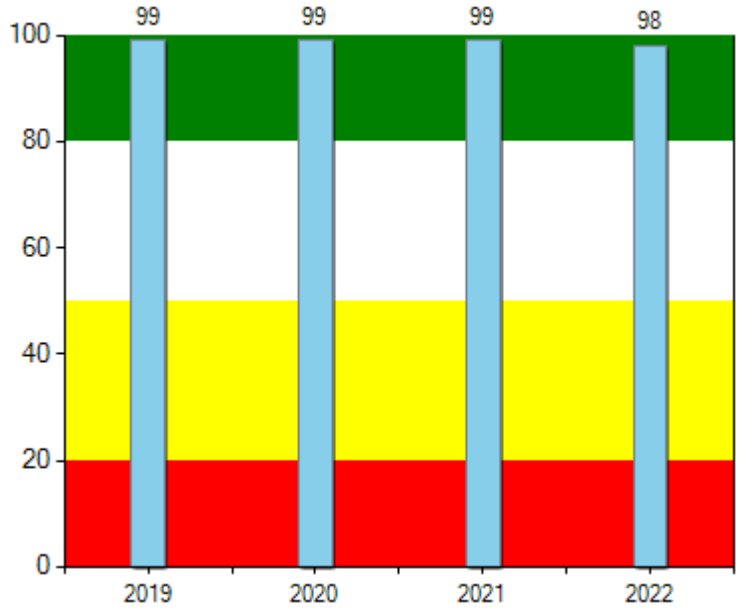

Fig 2. Functional indicator "Effectiveness of fire safety programs"

The functional indicator "Effectiveness of fire safety programs" consists of the following specific indicators:

1) Specific indicator “Number of potentially dangerous events with fires and ignitions occurring in a one-year period”

The indicator characterizes the fire events that have caused, or have the potential to cause, a threat to the nuclear safety and production cycle of the plant during the reporting period.

The purpose of the indicator is to monitor the fire situation in the plant and serves to assess the degree of hazard in it and to develop measures to improve the fire protection system.

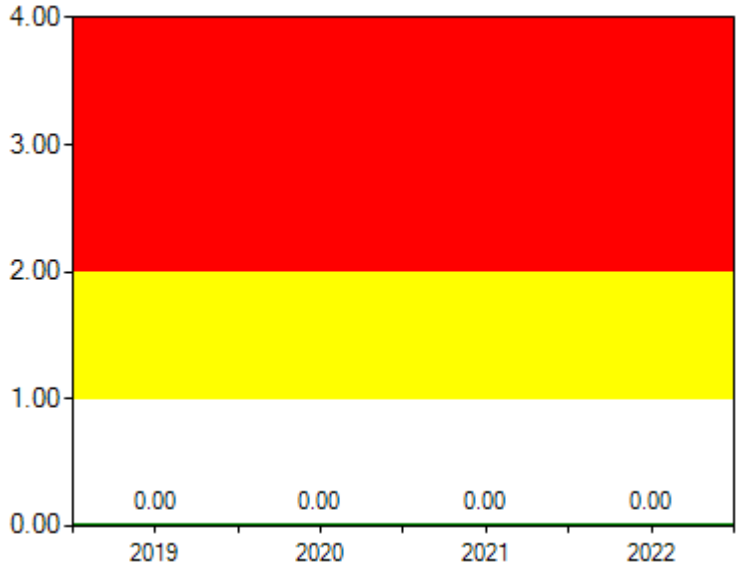

Fig 3. Specific indicator “Number of potentially dangerous events with fires and ignitions occurring in a one-year period”

2) Specific indicator “Number of non-potentially dangerous events with fires and ignitions occurring in a one-year period”

The purpose of monitoring the indicator is to determine the general fire situation in the plant and serves to develop measures to improve the fire protection system.

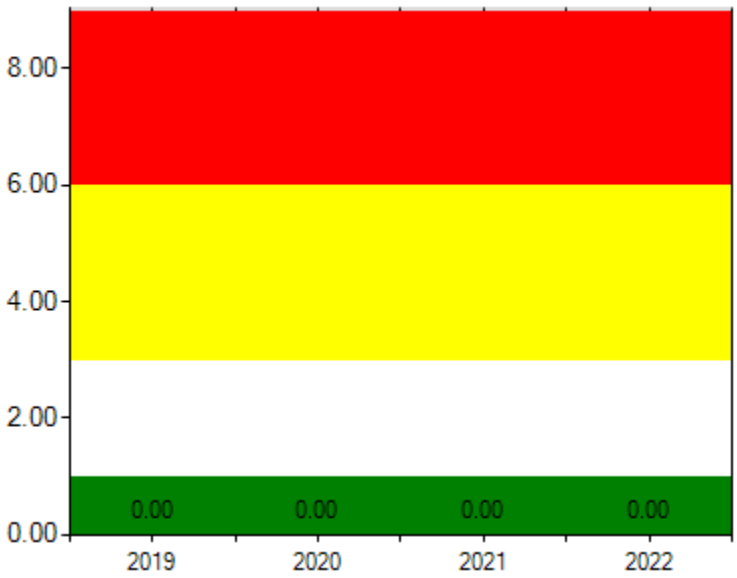

Fig 4. Specific indicator “Number of non-potentially dangerous events with fires and ignitions occurring in a one-year period”

3) Specific indicator “Measures to increase the facility's readiness to withstand fire events and countering fires that have occurred”

The indicator takes into account the degree of implementation of the prescribed actions related to fire safety, made by the Fire Safety department, during the inspections carried out by them.

The purpose of monitoring the indicator is to assess the degree of implementation of the prescribed actions by the Fire Safety department to increase the readiness of objects, territories and installations in EP-2, BPS, OSY, DSFSF and PSFSF for resistance to fire events and countermeasures to fires that have occurred.

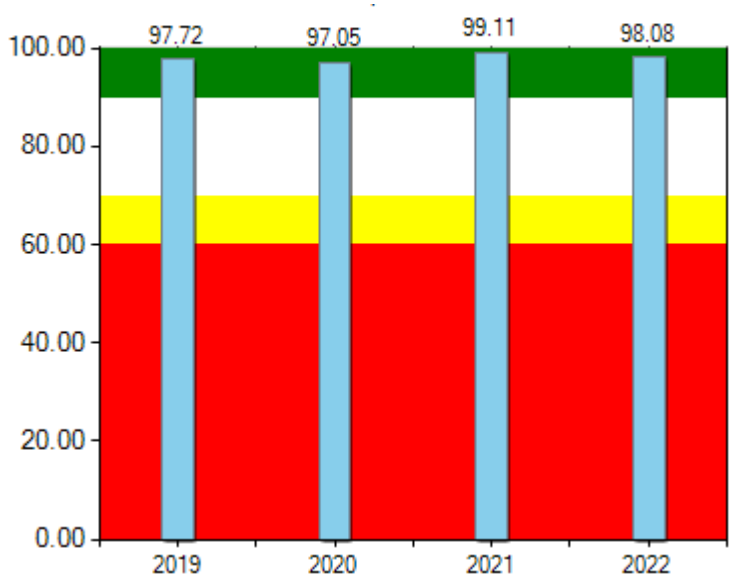

Fig 5. Specific indicator “Measures to increase the facility's readiness to withstand fire events and countering fires that have occurred”

4) Specific indicator “Corrective measures to increase the readiness of the site to withstand fire events and countering fires that have occurred”

The indicator takes into account the degree of implementation of the corrective measures related to fire safety, prescribed by the Fire Safety Authority, the National Fire Protection Agency, the Insurance Pool, WANO and OSART missions, during their inspections.

The purpose of monitoring the indicator is to assess the degree of implementation of the measures prescribed by the General Directorate "Fire Safety and Protection of the Population", the NRA, the Insurance Pool, WANO and OSART missions to increase the readiness of objects, territories and installations in EP-2, BPS, OSY, DSFSF and PSFSF for resistance to fire events and response to fires that occur.

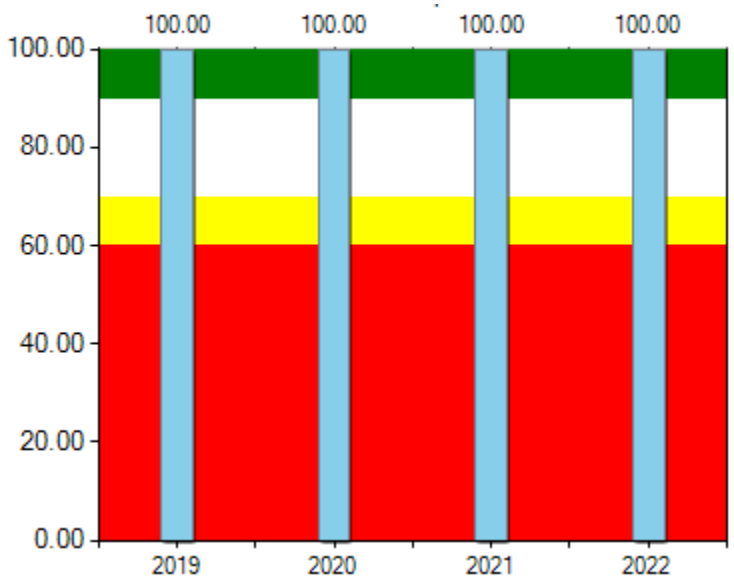

Fig 6. Specific indicator “Corrective measures to increase the readiness of the site to withstand fire events and countering fires that have occurred”

The values of the functional indicator and of the specific indicators for the activity of the sector during the reporting year are within the limits of the strategic objective and do not need improvements.

3.1.4. Regulator’s assessment of the fire prevention

3.1.4.1. Overview of strengths and weaknesses

“Kozloduy NPP” EAD is a facility of national strategic importance and reports directly to the General Directorate "Fire Safety and Protection of the Population" of the Ministry of Internal Affairs.

The General Directorate "Fire Safety and Protection of the Population" during the implementation of its activities carries out complex and control inspections on the territory of "Kozloduy NPP" EAD.

All passive fire protection measures fall within the scope of the complex inspections, which are carried out at least once every four years. The results of the complex inspections are reflected in a protocol, in which the detected violations and non-conformities are described as measures for elimination with specific deadlines.

The implementation of all measures is certified by protocols from certain committees. From all the complex inspections carried out up to now, the necessary organization was promptly created at "Kozloduy NPP" EAD and adequate measures were taken to eliminate the noted observations, and at the moment there are no unfulfilled measures.

Annually, the NRA and the General Directorate "Fire Safety and Protection of the Population" carry out inspections for the readiness for start-up of power units 5 and 6 of the "Kozloduy NPP" EAD, after a planned annual outage. The results of the inspections are reflected in protocols or statements with a conclusion on the stage of readiness for start-up of the respective power unit.

According to the NRA plan for inspection activities the following topical inspections were carried out last years and their results are documented in findings protocols:

- “Fire safety of "Kozloduy NPP" EAD – operation and maintenance“, March, 2016.
- “Measures to ensure the fire protection at NPP Kozloduy ”, December, 2021.

During the performed inspections, no substantial non-conformities were found, and no suggestions and recommendations were made.

3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

After the inspections, the regulatory authorities deliver protocols with inspection results and with the detected non-conformities, if any. The removal of non-conformities is subject to subsequent control by the regulatory authorities.

During the last topical inspections of the NRA, related to fire safety, no significant non-conformities were found.

3.1.5. Fire prevention in the spent fuel storage facilities

Pool-type Spent Fuel Storage Facility and Dry Spent Fuel Storage Facility

The design of the facilities reflects the following requirements:

- to reduce fire hazard;
- to provide physical separation of systems necessary to achieve plant safety objectives.

The instruction for ensuring fire safety in the PSFSF organizational unit that operates the buildings and facilities of the PSFSF and DSFSF defines the responsibilities of the officials in the PSFSF unit for the organization, maintenance and control to ensure fire safety and regulates:

- the criteria for the fire safety status of the objects, equipment and facilities;
- the requirements for fire safety in the performance of the various types of activities related to fire safety;
- the order of operation, checking the condition and maintenance of the passive and active means to ensure fire safety;
- the procedure for storage and use of flammable and combustible liquids, combustible gases and combustible materials;
- the organization and order of action of personnel in the event of a fire and ensuring evacuation.

The instruction was prepared according to the requirements of Regulation No. 8121z-647 on the Rules and Norms for Fire Safety during Operation of the facilities [9].

In the buildings, premises, and technological facilities of the PSFSF and DSFSF during operation, repair, and reconstruction, transformation, and re-engineering the principles of defence in depth and provision of adequate measures for passive and active protection are applied, which amount to:

- preventing the occurrence of fire by reducing the combustible load and sources of ignition to the minimum possible;
- regulation of smoking zones;
- periodic cleaning of building structures, technological and electrical equipment, heating elements and installations of combustible materials;

- regulation of the order of use of heating and heating appliances and equipment;
- turning off electrical equipment when not in use;
- creation of a special organization of technical and organizational measures when carrying out fire-hazardous activities (hot works Act);
- regulation of the procedure for storage and use of easily flammable and combustible liquids;
- ensuring the necessary degree of fire resistance of partition structures and elements of buildings and facilities in order to prevent the spread of a fire and the dangerous secondary effects of the fire;
- laying of fire-resistant coatings on building structures and cables;
- sealing of cable, pipe and ventilation ducts;
- ensuring the required rapid detection with subsequent localization and extinguishing of a fire;
- automatic shutdown of the ventilation systems when the fire alarm system is activated;
- regulation of the order and manner of action of the personnel in case of fire and evacuation.

Strengths

The PSFSF and DSFSF buildings do not contain combustible materials. The use of combustible materials outside the storage area in the receiving area is minimized by not storing materials and equipment that could pose a fire hazard. In the administrative area, where there are materials and equipment that could be a fire hazard, the fire load is minimized as far as possible. In addition, the administrative area is separated from the reception area and the storage area by a technical fire barrier with 1 hour fire resistance.

The types of electrical cables used do not maintain combustion and do not form poisonous smoke. All secondary electrical systems are shut down when the building is not in service. Backup generators and their fuel tanks are located at a distance from the PSFSF and DSFSF main building.

The main supporting structure of the DSFSF (columns and walls) is reinforced concrete with a fire resistance limit of more than 2.5 hours and more than 6 hours, respectively. The steel roof structures are covered with a fire protection coating that provides fire resistance of over 45 min. The roof panels are selected panels with required equivalent fire resistance.

Weaknesses

From an inspection of the insurance risk of "Kozloduy NPP" EAD in 2023, a "Report of the study of nuclear insurance pools for "Civil liability for nuclear damage" insurance" was received, in which a recommendation was made to revise the Fire Hazard Analysis (FHA) of the PSFSF.

Kozloduy NPP has decided to carry out a "Fire Hazard Analysis (FHA) of the PSFSF" by the end of 2025.

3.1.6. Fire prevention in the RAW storage facilities

Storage Facility for Conditioned RAW

For the introduction and implementation of the national legislation on ensuring the fire safety rules and norms for the SFCRAW facility, the following documents have been developed in the SDRAW Kozloduy:

- Emergency plan of SDRAW Kozloduy;
- Fire Safety Instruction of SDRAW Kozloduy;
- Personnel action plan for extinguishing fires at SDRAW Kozloduy;
- Evacuation action plan in case of fire, accident or natural disaster in SDRAW Kozloduy;
- Instruction on fire safety when carrying out hot works at SDRAW Kozloduy.

The concept of fire protection in the SFCRAW design is based on the implementation of measures to reduce the risk of fire, namely:

- physical separation of systems;
- personnel protection in case of fire;
- protection of technological and other equipment from fire;
- early detection of fire;
- timely extinguishing of fire.

SFCRAW is a facility for storing processed RAW, which must ensure the isolation of the radionuclides contained in the waste from the population and the environment for the entire intended period of storage. The purpose of this facility is:

- to protect RAW packaging from external events;
- through the created special security regime to prevent the intentional or unintentional spreading of radioactively contaminated materials into the environment;
- to protect the packaging from tampering.

Based on the complete analysis of the combustible load, a justification of the fire protection of the object was made. Regarding the category of fire hazard, the site is category F5D according to Regulation No. Iz-1971 [8]. For objects of this category, the installation of automated fire extinguishing and fire alarm systems is not required.

There are no combustible materials in SFCRAW, the structure and stored objects are mainly made of reinforced concrete, and the fire load is assumed to be 0 (zero).

Fire prevention includes:

- staff training and instructing;
- conducting fire drills;
- exercising control during the implementation of the activities.

In order to carry out internal fire safety control in SDRAW Kozloduy, the position of "Technical safety and fire safety" expert is provided. The person holding this position has the relevant professional qualification in the field of fire safety.

In SFCRAW, there are no permanent places for carrying out hot works, and if necessary, the procedure for carrying out hot works in temporary places, defined in the Fire Safety Instruction for hot works in SDRAW Kozloduy, is followed.

When violations are detected, immediate corrective actions are taken to solve the problem in accordance with the Instruction for maintaining the operational order and operational condition of the SSCs in SDRAW Kozloduy.

According to the Emergency Plan of SDRAW Kozloduy and the Emergency Preparedness Maintenance Program, a Thematic Plan-Schedule is developed annually for conducting emergency drills in the respective year.

Once a year, a fire drill is held with the entire personnel of SDRAW Kozloduy and the participation of teams from RSFSPP-NPP Kozloduy.

Joint fire drills are also conducted with those related to the activity and, due to the proximity of the facilities, with the organizations located at the Kozloduy NPP site and SDRAW Kozloduy.

After each training session, a debriefing is done and reported with a protocol, taking follow-up actions to eliminate any discrepancies.

3.1.7. Fire prevention in the facilities under decommissioning

Unit 4 of Kozloduy NPP

In the buildings, premises, and technological facilities of SDD Kozloduy 1-4, during operation, repair, reconstruction, transformation and re-engineering, it is necessary to observe the principles of defence in depth and ensure adequate measures for passive and active protection, which include:

- fire prevention:
  - allocation of permanent places for carrying out hot works equipped with necessary firefighting equipment;
  - regulating the procedure for carrying out hot works in temporary places;
  - control during work;
  - training and instructing of personnel on fire safety;
  - conducting fire drills;
  - maintenance of fire-technical equipment (FAS, FES, IFH, Evacuation and emergency lighting and portable fire extinguishers);
  - fire safety assessment in case of design modification.
- quick detection and extinguishing of a fire;
- preventing the spread of fire, minimizing its impact on safety systems.

The application of the defence in depth principle should ensure:

- reduction to the limits of practical justification of the possibility of a major fire;
- adequate protection of the safety systems so that the consequences of a single fire do not cause a common cause failure;
- the necessary conditions and possibilities for extinguishing fires with fire-technical means and equipment for initial extinguishing.

On the territory of unit 4, there are no designated permanent places for carrying out hot works. The allocation of temporary places for carrying out hot works follows the "Instruction on Fire Safety when carrying out hot works in SDD Kozloduy 1-4".

On the territory of unit 4, there are no separate rooms for storing and working with combustible materials. When the need to use combustible materials arises, the instructions for safe use of the manufacturer are followed and they are used in quantities that do not

change the fire hazard category and the functional purpose of the premises. The procedure for collecting and removing combustible waste is determined by an internal order.

For the implementation of internal control on fire safety in SDD Kozloduy 1-4, three jobs are planned for the position of chief expert "Fire and occupational safety". The persons occupying this position must possess the relevant professional qualification in the field of fire safety.

When violations are found, immediate corrective actions are taken to solve the problem in accordance with the SDD Kozloduy 1-4 Engineering Technical Personnel Walkdowns Instruction.

When organizing works and carrying out activities that temporarily change the level of fire hazard at the sites, plans are developed and presented to RDFSPP-NPP to ensure Fire Safety, and the conditions for safe evacuation.

All changes to the SSCs are implemented according to the Instruction "Amendment to the design" with prepared technical solutions that are evaluated from the point of view of fire safety, and new designs are evaluated and agreed by RDFSPP-NPP.

All malfunctions in electrical installations and equipment that can cause sparks, short circuits, heating of the insulation of cables and wires, failure of automatic control systems, and others are removed immediately.

After the end of the work day, the power supply to the electric circuits, except for the one provided for the power supply of consumers with a continuous mode of operation, is turned off.

The control to reduce the risk of fires in each installation is also managed by the daily presence of inspectors from RDFSPP-NPP, who carry out control and admission of personnel to conduct fire activities. Fire activities are conducted in a regulated manner by order of the executive director of SE RAW in accordance with Article 9 of Regulation No. 8121z-647 on the Rules and Norms for Fire Safety during Operation of the facilities [9].

An integral part of this activity is the Act for carrying out hot works. In this Act, all the details of the workplace, safety measures and the duties of each member of the brigade are regulated. The safety measures include a hot works observer, provision of fire extinguishers for initial extinguishing and a fire blanket. The workplace is secured the day before and RDFSPP-NPP is notified. For activities with increased fire risk, if necessary, a special on-duty firefighting vehicle of RDFSPP-NPP is provided.

When starting work, the authorizing operator instructs the personnel to familiarize themselves with the fire safety measures and explains the fire safety rules and the procedure for action in case of ignition or fire. The same operator supervises compliance with the fire prevention rules, requirements and regime by all personnel and workers from other departments and external companies during work and after the end of the work day and visually controls the condition and suitability of firefighting appliances and equipment. At the end of the work day/shift, the personnel performing the activities should check and leave the workplace, the devices, machines, equipment, etc., with which they worked, in a fire-safe condition.

The free yard area of all facilities belonging to SDD Kozloduy 1-4 is kept clean of combustible waste, dry vegetation, and other plant residues. Undeveloped areas, separated by the legally required distances between buildings and facilities, are not used for the

storage of materials, equipment, waste packaging, for parking transport and other technical means and for the construction of temporary buildings and facilities.

3.2. Active fire protection

At Kozloduy NPP, the approach of "Limiting the spread of fires" is applied, as it primarily uses passive protection systems, thus the protection of safety systems does not depend on the operation of stationary fire extinguishing systems. Buildings that contain equipment important to safety are designed to be fire resistant, divided into fire zones and fire cells.

The division of fire zones and fire cells was made depending on the amount of combustible load, which determines the required fire resistance. At the same time, passages such as doors, air ducts, manholes, fire dampers and cable routes, ventilation pipes and pipelines, which make up part of a fire barrier and the border of a fire zone, have at least the same fire resistance.

To achieve effective fire protection, addressable, self-diagnosing automatic fire alarm systems with high accuracy and reliability in fire detection have been installed. Fire alarm systems are of particular importance for taking timely and adequate firefighting action.

3.2.1. Fire detection and alarm provisions

For the timely and quick detection of fire or ignition, automatic fire alarm systems (FAS) have been installed .

FAS are intended to:

- detect the fire in the earliest possible stage of combustion;
- give signals and indications so that appropriate actions can be taken by the operational personnel on duty;
- provide sound and visual signals to the occupants of the buildings that may be exposed to the risk of the fire, in order to take the necessary evacuation actions.

Automatic fire alarm systems are intelligent, self-diagnosing systems. This increases their reliability by minimizing false activations.

All premises of the safety systems, as well as the fire-hazardous premises and technological facilities, are equipped with FAS consisting of automatic fire detectors. In accordance with the requirements of the current Bulgarian and applicable European standards and depending on the type and quantity of combustible materials, the following main types of automatic fire detectors have been selected and installed: smoke, combined (optical-thermal), thermal and linear.

3.2.1.1. Design approach

Buildings and productions on the territory of units 5 and 6

The fire alarm systems are built on a modular principle, latest generation Sinteso with microprocessor control and interactive addressing of the fire alarm sensors. This technology makes it possible to accurately determine the location of the fire. In the case of an event, the specific number of the activated fire detector, the room in which it is located and the fire zone to which it belongs are displayed. Also, if necessary, the fire alarm system

provides information about actuated output signals of the fire automation to activate the controlled fire extinguishing, ventilation systems and fire dampers.

The installed fire alarm sensors are characterized by very high reliability for fire detection, combined with high protection against environmental factors that would have a negative impact on the correct operation of the sensor - false activations. The detectors can be configured with different sets of parameters to adapt them to the prevailing conditions at the installation site.

All detectors have self-diagnostics and when the normal operating state changes, they immediately signal about it. Each detector has several modes of operation. The operating modes are set by the system installer depending on the characteristics of the working environment in the protected room. For each operating mode, the detector has built-in algorithms for processing and analysing the signals received from its sensors (optical and thermal).

The fire alarm systems are designed in accordance with the requirements of the National Norms and Standards as follows:

- Regulation No. 4 of 21.05.2001 on the scope and content of the investment projects;
- Regulation No. Iz-1971 of 29.10.2009 on building and technical rules and norms for ensuring fire safety;
- Regulation No. 2 of 22.03.2004 on the minimum requirements for health and safety working conditions when carrying out construction and assembly works;
- Regulation 8121z-647 on the rules and norms for fire safety in the operation of the objects;
- Regulation RD-02-20-1 of June 12, 2018, for technical rules and regulations for control and acceptance of electrical installation works;
- BDS EN 54 - Fire alarm systems. All current parts;
- BDS EN – 2:1998. - Fire classification;
- BDS IS0 8421 - Protection against fire. Part 1:1999¸8:2002;
- BDS ISO 60849:2000 – Sound systems for emergency situations;
- SD CEN/TS 54-14 Fire alarm systems. Part 14: Guidelines for planning, design, installation, commissioning, use and maintenance.

All fire alarm systems designed and put into operation are equipped with an emergency power supply (autonomous), which preserves their operability in the event of an emergency with a complete lack of power supply in the protected object.

Fire alarm lines are designed to maintain their operability in fire conditions for a minimum of 30 minutes.

The technical characteristics of the equipment are selected in such a way as to guarantee its operability in accordance with the specifics of the environment in which it is installed. The choice of the type of fire detectors for the specific premises is based on the type and quantity of combustible materials.

3.2.1.2. Types, main characteristics, and performance expectations

Buildings and productions on the territory of units 5 and 6

At the site of units 5 and 6 of the NPP, an approach has been adopted for the use of fire alarm equipment compatible with respect to data transmission. The installed fire alarm stations use the same communication protocol.

This approach allows the information from fire alarm networks of RC on units 5 and 6, diesel generator rooms, engine rooms, additional diesel generators and general station facilities (WTP, UAB, SRSB-3) to be unified and directed to common communication portals.

All fire alarm centers on the production site are connected in a common FCnet network with a loop topology. The flow of information is directed to a visualization system, from which control and management of the fire alarm equipment on the site is carried out.

The system consists of 3 computer configurations that are connected in a common network via physically independent Ethernet channels. A specialized application is installed on each computer configuration, which processes the received data and graphically displays the current state of the fire alarm systems.

The three computer stations are located at workplaces with 24-hour duty as follows:

- Operator of the fire protection systems of unit 5 - 1pc.
- Operator of the fire protection systems of unit 6 - 1pc.
- RSFSPP-NPP duty dispatcher - 1pc.

The signals transmitted by the fire alarm equipment are separated, and each operator of fire protection systems receives information on the current status (fire, isolation, damage, other abnormal condition, information on the status of individual components and confirmation of an available connection) only from the objects he operates. The dispatcher at RSFSPP-NPP receives only "Fire" signals from all objects on the production site.

The system allows operators to monitor in real time for the occurrence of fire or damage. When a signal is received, an explication of the object is called up on the monitor of the operator for whom it is intended, with the exact location of the place of occurrence of the event. Obtaining the correct information about the place of origin and the process of development of the fire at an early stage is of paramount importance for the evacuation of personnel and the minimization of material damage.

The following fire alarm stations are in operation on units 5 and 6:

Fire alarm stations in RC and safety systems of units 5 and 6:

Sinteso, model FC2080 with microprocessor control on a modular principle - 3 pcs. protecting premises of Safety Systems SS-1, -2, -3, RC and premises of normal operation of units 5 and 6. Each safety system has an individual fire alarm system (fire alarm control panel with associated fire alarm lines) that guards the respective premises. The stations are connected in a common communication network but perform their functions separately and independently of each other.

Fire alarm stations in the Turbine Hall of units 5 and 6:

Sinteso, model FC2060 with microprocessor control on a modular principle - 2 pcs. protecting premises in TB, CWPS, backup diesel generators on units 5 and 6.

Fire alarm stations controlling gas fire extinguishing systems at units 5 and 6:

Sinteso, FC2020 model with microprocessor control on a modular principle - 10 pcs. Protecting premises with installed gas fire extinguishing systems in I, II, III Safety Systems and TB of units 5 and 6.

Fire alarm stations in SRSB-3, WTP, UAB:

Sinteso, model FC2040 with microprocessor control on the modular principle 5 pcs.

The sensors have a dual power supply and a built-in isolator, which allows them to maintain their operability in the event of a break in the fire alarm line. This allows independence of operation of fire detectors between adjacent fire zones (premises).

The devices are intelligent with microprocessor control and the possibility of programmable selection of work depending on the place of installation and the characteristics of the protected environment. Thanks to this possibility, fire signals with no combustion products present are practically reduced to "0".

Quantities of fire alarm equipment:

For systems related to the operation of units 5 and 6 (TB unit 5; TB unit 6; SRSB-3; CWPS-3; CWPS-4; RSB; ELB; WTP and UAB) installed equipment is as follows;

Equipment	Amount/pcs.
Fire alarm stations	39
Fire alarm sensors	5496
Fire extinguishing control and signaling panels	20
Visualization system	1
Functional tests per year	196

For the rest of the common station facilities (CSF) at the NPP site (BPS; OSY; FPS-2; TQC; PSFSF; DSFSF) installed equipment is as follows:

Equipment	Amount/pcs.
Fire alarm stations	18
Fire alarm sensors	1891
Fire extinguishing control and signaling panels	13
Visualization system	2
Functional tests per year	72

Fire alarm systems maintenance and testing:

The technical maintenance of the fire alarm systems is carried out according to an approved annual schedule and scope for the facilities as follows:

- FPSE department schedule of preventive technical maintenance and repair of SSCs, during operation of units 5 and 6 at rated power in 2023.
- FPSE department volume of preventive maintenance and repair of SSCs, during operation of units 5 and 6 at rated power in 2023.
- Long-term schedule for preventive maintenance and repair of SSCs from safety systems and systems important to safety on units 5 and 6, and the common station facilities (CSF).

Functional tests are performed according to an approved annual schedule. A specific step-by-step test procedure has been developed for each fire alarm system.

The number of functional tests per year for units 5 and 6 is as follows:

- First train of safety systems (SS-1) – 12 times/per year for each unit;
- Second train of safety systems (SS-2) – 12 times/per year for each unit;
- Third train of safety systems (SS-3) – 12 times/per year for each unit;
- Non-system premises (Reactor Compartment Oil Systems) - 4 times/per year for each unit;
- Turbine Hall - 8 times/per year for each unit;
- Gas fire extinguishing – SS-1 - 4 times/per year for each unit;
- Gas fire extinguishing – SS-2 - 4 times/per year for each unit;
- Gas fire extinguishing – SS-3 - 4 times/per year for each unit;
- Gas fire extinguishing – non-system premises - 4 times/per year for each unit;
- Gas fire extinguishing – TB - 4 times/per year for each unit;
- Gas fire extinguishing – RAW storage facilities - 4 times/per year;
- CWPS – 4 times/per year for each unit;
- Back-up power supply - 4 times/per year for each unit.

Technical service and functional tests are carried out in volume and scope according to the requirements of the current Bulgarian national standard harmonized with European legislation - SD CEN/TS 54-14 "Fire alarm systems. Part 14: Guidelines for planning, design, installation, commissioning, use and maintenance".

3.2.1.3. Alternative/temporary provisions

Impaired functioning of fire protection systems is addressed in accordance with specific requirements set forth in corporate documents. They provide for a formal process to ensure that appropriate compensatory measures are implemented when fire protection systems are inoperative as a result of scheduled or unscheduled maintenance or due to the discovery of a defect. In this regard, in the operating procedures of the systems there is a special section in which the order and procedure for authorizing the taking out of service of each individual system for maintenance purposes and the compensatory measures to be taken during the maintenance are regulated.

Depending on the importance of the system, a period for restoring the functionality or a compensatory procedure is determined: 8, 24 or 72 hours.

The necessary repair and testing procedures and actions to restore the availability of the system are established in accordance with the affected organizational units. In the Information System for the Organization of Operational Activity (IS OOA) there is a module that describes how and where to submit requests for taking systems out of service. These requests are coordinated with the affected organizational units and permission is issued by the Chief Technologist of the relevant unit.

The Unit Shift Supervisor on duty at the MCR shall be informed of any malfunction of the firefighting system.

3.2.2. Fire suppression provisions

3.2.2.1. Design approach

<u>Buildings and productions on the territory of units 5 and 6</u>

In order to protect facilities important to safety, the NPP has effective fire control and extinguishing measures, including a combination of automatic extinguishing systems, as

well as creating conditions for manual fire extinguishing actions. In accordance with the regulatory requirements and the type of protected equipment, the following fire extinguishing systems have been implemented:

- Stationary systems with dispersed water, for cable rooms and rooms of oil systems located in containment, important to safety.
- Stationary water fire extinguishing system in the conventional part, non-system premises and external fire water supply on the site.
- Volumetric gas fire extinguishing systems, based on FM200 extinguishing agent, for rooms with electrical control equipment for safety systems.
- Volumetric gas fire extinguishing system based on extinguishing agent CO_2, for RAW storage facilities shafts.

Automatic fire extinguishing is carried out after two different sensors (smoke and thermal) from the fire alarm system of the relevant room are activated, and via output relays of the fire alarm station control signals are sent to open the adjacent electrical valves for the protected room and start the main fire pumps.

3.2.2.2. Types, main characteristics, and performance expectations

3.2.2.2.1. Systems for automatic water fire extinguishing of premises important to safety in RC

Stationary water automatic fire extinguishing systems are provided for the cable rooms of the safety systems.

Stationary sprinkler fire extinguishing systems in the cable rooms of the safety systems are self-contained for each unit and are designed as independent for each of the three safety systems. Each system consists of a tank, a pump, a system of pipes and valves.

The tanks, pumps and isolating (starting) valves are located at the height of 28.80 m, and the systems are separated from each other by partitions with the necessary fire resistance.

The water tank is supplied from two sources, from the fire protection pipeline and with technical water.

The system is designed to extinguish one fire, which corresponds to a supply of water in each tank of 40m³. The design is made with a safety factor of 1.5, which determines a volume of 70m³ of water in each tank. The amount of water in each of the tanks is sufficient for fire extinguishing of each of the protected rooms important for safety, including those in the hermetic volume. A technical possibility has been provided for back-up water supply for fire extinguishing from the other two systems.

Each room can be extinguished by motor operated valves (MOVs) from the three safety systems. The MOV belonging to a given system opens automatically upon a fire signal from the same system, and the MOVs from the other two safety systems intended for extinguishing the same room are redundant and are remotely controlled by switches on the control panel in the MCR.

When the automatic fire extinguishing for a given room is triggered on the MOV control switches of the other two safety systems intended for extinguishing the same room, a guidance signal (yellow light) lights up. This makes it easier for the fire protection systems

operator, in the event of failure of the automatic valve, to open one of the other two from a control switch and turn on the corresponding Fire Protection Pump (FPP).

The pipelines with the sprinklers in the protected premises are designed as dry pipes. MOVs are used for starting valves.

The fire extinguishing in the containment is designed so that at the entrance of the pipeline in the hermetic volume, a MOV and a non-return valve are located, and in the hermetic volume next to the protected room, there is one MOV for each extinguishing system.

Operation of the fire extinguishing system in the hermetic volume and in emergency situations, not exceeding the design ones, is foreseen. The non-return valve prevents the return of water when the pressure rises above 0.3kgf/cm^2.

The systems are operated in automatic mode, remotely from MCR and on site.

3.2.2.2.2. Stationary water fire extinguishing system in the conventional part, non-system premises and external fire water supply on the site

Optimal water supply for fire protection of the plant is ensured. The fire pumps take water from the cooling water channel, which is provided by the Danube River (i.e. there is an unlimited water supply).

Generally, two independent fire water pump stations are available at CWPS-3 and CWPS-4 and are supplied with independent water intake from the water channel. Each water supply system consists of a set of fire pumps connected to a large diameter underground fire water pipeline that forms a closed loop (with sub-loops) around each power unit so that each point of it is supplied with water from a minimum of two directions. Multiple manual valves are fitted to provide the ability to isolate part of the ring in the event of a pipe leak, or for use by firefighting systems during a fire and a damaged pipe. Each electric fire pump is independent, but by opening a normally closed motor operated valve the pumps can be connected to a common manifold.

Fire pumps are adequately separated (two independent pump stations) so that a single fire does not cause all pumps to fail. There are 3 electric main fire pumps and 2 emergency diesel pumps in each CWPS. At any given time, only one CWPS is in automatic mode and the other is in standby (reserve) mode. Switching in automatic operation of one of the two CWPS is carried out by three-position mode switches on the corresponding MCR of unit 5 or 6.

<u>External firefighting water supply to the site</u>

The external fire ring (EFR) is an underground infrastructure of polypropylene pipelines and manual isolation valves, built in a closed circuit. It is intended to supply the necessary amount of water with a certain pressure to the objects on the territory of the plant, for which water supply for fire extinguishing is ensured. The isolation valves provide the possibility of isolating individual sections, when carrying out maintenance and repair activities.

Outside the plant's technological premises and buildings, fire hydrants designed for water supply to firefighting vehicles are installed 80 meters away.

In the heat distribution station building, DGS, CWPS, TB, UAB, WTP, SRSB, PSFSF and DSFSF there are emergency ladders with dry pipes for firefighting on the roofs with firefighting vehicle.

In the EFR, a constant water pressure (6.0÷8.0) kg/cm^2 is maintained by electric centrifugal pumps, which eliminates the time for water to reach the fire.

EFR is supplied with water from the Danube River, through the equipment installed in CWPS-3 and CWPS-4. In the event of a complete failure of the water supply facilities, a connection from Fire Pumping Station 2 (FPS-2) is provided.

FPS-2 houses two electric fire pumps, two diesel pumps and two fire ring pressure pumps. The main electric fire pumps have a flow rate of 648 m^3/h with double redundant power supply. The diesel pumps have a flow rate of 648 m^3/h with a daily fuel tank with a capacity of 800 l - ensuring 24 hours of operation and a fuel reserve tank with a capacity of 10,000 l.

The system works in automatic mode after receiving a signal-requested start in case of fire, the selected FPP 3 or 4 in “operation” mode is switched on, and in case of failure, the pump selected in “backup” mode is switched on. In case of power failure, as well as failure of the backup FPP, the diesel pump selected in operation, or the backup diesel pump is automatically started.

External fire ring pressure maintenance pumps

As stated above in order to eliminate the time for water to reach the fire, a constant pressure 6.0 ÷8.0 kg/cm2 is maintained in the EFR. This is done through 5 pcs. pumps located on CWPS-3 (2 pcs) and CWPS-4 (3 pcs).

Main fire pumps

Each pumping station CWPS-3 (CWPS-4) is equipped with 3 main electric fire pumps. In the event of a fire in the facility supplied with water for fire extinguishing from the EFR, the selected fire pump is automatically started. According to the schedule for the operation of the pumping units in the respective year, the pumps are selected in one of the three positions "1st working", "(2nd) working" or "Reserve".

The presence of two working positions is determined by the sections for which a large amount of water is needed for fire extinguishing, i.e., in order to ensure sufficient pressure for effective firefighting, two pumps are started.

The pumps are located in the machine hall of CWPS-3,4 and are supplied with water from the inlet channel of EP-2. They are controlled by the fire alarm systems through output relays, after a fire signal in a given room (compartment), and for the transformers when a signal for triggered gas and differential protection is received.

Emergency diesel fire pumps

Emergency diesel fire pumps serve to supply water for fire extinguishing in the event of failure of all electric fire pumps. The pumps are located at elevation -9.15 in CWPS-3,4 and are supplied with water from the plant's inlet channel. They are equipped with a consumable fuel tank with a useful volume of 0.56 m3, located on its own steel structure, which ensures continuous operation of the pump for 8 h with the possibility of refueling during operation from a tank with a capacity of 8000 liters.

In the event of a fire in one of the sites, complete blackout of the power supply sections or failure of the electric fire pumps to provide water for firefighting, an emergency diesel pump is automatically started. In case of failure of the emergency pumps selected in the CWPS automation, those of the other CWPS are started.

Stationary systems for automatic fire extinguishing of technological rooms of oil systems in RC

The stationary systems for automatic fire extinguishing of the technological rooms of the oil systems are implemented as independent. They are controlled by the fire alarm system, through the unit control system. The system is composed of an initiating valve, steel pipelines and sprinklers. Water supply to the system is carried out by the external and internal fire water supply system in the reactor compartment.

The pipelines with the drainage sprinklers in the protected premises are designed as dry pipes. MOVs are used as initiating valves. To ensure the ability to carry out repairs, as well as to activate the system in the event of failure of the MOV, each MOV is duplicated with a manual valve.

The systems are operated in automatic mode, remotely from MCR and on the site.

Automatic water fire extinguishing system in TB and EER

Stationary automatic fire extinguishing systems are provided for all rooms with increased combustible load, namely in cable rooms at elevation 0.00 and 8.40 of the EER and oil systems in the TB.

All rooms subject to fire extinguishing are divided into separate sections. Each section is equipped with an independent stationary water fire extinguishing system, consisting of initiating valves, steel pipelines and drainage sprinklers.

The pipelines with the drainage sprinklers in the protected premises are designed as dry pipes. MOVs located on serviceable platforms at elevations 0.00; 5.70 and 15.00 are used as initiating valves accessible during the fire.

To ensure the ability to carry out repairs, as well as to activate the system in the event of failure of the electric MOV, each MOV is duplicated with a manual one.

The systems are operated in automatic mode, remotely from the MCR and on the site.

The automatic start is from the fire alarm system, through the unit control system. When an optic-smoke and thermo-differential detector are triggered in a given compartment, the fire alarm system sends a fire signal to the unit control system, which in turn processes the signal and sends signals to open the electric extinguishing valve and turn on the fire pump.

Water supply is provided by the internal fire water supply pipeline in the TB. The pipeline is fed from three locations, two on the east side and one on the south side of the TB.

System for automatic water fire extinguishing of unit transformers and house load transformers

For each transformer, an independent stationary water fire extinguishing system has been designed, consisting of initiating valves, steel pipelines and drainage sprinklers.

The pipelines with the sprinklers in the protected volume are designed as dry pipes. MOVs located on serviceable platforms at an elevation of 5.70 in the TB are used as initiating valves.

To ensure the ability to carry out repairs, as well as to activate the system in the event of failure of the electric MOV, each MOV is duplicated with a manual one.

The systems are operated in automatic mode, remotely from the MCR and on the site.

The automatic start-up is carried out in the event of a fire signal, which is formed by activated gas and differential protections of a given transformer and a disconnection signal from the energy system.

A fire signal is sent to the unit's control system, which in turn processes the signal and sends signals to open the electric extinguishing valve and turn on the fire pump.

Water supply for firefighting is carried out by the internal fire water supply system of the TB.

System for automatic water fire extinguishing of backup power supply transformers

For each transformer, an independent stationary water fire extinguishing system has been designed, consisting of initiating valves, steel pipelines and drainage sprinklers.

The pipelines with the sprinklers in the protected volume are designed as dry pipes. MOVs are used as initiating valves. To ensure the ability to carry out repairs, as well as to activate the system in the event of failure of the electric MOV, each MOV is duplicated with a manual one.

The systems are operated in automatic mode, remotely from the MCR and on the site.

The automatic start-up is carried out in the event of a fire signal, which is formed by activated gas and differential protections of a given transformer and a disconnection signal from the energy system.

A fire signal is sent to the unit's control system, which in turn processes the signal and sends signals to open the electric extinguishing valve and turn on the fire pump.

Water supply for firefighting is carried out by the internal fire water supply system of the TB.

Automatic water fire extinguishing systems in the cable rooms of SRSB-3, UAB, New Backup Power Supply, Diesel Generating Stations on Unit 5 and Unit 6 and CWPS 3 and CWPS 4.

Stationary automatic fire extinguishing systems are planned for the cable rooms of the listed objects. All premises subject to fire extinguishing are separated into fire compartments. Each compartment is equipped with an independent stationary water fire extinguishing system, consisting of initiating valves, steel pipelines and drainage sprinklers.

The pipelines with the drainage sprinklers in the protected premises are designed as dry pipes. MOVs located in rooms accessible for service during a fire are used as initiating valve.

To ensure the ability to carry out repairs, as well as to activate the system in the event of failure of the electric MOV, each MOV is duplicated with a manual one.

The systems are operated in automatic mode, remotely from the MCR and on the site.

The automatic start is from the fire alarm system, through the unit control system. When an optic-smoke and 75 thermo-differential detector are triggered in a given compartment, the fire alarm system sends a fire signal to the unit control system, which in turn processes the signal and sends signals to open the electric extinguishing valve and turn on the fire pump.

The supply of water is carried out through branch pipes from the external fire ring of the site.

3.2.2.2.3. Stationary water systems for fire extinguishing

Fire hydrants above ground type

They are used for manual fire extinguishing of external objects and facilities. They have three fire hose connector (Storz) each – two ∅52mm and one ∅75mm. The normal position of fire hydrants is with the underground supply valve open and the main valve to use water from the hydrant closed.

Cooling of trusses and columns in TB units 5 and 6

A system for cooling with water (open water sprinkler system) has been built in the TB of units 5 and 6 for additional cooling of the load-bearing metal structures and roof trusses.

Water supply is provided by the fire water ring of trusses and columns in the TB. The pipeline is fed from three locations, two on the east side and one on the south side of the TB. A constant pressure in the range 6.0 ÷ 8.0 kg/cm2 is maintained in the system.

Each branch of the system is equipped with a manual valve, which can be open when necessary, by the Fire Protection Systems Operator.

Cooling of diesel fuel tanks with firefighting water spray guns

To cool the diesel fuel tanks in the event of a fire, 3 firefighting water spray guns have been installed that are fed by the EFR. RSFSPP-NPP staff operates with them. Additional water protection is provided for the steel supporting structure of the spray guns. The possibility of additional water supply from a fire truck is provided.

The two large tanks with a volume of 2000 m3 each have stationary installations for fire extinguishing and cooling, supplied with water from the EFR.

Internal water supply and manual fire extinguishing systems

Internal water supply for manual firefighting is filled with steel pipes.

For the needs of the internal fire extinguishing of the buildings, independent deviations from the EFR are provided. For internal fire extinguishing, firefighting cassettes are provided for installation on columns, complete with a fire hydrant with a fire hose connector (Storz) and a box equipped with a drum with a hose and a nozzle.

The locations of the fire hydrants and the distances between them are in accordance with the requirements of the regulations, in order to ensure the possibility of fire extinguishing at any point of the building.

During PAO of unit 5 or 6, a control measurement of flow and pressure of the internal water supply system and manual fire extinguishing is carried out. The results show that the system provides the required amount of water and pressure in the internal fire water supply.

3.2.2.2.4. Gas fire extinguishing systems

Volumetric gas fire extinguishing systems based on extinguishing agent FM200

A fire extinguishing system has been installed for volumetric fire extinguishing based on extinguishing agent FM200. FM-200 (1,1,1,2,3,3,3-heptafluoropropane) is a compound of carbon, fluorine, and hydrogen (CF3CHFCF3).

The fire extinguishing effect of FM200 is based on a combination of chemical and physical mechanisms without directly affecting the available oxygen. Thanks to its low toxicity, it allows people to safely leave the fire area.

The system is seismically qualified. It is used to extinguish all classes of fires within the limits specified in Article 4 of ISO 14520 – Part 1:2000.

The management and control of the automatic gas fire extinguishing systems consists of 10 Sinteso fire alarm control stations, model FC2020 for each unit. These 10 control stations per unit are linked together with an additional control panel located at a workplace with constant presence of operating personnel.

The control stations of fire extinguishing are single-zone and two-zone, depending on the configuration of the premises, and each control station consists of an independent control unit with independent emergency power supply.

FM200 is stored in a liquid state in steel bottles under pressure provided with nitrogen. Seamless (no welding) steel bottles with a siphon tube and a quick opening valve are used. The size, number, and gas filling of the bottles in each battery is determined by the specific situation for each room.

When the system is activated by the control head, fluid flows through the valve outlet and is directed through the distribution line to the nozzles. The nozzles ensure the appropriate flow and distribution of the gas in the room.

Extinguishing systems with FM200 are designed as systems to fill the entire volume (volumetric fire extinguishing systems) and protect premises in SS-1,2,3 and TB.

Volumetric gas fire extinguishing systems based on CO_2 extinguishing agent

For the RAW shafts in SRSB-3 (special building -3), a gas fire extinguishing system for volumetric fire extinguishing based on CO_2 extinguishing agent has been installed. The management and control of the automatic gas fire extinguishing system is carried out by one fire alarm control station located at a workplace with the constant presence of operational personnel. The control station manages the gas fire extinguishing for each individual shaft.

Fire extinguishing installation consists of 6 CO_2 distribution devices and 16 gas bottles, grouped by 4. A reserve of one group of 16 gas cylinders grouped in the same way is also provided.

The management and control of the automatic gas fire extinguishing system is carried out by one Sinteso fire alarm station, model FC2040, located in SRSB-3. This station is connected to a control panel located at a workplace with constant presence of operating personnel.

When a fire signal is confirmed, the distribution devices serving the respective shaft are activated, all cylinders from the working group (16 units) of the fire extinguishing installation are activated and the amount of gas is poured into the shaft threatened by fire. The gas concentration is 30% and extinguishing takes place in one minute.

3.2.2.2.5. Powder fire extinguishing systems

For fire extinguishing of the pumps, located at elevation – 3.60 behind the main oil tank in the TB on units 5 and 6, a powder fire extinguishing system has been built. Powder fire extinguishing is provided in order not to disturb the functionality of the pumps. For this purpose, demountable partitions are built between the pumps and separate automatic powder modules are used for fire extinguishing.

They are controlled in automatic mode by the fire alarm system, and in case of failure, it is triggered by the breakdown of the thermal bulb when a critical temperature is reached.

3.2.2.2.6. System maintenance and testing

To organize the operation of fire extinguishing systems, the plant has developed instructions for maintenance and repair and functional tests. The instructions have been developed in accordance with the factory instructions for operation and maintenance, the requirements of the national legislation, as well as the international requirements in the field of nuclear energy.

Operation, maintenance, and testing are organized in accordance with the following standards:

- maintenance, recharging and hydrostatic pressure resistance testing of portable and mobile fire extinguishers are carried out in accordance with the manufacturer's operating instructions and in compliance with the requirements of items 4.3, 4.4 and 5 of BDS ISO 11602-2:2002;
- fire alarm systems – SD CEN/TS 54-14 "Fire alarm systems. Part 14: Guidelines for planning, design, installation, commissioning, use and maintenance";
- stationary fire extinguishing systems with powder – BDS EN 12416-2 "Stationary fire extinguishing installations. Powder installations. Part 2: Design, construction and maintenance";
- stationary fire extinguishing installations with gaseous substances – BDS EN 15004-1 "Stationary fire extinguishing installations. Installations for extinguishing with gaseous substances. Part 1: Design, installation and maintenance (ISO 14520-1:2006, as amended)";
- stationary fire-extinguishing installations with water spraying – SD CEN/TS 14816 "Stationary fire-extinguishing installations. Installations with water spraying. Design, Installation and Maintenance";
- stationary fire extinguishing installations based on CO2 extinguishing agent – BDS ISO 6183 «Technical equipment for protection against fire. Carbon dioxide extinguishing systems for indoor use. Design and installation;
- fire hydrants are maintained in accordance with the manufacturer's operating instructions and in compliance with the requirements of BDS EN 671-3 "Stationary fire protection systems. Hose systems. Part 3: Maintenance of semi-rigid hose reels and flat hose systems";
- fire hydrants according to BDS EN 14384 "Above-ground fire hydrants column type" and BDS EN 14339 "Underground fire hydrants".

Control of the functional state of the fire alarm and fire extinguishing systems is carried out by shift personnel. There are three Fire Protection Systems operators on shift. In the event of a fire the operational staff of the "Kozloduy NPP" EAD acts according to

developed and approved fire extinguishing schemes for each organizational unit, and their actions are coordinated with RSFSPP-NPP.

During the shift, regular walkdowns are carried out by the operational staff. They monitor the operational conditions of fire doors, sealing of passages, portable fire extinguishers.

Functional tests are carried out according to an approved schedule for the year "Schedule for functional testing and switching of equipment of fire protection systems", and are carried out according to approved instructions, for example "Instruction for functional tests of the FAS and FES in TB and EER", "Instruction for functional tests on a gas fire extinguishing system with FM-200".

Functional tests of the FAS and FES are performed according to an approved annual schedule as follows:

- First train of safety systems (SS-1) – 12 times/per year for each unit;
- Second train of safety systems (SS-2) – 12 times/per year for each unit;
- Third train of safety systems (SS-3) – 12 times/per year for each unit;
- Non-system premises (Reactor Compartment Oil Systems) – 4 times/per year for each unit;
- Turbine Hall – 8 times/per year for each unit;
- Gas fire extinguishing – SS-1 – 4 times/per year for each unit;
- Gas fire extinguishing – SS-2 – 4 times/per year for each unit;
- Gas fire extinguishing – SS-3 – 4 times/per year for each unit;
- Gas fire extinguishing – non-system premises – 4 times/per year for each unit;
- Gas fire extinguishing – TB – 4 times/per year for each unit;
- Gas fire extinguishing – RAW storage facilities – 4 times/per year;
- CWPS – 4 times/per year for each unit;
- Back-up power supply – 4 times/per year for each unit.
- Functional tests of systems to the EFR:

  1) Once a year, flow and pressure are measured from the highest point of each unit and from a hydrant on the site, to prove compliance with the requirements of the regulatory documents.

  2) Once a year, flow and pressure are measured by stationary measuring devices at the farthest point of the EFR with a fire pump running, to prove compliance with the requirements of the design documents.

  3) According to the schedule, 6 flushes of sections of the EFR are carried out with testing of different fire pumps.

During the year, the FPSE department staff performs technical maintenance and functional inspection of firefighting equipment owned by "Kozloduy NPP" EAD, quantitatively, as follows:

- Fire alarm systems, Fire extinguishing panels, management and automation of fire extinguishing systems (water and gas), - 4 times/year;
- Actual on-site operation of all fire detectors – 1 time/year.
- Pumps, Manometers, MOVs and manual valves of automatic fire extinguishing systems, Switchboards of fire dampers control systems, Fire doors, Fire extinguishers, Internal fire hydrants, Manual valves of internal fire ring, Dry pipes for extinguishing roofs of buildings from fire truck – 1 time/year;

- Manual valves from outer ring and Fire hydrants – 2 times/year;
- Cylinders with FM200, Nitrogen bottles, Pressure switches, Sectional valves, Electric and pneumatic valves from gas fire extinguishing systems – 1 time/year:

The volume and frequency of the inspections, maintenance, repairs and functional tests of fire protection systems are updated depending on the amendments to the regulations, operational experience and good international practices in this area.

3.2.2.3. Management of harmful effects and consequential hazards

The main objectives of fire consequences mitigation are as follows:

(a) To limit the spread of fire, heat and smoke in a designated fire zone in order to minimize the spread of fire and subsequent effects on installations located in the immediate vicinity of the zone;

(b) To provide safe emergency exits and access roads for the personnel and teams of the fire brigade;

(c) To provide access for manual fire extinguishing, manual activation of stationary fire extinguishing systems and personnel operation of the systems necessary to achieve and maintain a safe shutdown;

(d) To provide means to remove smoke and heat during or after a fire, if necessary;

(e) To control the operation of automatic fire extinguishing systems to prevent damage to elements important to safety.

In the developed Fire Hazard Analysis, the possible harmful effects and subsequent risks of the occurrence and extinguishing of fires are considered. The secondary effects of fire and means of fire protection have been checked.

Fire protection measures are initially designed to reduce the possibility of fire spreading and to enable firefighting to satisfy safety requirements.

“Secondary effects of water extinguishing systems” and “Secondary effects possible through the ventilation system” are assessed in detail.

All parts and components forming the fire barriers surrounding the fire zones or fire cells are considered as passive measures. Passive measures – these are the building structures (walls, ceilings) and the necessary components such as doors, fire dampers, cable and pipe passages and separation elements and are of the required degree of fire resistance to meet the requirements for a fire zone or fire cell.

As a result of the study, recommendations for improvements and necessary additional measures to mitigate the secondary effects of the fires have been prescribed. All recommendations have been implemented.

3.2.2.4. Alternative/temporary provisions

The impaired functioning of fire protection systems is addressed in accordance with specific requirements laid down in corporate documents. They provide for a formal process to ensure that appropriate compensatory measures are implemented when fire protection

systems are inoperative as a result of scheduled or unscheduled maintenance or due to the discovery of a defect. In this regard, in the operating procedures of the systems there is a special section in which the order and procedure for authorizing the taking out of service of each individual system for maintenance purposes and the compensatory measures to be taken during the maintenance are regulated.

Depending on the importance of the system, a period for restoring the functionality or a compensatory procedure is determined: 8, 24 or 72 hours.

The necessary repair and testing procedures and actions to restore the availability of the system are established in accordance with the affected organizational units. In the Information System for the Organization of Operational Activity (IS OOA) there is a module that describes how and where to submit requests for taking systems out of service. These requests are coordinated with the affected organizational units and permission is issued by the Chief Technologist of the relevant unit.

The Unit Shift Supervisor on duty at the MCR shall be informed of any malfunctioning of the firefighting system.

A fire truck with staff from RSFSPP-NPP are on duty on the place if necessary.

3.2.3. Administrative and organizational fire protection issues

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

Each building is equipped with an internal firefighting water supply system. Indoor fire hydrants (IFH) are installed in the buildings of RC, TB, DGS, SRSB-3, PSFSF and DSFSF. Their water supply is carried out through pipelines from an external fire ring.

Control of the operational and functional condition of the IFH is carried out by shift personnel. Daily walkdowns are carried out by the operational staff during which the operating conditions of the IFH is monitored. The operational staff performs daily walkdowns, according to an approved schedule and route. Walkdowns are registered in checklists along the routes. When a malfunction is detected, the operational staff reports to the Unit Shift Supervisor and notifies the Electrical Equipment Shift Foreman, then records it in the IS OOA, Module Operation, Submodule “Defects” or “Comments”.

Once a year, flow and pressure are measured from the highest point of each unit and from a hydrant on the site, to prove compliance with the requirements of the regulatory documents.

Technical service and maintenance are carried out in accordance with the requirements of the current Bulgarian state standards harmonized with European legislation as follows:

- The fire hydrants are maintained in accordance with the manufacturer’s operating instructions and in compliance with the requirements of BDS EN 671-3 “Stationary firefighting systems. Hose systems. Part 3: Maintenance of semi-rigid hose reels and flat hose systems”;
- Once a year, the hoses are rewound, the fire house connectors are checked, the IFH valves and the markings are checked;
- Every 5 years hydraulic pressure tests of the hoses are performed. After the technical services and tests, the necessary sticker is placed.

The technical maintenance of the IFH is carried out according to an approved annual schedule and scope for the facilities as follows:

- FPSE department schedule of preventive technical maintenance and repair of SSCs, during operation of units 5 and 6 at rated power in 2023.
- FPSE department volume of preventive maintenance and repair of SSCs, during operation of units 5 and 6 at rated power in 2023.

Every building or fire-hazardous facility is equipped with portable or transportable fire extinguishers. In accordance with the requirements of the normative documents, a list has been drawn up of certain types and numbers of firefighting equipment required for initial fire extinguishing, according to Appendix 2 to Art. 3, para. 2 of Ordinance No. Iz-1971 “on construction and technical rules and norms for ensuring safety in case of fire”.

Depending on the qualitative (class of functional fire hazard) and quantitative indicators of the premises, facilities and installations, the type and quantity of fire extinguishers is determined, in accordance with the requirements of regulatory documents. Regarding the location and number of fire extinguishers, the “List of firefighting equipment for initial extinguishing of fires in premises, facilities, and installations, including free yard areas of “Kozloduy NPP” EAD has been approved.

Control of the operational and functional condition of firefighting equipment is carried out by shift personnel who perform daily walkdowns.

By an order of the NPP Executive Director, fire safety officers are designated in the NPP subdivisions who keep logs for inspection of firefighting devices. They carry out a monthly supervision of the operational condition of the fire extinguishers and reflect these checks in the logs.

The frequency and number of internal inspections are regulated and defined in the Instruction for the inspection activity of the Fire Safety department. The scope of the inspections is tailored to the specifics of the inspected objects and is described in the checklists attached to the same instruction.

Every year, the FPSE department carries out technical maintenance and a functional check of the firefighting equipment and technical maintenance of all fire extinguishers. Fire extinguishers are emptied and refilled every five years. At ten years, hydraulic tests are carried out on the vessels of the fire extinguishers.

Technical service and maintenance are carried out in accordance with the requirements of the current Bulgarian state standards harmonized with European legislation, in compliance with the requirements of items 4.3, 4.4 and 5 of BDS ISO 11602-2:2002.

Pursuant to Ministerial Decree No. 109/1992, a separate state Regional Service “Fire Safety and Protection of the Population” (RSFSPP-NPP) has been established, whose duties include the performance of state fire control, firefighting, and emergency rescue activities on the territory of the NPP. To fulfill its specific duties, RSFSPP-NPP has a sufficient number of well-trained professional employees and 9 specialized vehicles.

The chief and the management staff of the fire command should have at minimum an educational classification degree “bachelor” in the specialty “Fire and emergency safety”. The entire staff undergoes initial training at the Academy of the Ministry of Internal Affairs

and its specialized centers, subsequent training for qualification acquisition and periodic refreshment training.

Lists of emergency drills and instructions of departments from the “Operation” Division have been developed, for example “Topics for emergency drills of operating personnel, Division of Operation”.

After all the exercises are conducted, the results are analysed and, if necessary, actions are taken to improve the performance of the participants.

The firefighting plans are tailored to the specifics of each specific site, agreed with the NPP management and are an integral part of the emergency plan of the Kozloduy NPP.

3.2.3.2. Firefighting capabilities, responsibilities, organization, and documentation onsite and offside

At RSFSPP-NPP Kozloduy there are 9 fire trucks on duty and in operational reserve – 7 pcs. With main purpose for combined extinguishing – powder, foaming agent and water and 2 pcs. With a special purpose. The staff has received the necessary training to work with them.

In the equipment of the RSFSPP-NPP on duty, in addition to the fire trucks, there are also mobile pumps for drainage action. One fire truck is intended for the construction of a Ø150mm hose line with a length of up to 2 km both for water supply and for water delivery.

The RSFSPP-NPP is located in close proximity to the plant and is fully equipped with equipment and resources, ready to respond at any time. RSFSPP-NPP was provided with the necessary data and developed 28 firefighting operational plans. They are agreed upon by the executive director of the company.

In the fire brigade, a dispatch centre has been built with an employee on permanent duty (dispatcher on duty).

The following is available in the dispatch centre:

- direct telephone connections with the command rooms (MCR, OSY, BPS, PSFSF and the Operational centre of the Vratsa Regional Directorate of “Fire Safety and Protection of the Population” (RDFSPP-Vratsa);
- Signals from the fire alarm systems in the production sites are displayed on monitors, giving information in real time about the presence of a fire, accident, or defects. The following objects are covered by the visualization systems of RC units 5 and 6, TB 5 and 6, DGS of units 5 and 6, CWPS 3 and 4, ELB, RSB, SRSB-3, WTP, UAB, OSY, TQC, BPS, PSFSF and DSFSF ;
- Signals through the INMOD system from Administration Building, Investments Department Building, Stock Logistics;
- Output signal from the emergency alarm system of the NPP;
- Radio telephone and radio connection with the operational centers of the NPP, the Ministry of Internal Affairs and the teams of the fire brigade.

The relevant specialized units of the NPP conduct periodic tests of the systems. The dispatcher on duty monitors the status of the systems.

In order to organize the theoretical and practical training of the staff for the proper operation of the fire and rescue equipment, 70 theoretical and practical classes were planned and conducted with the employees for the first half of the year. During the training, the following matters were elaborated:

- improving the effectiveness of the teamwork;
- ensuring proper use of equipment;
- confirming the effectiveness of previously developed operational plans and verifying command coordination with operational personnel, emergency teams, plant on-site medical service and external emergency organizations.

Each shift team conducts monthly training in different areas of the NPP, paying particular attention to safety systems and areas with increased fire risk. The conduct of the training sessions is documented, and a debriefing is carried out after each exercise.

"Plans for extinguishing fires in ..." have been developed for conducting fire tactical classes for all fire hazard sites or facilities. They have been developed taking into account different scenarios for the development of fire in the most unfavorable conditions, including non-operational fire extinguishing systems in the objects or facilities.

Members of the fire brigade annually undergo refreshment training on the territory of Kozloduy NPP. The curriculum includes matters of professional training, theoretical and practical training, psycho-physical and physical training. Training classes are held according to approved plans. Included in the scope of the curriculum are matters regarding actions in radioactivity hazards and health hazards in fire and natural disasters. The academic year ends with each member of the brigade passing exams on professional training, theoretical and practical training, psycho-physical and physical training.

In addition to training to maintain and increase the capabilities of the fire brigade, on-site training is also essential. During training, emphasis is given to improving the work of the brigade as a team, ensuring the correct use of equipment, confirming the effectiveness of the operational plans and checking the coordination of the brigade with operational personnel, emergency teams, plant on-site medical service and external emergency organizations.

According to the plan of RDFSPP-Vratsa, fire tactical exercises are conducted periodically at the NPP with the participation of these services at least once a year.

The action plan of RSFSPP-NPP Kozloduy for emergency situations and for protection in the event of disasters is directly related to the plans of RDFSPP-Vratsa and regional RSFSPP for calling the off-duty staff, when escalating to a higher level of combat readiness, extinguishing of large and complex fires and in the case of a radiation accident at the Kozloduy NPP. The plan is directly related to the emergency plan of the NPP.

3.2.3.3. Specific provisions

By design, buildings are provided with a sufficient number of emergency exits, clearly and permanently marked, with reliable emergency lighting, ventilation and other services essential for the safe use of these emergency exits. It is also necessary to take into account the approach to the organization of roads and access approaches for the emergency teams (access to a room in the main buildings is provided from at least two sides).

Adequate access routes are provided for firefighting teams or personnel. The use of combustible materials (e.g. lighting, paints, coatings) in emergency exits and access routes shall be limited as far as practicable. The layout of buildings is organized to prevent the spread of fire and smoke from adjacent fire zones or fire cells to emergency routes or access roads.

The following general conditions are met for each route:

(a) Access roads and emergency exits are protected from the effects of fire and fire by-products. Protected access routes and emergency exits include stairways and passageways leading to an exit from the building. Fire extinguishers are located at appropriate locations along access roads and emergency routes as required by national regulations.
(b) Access and evacuation routes are clearly and permanently marked and easy to recognize. The marking of access roads and emergency exits shows the shortest possible safe routes.
(c) Emergency lighting is provided along access routes and evacuation routes.
(d) Appropriate means of triggering the alarm (e.g. fire call points) are located at all locations identified in the fire hazard analysis and at all emergency routes and building exits.
(e) Access and escape routes shall have the ability to be ventilated by mechanical or other means to prevent the accumulation of smoke and facilitate access.
(f) Stairways that serve as access routes and escape routes are free of combustible materials. Overpressure ventilation is built in to keep the stairwell smoke free. The removal of smoke from corridors and rooms leading to staircases is regulated.
(g) Doors leading to stairways or access routes and emergency exits are self-closing and open in the direction of evacuation.
(h) All emergency lighting systems are always powered and provided with uninterruptible emergency power supplies.

In order to ensure the actions of the personnel from RSFSPP – NPP in the various scenarios, the staff are equipped with firefighter's protective clothing, shoes (boots) firefighter's helmet and belt, gloves and air breathing apparatus with increased pressure as well as the necessary personal protective equipment for working in an ionizing environment.

Firefighters have their own dosimeters and are qualified to intervene in all radioactive controlled areas. A spare bottle is provided for each air apparatus. Loading and storage of the bottles is organized on the service territory and in an outsourced emergency station in the town of Kozloduy. Fire trucks, in addition to the fire-technical equipment according to the specification, are additionally equipped with portable fire extinguishers.

3.2.4. Active fire protection in the spent fuel storage facilities

3.2.4.1. PSFSF and DSFSF – Fire detection and alarm provisions

On the territory of the PSFSF and DSFSF sites of the NPP, an approach has been adopted for the use of fire alarm equipment, compatible with the fire alarm equipment of the NPP in terms of data transmission. The installed fire alarm stations use the same communication protocol.

This approach allows information from PSFSF and DSFSF fire alarm networks to be aggregated and routed to common communication portals.

All fire alarm centers in the two sites are connected in a network with a loop topology. Through a physically independent Ethernet channel, the flow of information is directed to a visualization system, from which control of the fire alarm equipment of the objects is carried out.

The visualization system is a computer configuration with a specialized graphical application installed to control the state of the fire alarm system in the objects. The system is located at the on duty RSFSPP-NPP workplace, where 24-hour control is carried out.

When a signal is received, information is displayed on the user's monitor with the exact location of the triggered fire detector. Obtaining the correct information about the place of origin and the process of development of the fire at an early stage is of paramount importance for the evacuation of personnel and the minimization of material damage.

Fire alarm systems are ESSER IQ8control. The equipment is built on a modular principle, with microprocessor control and interactive addressing of the fire alarm sensors. This technology makes it possible to accurately determine the location of the fire. In case of an event, the specific number of the activated fire detector, the room in which it is located and the fire zone to which it belongs are recorded. Also, if necessary, the fire alarm system provides information about triggered outputs of the fire automation to activate the controlled ventilation systems and fire dampers.

The fire detectors used are from the IQ8 Quad series. These are intelligent,86 interactive, addressable fire alarm sensors with high operational reliability, guaranteeing safe and early fire detection. The sensors have decentralized intelligence, automatic self-diagnosis function, CPU Fault mode, alarm and operation memory, alarm indicator, software addressing, working status indication. Each sensor is equipped with a built-in isolator. Allows a parallel indicator to be connected to it.

Sensors automatically compensate for changing levels of atmospheric pressure, air humidity, smoke concentration in accordance with their working principle. They have a high immunity against false alarms by evaluating at a certain time against various sensor criteria. Alarm patterns not typical for fires are removed by using a special filter with algorithms.

The sensors continuously monitor for short circuit and/or open in the ring. The decision to signal a fire or failure is made by the sensor, not by the fire alarm station. The sensor has a built-in microprocessor with the help of which they perform a real-time analysis of environmental parameters and compare the characteristics of over 60,000 fire models. This dramatically reduces the time of their engagement while simultaneously reducing the possibility of false activation. Unlike conventional detectors operating on computer logic "0" / "1" IQ8Quad series detectors include the possibility of "suspected fire".

The sensors have a dual power supply and a built-in isolator, which allows them to maintain their operability in the event of a break in the fire alarm line. This allows independence of operation of fire detectors between adjacent fire zones (premises).

For PSFSF and DSFSF installed equipment is as follows:

Equipment	**Amount/pcs.**
Fire alarm stations IQ8 Control M	2
Fire alarm sensors IQ Quad	91
Fire extinguishing control and signalling panels	2
Visualization system	1
Functional tests per year	8

3.2.4.2. PSFSF and DSFSF – Fire suppression provisions

According to national legislation, and more specifically the requirements of Appendix 1, to Article 3, Paragraph 2 of Ordinance No. Iz-1971 on the construction and technical rules and norms for ensuring safety in case of fire [8], for closed warehouses for the storage of non-combustible materials, the construction of a fire extinguishing installation is not required, and none has been built.

Fire extinguishers are deployed for the initial extinguishing of fires, according to the current regulatory requirements. Their location and type are regulated in the instruction "Maintaining the operational order and operational condition of the equipment in the PSFSF department". They are marked with signs according to the requirements of Ordinance No. RD-07/8 on the minimum requirements for signs and signals for safety and/or health at work.

Their maintenance, recharging and repair is carried out by personnel of the FPSE department at “Kozloduy NPP” EAD.

3.2.5. Active fire protection in the radwaste storage facilities

3.2.5.1. SFCRAW – Fire detection and alarm provisions

The main approach in designing the fire alarm system is related to the risk analysis - an assessment of the probability of fire occurrence and its spread in the objects is carried out. This allows for the required number and location of fire alarm devices to be determined.

During the design and construction of the fire alarm system of SDRAW Kozloduy, which includes SFCRAW, the following requirements have been met:

- to detect a fire at an early stage, to obtain accurate information about the place of its occurrence;
- to use a loop (circular) structure;
- to monitor for short circuit or mechanical failure in a convenient manner;
- general information from the system to be received in the Command Room and the information to be stored locally in the receiving station;
- to be provided with non-interruptible electrical power supply;
- control of the ventilation installation should take place at signal 1 of 1;
- the risk of fire when determining the protected area of the fire detectors should be chosen depending on the importance for the protected equipment;
- transmission of information to RSFSPP NPP;
- the maximum number of points in one circuit should be 127 pieces, as separators (isolator) are provided for through 32 points in case of short circuit.

The fire alarm station is an ESSERTRONIC IQ8M type and is installed in the control room, where there is constant monitoring by operational personnel. Three circuits are planned for maximum coverage of the guarded areas. Sound signalling is provided to notify all staff in the event of a "Fire" signal. Automatic transmission of information in the event of a "Fire" signal to RSFSPP NPP is also foreseen.

In the SFCRAW section, three smoke detectors are provided for vestibule rooms, control panel and electrical panels, and three manual fire detectors, with two located in the

warehouse near the doors for receiving the conditioned RAW in the RCC and one in the vestibule.

The operation of the system is carried out by the operating personnel who have undergone training according to the Instructions for the operation of the fire alarm system at the SDRAW Kozloduy.

Technical service, functional tests and repairs are carried out by personnel of “Kozloduy NPP” EAD under contractual relations, and for this purpose, the contractors have prepared a Procedure for functional tests of the automatic fire alarm system "ESSERTRONIC - IQ8 CONTROL M" in SDRAW Kozloduy.

3.2.5.2. SFCRAW - Fire suppression provisions

According to national legislation, and more specifically the requirements of Appendix 1, to Article 3, Paragraph 2 of Ordinance No. Iz-1971 on the construction and technical rules and norms for ensuring safety in case of fire [8], for closed warehouses for the storage of non-combustible materials, the construction of a fire extinguishing installation is not required, and none has been built.

Fire extinguishers are deployed for the initial extinguishing of fires, according to the current regulatory requirements. Their location and technological designation are regulated in the List of technological designations of firefighting equipment for initial extinguishing and their location in the facilities of SDRAW Kozloduy and the corresponding Technological drawing.

They are marked with signs according to the requirements of Regulation No. RD-07/8 on the minimum requirements for signs and signals for safety and/or health at work.

Technical service, recharging and repairs are carried out by personnel of "Kozloduy NPP" EAD under contractual relations.

The water supply for firefighting is provided by the site external fire ring, provided by “Kozloduy NPP” EAD. An internal fire water supply is not required and is not provided.

There are combustible materials in SFCRAW in limited quantities and the probability of a high-energy ignition source occurring is minimal and refers to the first group "Normal fire hazard". All measures to ensure fire safety in the electrical systems and installations of the warehouse are in accordance with the requirements for this group.

In the event of emergency situations, the staff is obliged to immediately notify the on-duty SDRAW Kozloduy Shift Supervisor, who notifies the RSFSPP NPP and takes action in accordance with:

- Emergency plan of SDRAW Kozloduy;
- Personnel action plan for extinguishing fires at SDRAW Kozloduy;
- Evacuation action plan in case of fire, accident, or natural disaster in SDRAW Kozloduy.

3.2.6. Active fire protection in the installations under decommissioning

3.2.6.1. SDD Kozloduy 1-4 - Fire detection and alarm provisions

In the supervised area, which includes the TB of unit 4, MCR-4 and electrical distribution panels of unit 4, relay panels, ventilation center and the controlled area the following are provided: Fire alarms (FAS) and Fire extinguishing systems (FES). These systems have signals on: MCR-4, room of shift operator of fire protection systems (OFPS) and

dispatcher at RSFSPP NPP. For the controlled area, the signals are also duplicated in the RAW treatment systems control room located in the same area. Control and operation of these systems is carried out by shift OFPS on a continuous basis (24 hours/day).

The testing and service maintenance of FAS and FES is carried out according to contractual relations with "Kozloduy NPP" EAD. Checks for readiness and serviceability of FAS and FES are carried out according to an approved annual schedule.

Electronic and manual fire alarm systems were installed in accordance with the design. They are equipped with TESLA-LIBEREC equipment: MHU103 fire alarm stations with smoke, thermal and optical-smoke sensors reacting to combustion products. They cover cable routes in the RC, TB, and main building, former fresh fuel centre, electrical and control rooms, and safety systems. Such systems are also installed in CWPS-1, CWPS-2, FPS-2.

In the rooms where there is no automatic extinguishing, only lines with smoke sensors are installed. For the rooms with automatic fire extinguishing, two lines are installed - one with smoke and the other with thermal sensors.

ESSERTRONIC (on unit 3) and FLEX EX 18-10 (on unit 4) fire alarm stations with the corresponding 3D optothermal differential sensors manufactured by the Austrian company ESSER, guarding the cable routes at elevations -3.60, +6.30 and +5.40 of main building, reactor compartment (RC) are installed on units 3 and 4.

Fire alarm stations operate in automatic mode and, in the event of a fire, provide a signal to control automatic fire extinguishing and signals (sound and light) in case of fire or failure, which are duplicated on a duplicate station in OFPS room.

3.2.6.2. SDD Kozloduy 1-4 - Fire suppression provisions

Fire extinguishing system in cable routes of main building, RC, TB

The fire extinguishing system includes cable management in the main building, reactor compartment (RC), turbine building (TB). Extinguishing is carried out with dispersed water in the volume of the room.

The system consists of:

- pipe system of steel pipes, fixing supports and suspensions;
- manual valves and MOVs;
- drainage sprinklers;
- four electric fire pumps (FPP) - 1FPP and 2FPP located in CWPS-1, 3FPP and 4FPP located in FPS-2;
- two diesel fire pumps located in FPS-2. They are intended to work in emergency operation mode - when it is impossible to use 1FPP, 2FPP, 3FPP, 4FPP. Each pump is equipped with an operational and emergency tank with a capacity of $0.8m^3$ and $10m^3$, respectively;
- two electric pumps for maintaining a constant pressure from 4 to 6kg/cm2 in the fire ring located in FPS-2.

The system is supplied with water from the inlet channel, which is fed from the Danube River, through the above-mentioned pumping units and is secured by an emergency connection of the fire ring on units 5 and 6 and external fire protection pipeline of units 1÷4.

The system is activated automatically as follows:

- From fire alarm systems MHU 103.

Opening of the electric valve, start-up of the FPP, selected in the working position and preparation for the back-up start of another FPP according to logic 2 of 2, i.e., following a signal from two sensors - thermal and smoke, located in a given room.

- From fire alarm systems ESSERTRONIC and FLEX EX 18-10

Opening of the electric valve, start-up of the FPP, selected in the working position and preparation for the back-up start of another FPP according to logic 2 of 2, i.e., following a signal from two sensors, from groups 1 and 2 located in a given room.

- For the transformers 1, 2 and 3AT

The activation of the FES is based on a signal sent by the electrical protections of the respective transformer.

Other fire extinguishing means

For extinguishing fires and for household needs, external and internal fire protection pipelines are built on the territory of the NPP, equipped with fire hydrants and indoor fire hydrants (IFH).

Water supply is provided by 2 fire service pumps (FSP) located in CWPS-1. 1FSP and 2FSP take water from the inlet channel, fed by the Danube River.

A connection is made between the external fire protection pipeline and the pipeline for automatic fire extinguishing, and if it is necessary to supply an additional amount of water to the external fire protection pipeline, constant pressure pumps in FPS-2 can also be used.

Fire extinguishers are provided on the territory of SDD Kozloduy 1-4 for initial extinguishing. Firefighting equipment is placed in easily accessible and well-visible places. The location of the fire extinguishers and the access roads to them are marked with signs, according to Regulation No. RD-07/8 on the minimum requirements for signs and signals for safety and/or health at work. Powder, water-foam and CO_2 fire extinguishers are provided.

The control of portable and transportable fire extinguishers is carried out by the supervisor of the site or by those responsible for fire safety by carrying out periodic inspections in compliance with the requirements of item 4.2 of BDS ISO 11602-2:2002.

The maintenance, recharging and hydrostatic pressure resistance testing of portable and transportable fire extinguishers are carried out in accordance with the manufacturer's operating instructions and in compliance with the requirements of items 4.3, 4.4 and 5 of BDS ISO 11602-2:2002. The maintenance, recharging and hydrostatic pressure resistance testing of portable and transportable fire extinguishers are carried out under contractual relations with "Kozloduy NPP" EAD.

Firefighting equipment, fire hydrants, ladders for firefighting and emergency-rescue activities, alarm or notification devices, devices for the manual activation of FAS and FES, evacuation routes and exits, as well as places without direct visibility to evacuation exits are marked with signs according to the Regulation No. RD-07/8 on the minimum requirements for signs and signals for safety and/or health at work.

Organizational aspects of fire protection

In order to create the necessary organization, orders have been issued in accordance with Article 9 of Ordinance No. 8121z-647 of 01.10.2014 on the Rules and Norms for Fire Safety during Operation of the facilities [9], as well as the following internal documents:

- SE RAW Fire Safety Regulations;
- SDD Kozloduy 1-4 Fire Safety Instruction;
- Instruction on Fire Safety when carrying out hot works in SDD Kozloduy 1-4;
- Action plan for extinguishing fires SDD Kozloduy 1-4;
- Rules for ensuring health and safety in working conditions in SE RAW;
- SE RAW Risk Assessment Program;
- Current SDD Kozloduy 1-4 Fire Action Plan as well as SE RAW Emergency Plan, SDD Kozloduy 1-4 Internal Emergency Plan.

For the control and supervision of the FAS and FES, an operational staff has been formed, which is on 24-hour duty. The FAS and FES have output signals in the RSFSPP-NPP, where there is a dispatcher station with an employee on duty (dispatcher on duty).

The Duty Operator of Fire Protection Systems (OFPS) has a telephone connection with the duty dispatcher at RSFSPP-NPP.

The operational control of the fire protection systems is performed by the OFPS on shift, who is directly subordinate to the Plant Shift Supervisor for units 1-4.

For the protection of the staff and residents on the territory of the SDD Kozloduy 1-4 the actions and responsibilities of the personnel in the evacuation, rendering of medical aid if there are injured people and control of the fire are described. In this plan, the actions are agreed together with RDFSPP-NPP and the on-site plant medical service of NPP Kozloduy.

The overall control and organization in the event of a fire is carried out by Plant Shift Supervisor for units 1-4. He is the official who coordinates the activities of notification, evacuation and organization of the management activities of the events that have occurred.

Plant Shift Supervisor for units 1-4 implements the interactions with the RSFSPP-NPP in the event of a fire, namely notification, providing access and additional information, assisting the fire brigade teams.

Anyone working at the sites of SDD Kozloduy 1-4, who notices or establishes ignition or fire, is obliged to immediately notify his immediate supervisor, Plant Shift Supervisor for units 1-4 and RSFSPP-NPP.

Depending on the situation, upon receipt of a fire signal the Plant Shift Supervisor for units 1-4, he notifies:

- RSFSPP-NPP;
- Chief Engineer of SDD Kozloduy 1-4 ;
- Chief Expert on fire and industrial safety;
- Residents in all areas for the need to evacuate.

According to Regulation No. 8121z-647 [9], a training on evacuation is planned and is performed at least once a year together with RSFSPP-NPP and on-site plant medical service of NPP Kozloduy.

Twice a year, Emergency training is also carried out according to certain scenarios for fires in different departments according to the current Emergency Plan of SE RAW.

3.3. Passive fire protection

As a result of the implementation of Measure 21111 of the Units 5 and 6 Modernization Programme, the fire zones and cells have been determined, for which it is necessary to ensure limitation and localization of the spread of combustion products to neighboring premises within the boundaries of the affected fire zone or cell. The required fire resistance limits of fire walls, partitions, air ducts, doors, corridors, and staircases have been ensured.

MCR and ECR are defined as different fire zones and with the implementation of measures 18111 and 18121 the required fire resistance limits of doors, partitions, walls, and air ducts have been ensured. With the installation of new equipment qualified according to European codes and standards, smoke-proofing of personnel evacuation routes is ensured.

For the implementation of Measure 18111, a detailed design for ensuring the necessary quality of fire zones and cells, according to the requirements of the "Fire Hazard Analysis" has been developed, which includes the delivery and installation of new qualified fire doors and the restoration of the necessary fire walls and partitions for the boundaries of fire zones and cells.

In addition to the specified degree of fire resistance of 90 minutes for a fire zone and 30 minutes for a fire cell, doors meet the following requirements:

- the double-winged doors on the escape routes are equipped with a lock to be fixed in the closed position with the possibility to open both wings if necessary, without using the lock handles;
- they are equipped with a secure and self-closing mechanism. This ensures the required self-closing function to avoid unwanted doors being left open;
- they are gas-smoke sealed. The size of the leak is determined according to standard DIN18095, part 1 or equivalent.

In order to limit the spread of the products of the fire, new qualified fire dampers were delivered and installed, the ventilation ducts were isolated with an additional fire protection coating.

Isolation of the ventilation ducts was undertaken in all cases of ventilation ducts transiting through the fire zones.

The new fire dampers are types FKS-K90, FKR-K90 and FKF-K90 with the required fire resistance. They meet the requirements of 90 minutes fire resistance, in group closing/opening by signal or remotely and signaling of the flap position.

The fire dampers are qualified in accordance with the requirements of design standard НП-031-01 “Standards for the design of earthquake-resistant nuclear power plants for seismic category 1 equipment”. The qualification was carried out for seismic impact applicable to their installation location at the Kozloduy NPP, for a maximum design basis earthquake.

A total of 372 fire dampers have been installed on units 5 and 6 and on SRSB-3.

The licensing process is ensured by providing damper fire certificates, seismic certificate, and damper test report from the supplier.

The flaps operate in hot stand-by mode. Their normal state is "open". In the event of a fire in the room, the fire alarm system sends a control signal to close the installed fire

dampers for the specified zone. A remote control is provided, from where the operator can, if necessary, close all the flaps for the respective zone using a button on the Control and Alarm Console. After closing, the dampers are able to prevent the spread of fire for 90 min.

If the flaps do not receive a signal to close for some reason, then after reaching 72^{o}C in the air ducts, a thermo-fuse breaks the electrical circuit and the flap closes. After a fire, the dampers can be opened remotely to allow smoke to escape without it entering other rooms.

3.3.1. Prevention of fire spreading (barriers)

The fire protection system is designed to protect, detect, locate, and extinguish fires on the territory of the plant within the limits of the room in which they occurred.

At the Kozloduy NPP, efforts are aimed at minimizing the risks of fires. In general, to prevent the spread of fires, emphasis is placed on passive protection. Thus, the operation of safety systems does not depend on the operation of active fire extinguishing systems.

In the design of the main buildings and facilities, the construction of firefighting horizontal and vertical partitions is foreseen, which will serve as an obstacle along the road for the spread of the fire. This aims to reduce the consequences of a possible fire to the extent practically possible. In this way, it is guaranteed that systems performing safety functions will be sufficiently protected to fulfill their intended purpose.

A fire sector corresponds to the concept of a fire zone in the design of units 5 and 6 of the Kozloduy NPP, from which it is deducted that it is necessary to evaluate the structural elements walls, floors, ceilings whether they correspond to the fire resistance time of the enclosing structures, from 90 to 120 minutes.

Partitions of the fire sector are made of products with a fire reaction class not lower than A2.

The minimum fire resistance of the vertical and horizontal partitions of the fire sector is REI 120.

The minimum fire resistance of doors that separate the fire sector from corridors and stairwells intended for simultaneous service of two or more fire sectors in one building is EI 90.

The places of passage of pipelines, air ducts, cables and other equipment and communications through horizontal and vertical fire protection partitions are sealed with products with a fire reaction class not lower than A2, without lowering the fire resistance of the corresponding partition.

Barriers serve to prevent the spread of fire in a horizontal and vertical direction to neighboring buildings, facilities, and communications, as well as to shape the boundaries of fire zones and fire cells. They are physically implemented as firewalls, fire protection walls and partitions (in buildings, cable mezzanines, cable ducts, cable boxes, technological overpasses) and fire protection vestibules.

The degree of fire resistance of the barriers that form the boundaries of the fire sectors is determined according to the requirements of Regulation No. Iz-1971 on construction and technical rules and norms for ensuring safety in case of fire [8].

3.3.1.1. Design approach

In connection with the "Fire hazard analysis" a detailed design for ensuring the necessary quality of fire zones and cells, according to the requirements of "Fire hazard analysis in the buildings of reactor compartment of units 5 and 6, TB-EER 5 and 6, CWPS-3 and 4, DGS units 5 and 6 and SRSB-3 has been developed.

The following design principles are applied:

- The "limitation of the spread of fire" approach is preferable because it makes use of passive protection systems in preference, thus the protection of safety systems does not depend on the operation of stationary fire extinguishing systems.
- Buildings that contain equipment important to safety are designed to be fire resistant, divided into fire zones and fire cells.
- The separation of fire zones and fire cells is carried out not only in the presence of electrical equipment important for safety, but also depending on the amount of combustible load per m², in accordance with the current national standards.
- The fire resistance of passages such as doors, air ducts, manholes, fire dampers and cable runs, ventilation pipes and pipelines that form part of a fire barrier and the boundary of a fire zone shall have a fire resistance that is at least equal to the fire resistance of the fire barrier itself.

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

A fire sector is a building or part of a building that is completely surrounded by fire-resistant barriers: walls, floor and ceiling. All devices that are fitted to or are crossing trough fire barriers such as doors, hatches, cable runs, pipes and air ducts must have a fire resistance rating at least equal to the fire resistance of the same fire sector.

The firewalls are made of building products with a fire reaction class not lower than A2 and with a minimum fire resistance REI (EI)120. They are intended for:

- division of buildings into fire sectors;
- separation of buildings, premises and facilities of functional fire hazard class F5 according to Regulation No. Iz-1971 [8] from neighboring buildings, premises, facilities and installations;
- reduction of the minimum distances between buildings and facilities of all classes of functional fire hazard.

Fire protection walls are made of building products with a reaction to fire class not lower than A2 and with a minimum fire resistance REI (EI) 60. They are intended for:

- separation of premises of different class of functional fire hazard;
- separation of productions with different fire hazard categories F5A – F5D according to Regulation No. Iz-1971 [8].

Horizontal fire barriers are made of building products with a fire reaction class not lower than A2 and with a minimum fire resistance of REI 60. They are designed to limit the spread of fire in the vertical direction.

Fire-resistant vestibules are made of building products with a fire reaction class not lower than A2 and with a minimum fire resistance REI (EI) 60. They are intended for:

- separation of explosive premises from adjacent non-explosive premises;
- ensuring non-smoke stairwells in multi-story buildings.

The characteristics of fire doors, fire dampers and all other devices for the protection of openings in partitions (barriers) are established and guaranteed by the accompanying documentation at the stage of delivery before they are installed into the structural elements. Mandatory element of this documentation are protocols from tests, opinions on admissibility and production certificates proving and guaranteeing their operational qualities and compliance with the applicable current national and international standards.

The "Fire Hazard Analysis" (Measure 21111) and the technical design "Improving the fire resistance of fire doors" were implemented for the following buildings in units 5 and 6:

- Reactor compartment inside and outside the hermetic zone;
- Turbine building including the electric rack;
- Diesel generating station;
- Circulation water pumping stations;
- Special Radwaste Storage Building -3 and restricted access zone.

The fire hazard analysis results in a list of fire zones and fire cells in buildings, as well as recommendations (measures) that need to be implemented to ensure the necessary limit for:

- Fire zone - 90 minutes for all structural elements;
- Fire cell - minimum 30 minutes for all structural elements.

The required fire resistance of the doors is certified by Test Reports according to the requirements of EN 1361-1, EN1634-1 or Certificates from authorized laboratories. In addition to the specified fire resistance, the doors are:

- Made of non-combustible material;
- They are equipped with a closing and self-closing mechanism, which guarantees the required self-closing function to avoid being left in an undesired open position;
- They are gas-smoke sealed.

Fire doors located at the borders of fire zones are a barrier against the spread of fire products (heat, smoke, flame) and have a fire resistance limit of 90 minutes.

Fire doors at the boundaries of a fire cell have a minimum fire resistance limit of 30 minutes and are also a barrier against the spread of fire products.

The structural elements of the main buildings of the power units are described below:

1) The building of the Reactor compartment of units 5 and 6 consists of a hermetic zone, in which the reactor and the equipment of the primary circuit are located, protected by a hermetic shell and surrounding constructions (rooms in which the equipment of the auxiliary systems and safety systems are located). According to Art. 311(1) of Regulation Iz-1971 [8] the required degree of fire resistance of the structural elements is 1st, and the permissible area of the fire sector is 2200m^2.

The actual degree of fire resistance of the building of the reactor compartments is 1st. The fire resistance of the partition structural elements significantly exceeds the fire resistance required by the regulatory framework. Only non-combustible products that do not contribute to the development of uncontrolled combustion are used.

2) The DGS building is designed to supply electricity to users of the safety systems in the event of loss of the off-site power at the NPP, as well as to house the electrotechnical equipment of the safety control systems. The building has an underground (elevation -4.20 m) and an above-ground part.

In the underground part the auxiliary equipment of the diesel generator and the chiller, the rooms of the ventilation filters of the air intake and the cable rooms are located.

In the above-ground part of the building at an elevation of 0.00 m, there are double-height rooms of the engine room of the diesel generator and the rooms of the chillers' machines. The remaining rooms are located at elevations of 0.00 and +4.80 m (ventilation chambers, electrical rooms, etc.). According to Art. 12(3) of Regulation Iz-1971 [8] the required degree of fire resistance of the structural elements is the 1st. All supporting structures, staircases and partitions of the building are made of monolithic reinforced concrete.

The actual degree of fire resistance of the structural elements of the DGS building is 1st. Only non-combustible products that do not contribute to the development of uncontrolled combustion were used. The degree of fire resistance of building structures and elements significantly exceeds the required.

3) The turbine building is over 28 m high. It houses the systems and equipment of the secondary circuit related to the power conversion system.

The building consists of a Turbine Hall (rows "A-B") and a Deaerator Department (rows "B-C").

The Turbine Hall houses the turbine-generator unit and its supporting systems, the moisture-separators re-heaters, the high and low pressure feed-water heaters, the turbine condensers and condensate pumps, oil systems.

The deaerators, main and auxiliary feed-water pumps with lifting mechanisms for their service are located in the deaerator compartment.

The bearing columns and roof trusses of the TB are built of metal elements with additional fire protection applied in accordance with the design, and for additional protection a water drenching sprinkler system was also built. The columns of steel shelves, as well as the columns of the steel structures on which technological systems and equipment are located in the production buildings of fire hazard categories F5A and F5B according to Regulation No. Iz-1971 [8], are designed with fire resistance R60, and the horizontal supports elements - with fire resistance R30, through additional fire protection.

According to Art. 336 of Regulation Iz-1971 [8] the required degree of fire resistance is 2nd. The actual degree of fire resistance of the building is 2nd. The degree of fire resistance of building structures and elements meets the required.

4) SRSB-3 (Special Radwaste Storage Building) is a complex of four buildings with a total size of 60x218 m, built with a joint between them. The area of SRSB-3 is conventionally divided into rows A to E and axes 1 to 30. The buildings are separated by expansion joints according to their functions and purpose, namely:

- Maintenance workshop building, axes 1 to 6

  This part houses repair shops for repairing contaminated equipment, a fresh fuel center, supply and exhaust ventilation center.

- sanitary- services building, axes 6 to 11

  The sanitary- services building at an elevation of ±0.00 m includes: main entrance of the building, hot water supply facility, laundry facilities, etc.

  At an elevation of 4.80 m, there are "clean" laundry and special laundry rooms. At elevations +9.00, +13.20, +16.50 and +19.80 m, there are laboratories and a sanitary passage for access to the zone with a restricted access, where dosimetry control of the body, hands and clothes is carried out when leaving the zone. In this part (in the clean area) there are also working rooms for the staff and offices.

- Special water treatment building, axes 11 to 27

  In the special water treatment building, the water purification systems, bitumen facility, supply and exhaust ventilation centers, control centers for radiation control and special water treatment, laboratories, etc. are located.

- Liquid radwaste storage building, axes 27 to 30

  The tanks and systems for storing liquid radioactive waste are located in this part.

According to Regulation Iz-1971 [8], the required degree of fire resistance is 2nd. The actual degree of fire resistance of the building is 2nd. Only non-combustible products that do not contribute to the development of uncontrolled combustion were used. The degree of fire resistance of building structures and elements significantly exceeds the required one.

The internal layout of the RC, DGS, TB-EER, SRSB-3 and PSFSF buildings was also checked for compliance with Regulation Iz-1971. Internal layout refers to the mutual arrangement of rooms and volumes in relation to each other in a given object or building. This is an important part of the fire safety of any site in general. Compliance with the requirements for internal layout according to the regulatory documents ensures the significant reduction of the risk of fire, or if it occurs, its spread is limited, which in turn means a reduction of the assumed losses from fire.

3.3.1.3. Performance assurance trough lifetime

Ensuring the operational characteristics during the entire operational period of the structures and facilities providing passive fire protection is carried out through periodic inspections, the scope and frequency of which are documented in the "Procedure for controlling the state of passive measures for fire protection and preventing the spread of fire".

Control of the condition of the fire sectors, firewalls, fire barriers, horizontal fire barriers and fire protection vestibules is carried out at:

- development and coordination with the control bodies of technical documentation for technologically necessary changes to fire barriers, horizontal fire barriers and fire protection vestibules;

- implementation of changes to fire barriers, horizontal fire barriers and fire protection vestibules in accordance with the normative documents for not allowing reduction of their fire resistance limit;
- partial or total destruction of fire barriers and horizontal fire barriers and their restoration to the required fire resistance limit;
- the presence of holes and openings between the frames of fire-resistant doors and fire-resistant walls.

Frequency of inspections:

- inspections during rounds by the employees of the owner of the premises or the department of the company, according to the rounds schedule and route maps;
- annually, by an interdepartmental committee appointed by order of the Executive Director to establish the readiness for putting units 5 and 6 into operation after PAO (planned annual overhaul);
- every 5 years when carrying out a technical inspection of the elements of the building structures of the main production buildings and facilities, according to the requirements of Regulation No. 9 on the technical operation of power plants and networks of 2004.

Responsibility for the condition and repair of fire protection walls (in buildings, cable mezzanines, cable ducts, cable routes, technological overpasses), horizontal fire barriers and fire protection vestibules, fire-resistant coatings of building structures and cables, the sealing of cable, pipe and ventilation passages with a certified non-combustible material is carried by the owner of the premises as per the organizational structure of the company.

Activities for the repair and restoration of cable, pipe and ventilation ducts, as well as the fire protection of electric power cables, are detailed in the Technology for sealing and revision of cable ducts and fire protection of cables.

The responsibility for the condition of fire doors, as elements to protect openings in built fire barriers, is borne by the relevant officials specified in "Procedure for technical maintenance, ensuring normal operability of fire doors installed in sites of "Kozloduy NPP" EAD".

Technical maintenance of fire doors is carried out according to established annual schedules:

- Schedule of preventive maintenance and repair of SSCs, when operating units 5 and 6 at rated power level;
- Schedule for execution of planned annual outage of unit 5;
- Schedule for execution of planned annual outage of unit 6.

Technical service is carried out by the FPSE department according to:

- Procedure for technical maintenance ensuring normal operability of fire doors installed in premises of "Kozloduy NPP" EAD;
- Procedure for maintenance of automatic devices installed on fire doors.

The independent control of the constructed passive measures for fire protection is carried out by the inspectors from the Fire Safety department in the Safety Directorate, in accordance with the "Instructions for the control activities of the Fire Safety department"

and in compliance with the requirements of the "Instructions for the control of the status of the constructed active and passive measures in Kozloduy NPP".

During the inspections, a control sheet with predetermined criteria is filled out as a reporting document, one of which is the state of the passive barriers in the object specified in the inspection route. When deviations are found, they are reflected first in the control sheet and then in the IS OOA, being directed for implementation to the relevant organizational structure. The IS OOA also sets deadlines for the elimination of deviations and nonconformities.

The activity of the Fire Safety department is carried out according to approved plans and schedules on a monthly basis. Control is also carried out by the Regional Office for Fire Safety and Protection of the Population RSFSPP-NPP, which is part of the structure of the Ministry of Internal Affairs.

3.3.2. Ventilation systems

3.3.2.1. Ventilation system design: segregation and isolation provisions

The ventilation systems in the Reactor Compartment are not centrally located. This means that specific groups of rooms or types of rooms are equipped with supply and suction ventilation respectively.

Typical examples of these decentralized systems are:

• Ventilation systems in the hermetic zone:

Containment ventilation systems provide a negative pressure inside the containment during normal operation to prevent release of radioactivity to the atmosphere. The systems also ensure optimal environmental conditions (temperature, humidity) for the normal operation of the plant equipment. In addition, the systems provide for normal operating conditions for carrying out the necessary repairs and maintenance.

Inside the hermetic zone there are specific recirculation systems to cool certain areas and to remove humidity. Heat removal is carried out by the technical water system.

• Ventilation systems for the restricted access zone:

Oil rooms have specific inflow and suction systems. Also, the additional oil rooms of the primary circuit make-up/purge system have a common ventilation system.

System rooms (containing components such as valves, heat exchangers, pumps, etc.) have a specific suction system (common to individual train rooms).

Instrumentation rooms have a specific general suction ventilation (common to the rooms of the individual train). The inflow is carried out mainly through the over-pressure passive valves from the corridor.

The rooms of safety systems and systems important to safety usually have a specific recirculation cooling system.

The stairs have an inflow system to create overpressure in case of fire.

• Ventilation systems for the free access zone:

Cable rooms have specific split ventilation systems.

The ventilation systems for the cable rooms from different train of the safety systems are also separated.

The premises of the control cabinets have specific split ventilation systems. Ventilation systems for control rooms from different trains are also divided by trains.

Switchgear and electrical cabinet rooms have specific, separate ventilation systems. The ventilation systems for the different trains are also divided according to the trains principle.

Battery rooms have specific split ventilation systems (by trains).

The stairs have an inflow system to create overpressure in the stairwell in the event of a fire.

MCR / ECR have a common air conditioning system. MCR and ECR are supplied with fresh air by a common system. However, each of these rooms has an independent redundant recirculation cooling system.

In order to limit the spread of the products of the fire, new qualified fire dampers were delivered and installed, the ventilation ducts were isolated with an additional fire protection coating. Isolation of the ventilation ducts was undertaken in all cases of ventilation ducts transiting through the fire zones.

3.3.2.2. Performance and management requirements under fire conditions

The "Fire Hazard Analysis" sets out the basic requirements for ventilation systems to meet the "Fire Limitation Approach" as follows:

- the fire and smoke must be contained in designated fire zones in buildings to minimize their spread and consequences for other facilities and premises.
- the spread of smoke, heat and flame through ventilation ducts crossing fire zone boundaries must be prevented.
- evacuation routes and access routes for manual firefighting must be secured. Therefore, smoke and heat are not allowed to enter them.

Considering the results from the FHA, ventilation systems are defined that are automatically switched off by the fire alarm system. Interlocks to the ventilation systems are implemented when the fire alarm systems are activated in the event of a fire, they close the fire dampers and/or shut down the designated ventilation systems.

The flaps normal state is "open". In the event of a fire in the room, the fire alarm system sends a control signal to close the installed fire dampers for the specified zone. A remote control is provided, from where the operator can, if necessary, close all the flaps for the respective zone using a button on the Control and Alarm Console. After closing, the dampers are able to prevent the spread of fire for 90 min.

If the flaps do not receive a signal to close for some reason, then after reaching 72^{o}C in the air ducts, a thermo-fuse breaks the electrical circuit and the flap closes. After a fire, the dampers can be opened remotely to allow smoke to escape without it entering other rooms.

3.3.3. Passive fire protection in the spent fuel storage facilities

3.3.3.1. PSFSF and DSFSF – Prevention of fire spreading (barriers)

The fire protection of the facilities includes active and passive measures providing defence in depth. The passive measures ensure the maintenance of the load-bearing capacity and the stability of the structure and limit the spread of fires. The active measures complement the passive ones, which increases the fire safety of the constructions.

All PSFSF main building structures are reinforced concrete and should be considered non-combustible. The roof structure is filled with steel trusses and is covered with panels with combustible thermal insulation, with fire barrier belts made of non-combustible panels every 6 m, and a coating that prevents combustion is laid on the roof. In view of these measures, the roof structure must be considered fire-resistant.

All main building structures of the DSFSF are reinforced concrete or steel. Fire resistance of DSFSF support structures is provided in the design as required. Vertical reinforced concrete walls were used for protective shielding along the outer perimeter of the storage hall and for protective shielding between the receiving area and the storage hall.

The roof panels are made of sheet steel with mineral wool filling and the necessary multi-layer protective coating. The steel roof is protected with a fireproof coating certified for use in Bulgaria.

Passive defence means that are implemented in PSFSF and DSFSF are:

- fire protection walls;
- fire-resistant coatings of building structures and cables;
- seals of cable, pipe and ventilation ducts;
- fireproof and smoke-proof doors;
- lightning protection and grounding;
- evacuation routes, roads and stairs for fire-extinguishing and emergency rescue activities and dry pipes;
- established rules regarding storage conditions for flammable and explosive materials, flammable liquids, combustible liquids, and combustible gases.

3.3.3.2. PSFSF and DSFSF- Ventilation systems

The supply air ducts of the ventilation systems in the PSFSF are made of galvanized sheet metal and are thermally insulated with mineral wool mats. The materials used are non-combustible, with fire reaction class A1 and meet the regulatory requirements for the degree of fire resistance.

By controlling the ventilation systems of the PSFSF or DSFSF, the Fire Alarm System (FAS) prevents the spread of fire in the premises it guards - when any sensor is triggered, a signal is sent to turn off the corresponding operating ventilation system, prohibit re-connection and ban on turning on a back-up non-working system until the root cause is eliminated.

Ventilation of the storage room and container receiving area in the DSFSF is done naturally. Air intake is through ventilation grills mounted on the walls. Discharge of air from the room is provided by ventilation grills mounted on the roof of the building.

3.3.4. Passive fire protection in the radwaste storage facilities

3.3.4.1. SFCRAW - Prevention of fire spreading (barriers)

The main supporting structure of SFCRAW consists of 13 pcs. transverse two-nave frames with columns wedged into the foundation slab, rigidly connected to the roof purlins. The construction is unprotected steel.

The enclosing facade walls are made of monolithic reinforced concrete with a predominant thickness of 200mm. and after the installation of the steel structure, the dowel connection is made between the steel columns from the periphery of the building and the surrounding walls. The roof covering is made of prefabricated reinforced concrete panels.

The construction of the panels provides the necessary radiation and fire protection. The storage facility consists of two independent halls, united by a transport corridor. The total built-up area of the building is 1946 m^2. The building is fire hazard category F5D according to Regulation No. Iz-1971 [8]. The degree of fire resistance is defined as 1st. The entire SFCRAW building is one firefighting sector, separated from neighboring buildings and premises by means of firewall-type fire protection walls. Openings in the firewall do not exceed 10% of its area. Doors and covers to protect openings have a minimum fire resistance of 90 minutes. The doors are self-closing.

In order to minimize the time spent by personnel in the storage facility, a separate "Control Center" room is provided for the management and control of the systems directly related to receiving, positioning and storing RCC. This room is separated from the warehouse by means of fire barriers with fire resistance of at least 120 minutes.

The switchboards are provided in a separate room with non-combustible walls with a fire resistance of 150 minutes and a non-combustible door.

All roads serving the site are used for fire protection purposes, and they are designed closed and with a durable surface. The width of all fire roads is more than 3.5 meters.

According to the current national legislation for firefighting and emergency rescue activities, three ladders with a width of 0.6 meters are provided. Next to the fire escapes, dry pipes with a diameter of two inches, with outlets on the roof of the storage facility, with shut-off valves and fire hose connectors are provided.

In the SFCRAW, as well as in the control center, no permanent resident staff is provided, and in the performance of operation or repair activities, they do not exceed 10 people. For safe evacuation from the storage facility, three final evacuation exits with a width of more than 0.9 meters and a height of at least 2 meters are provided.

3.3.4.2. SFCRAW - Ventilation systems

According to national legislation, fire prevention ventilation is provided for rooms, areas or facilities in which, during normal operation, combustible substances are emitted and a general or local explosive atmosphere can be created. Only non-combustible materials (RCC) are stored in SFCRAW, the building is also constructed of non-combustible materials, which does not mandate the construction of ventilation to prevent fire.

The ventilation system in SFCRAW is designed to remove smoke and heat and supply fresh air in the event of a fire. It consists of two subsystems:

"SFCRAW Suction Ventilation System" subsystem
“SFCRAW Deflectors” subsystem

The storage facility is ventilated naturally. Air intake is through 44 ventilation grills installed at a height of 1.8 m from the floor. Discharge of air from the room is provided by deflectors mounted on the roof. Emergency ventilation is provided through 4 (four) fans mounted on the roof of the building. The fans are switched on when the temperature in the room exceeds 40°C.

No heating is provided for winter mode. As ventilation is only required for summer mode, the louvres for fresh air intake are closed in winter.

3.3.5. Passive fire protection in the facilities under decommissioning

3.3.5.1. SDD Kozloduy 1-4 – Prevention of fire spreading (barriers)

Passive fire protection measures were taken into account during the design, construction and operation of unit 4 of the Kozloduy NPP, ensuring the preservation of the load-bearing capacity and the stability of the structure and the limitation of the spread of fires.

During the decommissioning process, the functional fire hazard class of unit 4 of Kozloduy NPP is maintained. According to Regulation Iz-1971, it is designated with hazard class - F5, subclass - F5.1 of fire hazard.

The degree of fire resistance of the building is determined according to Art. 12 paragraph 1 table. 3 of Regulation No. Iz-1971 "Construction-technical rules and norms for ensuring safety in case of fire" [8]. The building is of the2ndI degree of fire resistance.

3.3.5.2. SDD Kozloduy 1-4 – Ventilation systems

There are operating ventilation systems in the controlled area which are related to maintaining the radiation environment. The regulation of operation and control is described in an instruction for the operation of ventilation systems and is maintained by operational personnel of the Reactor Department. In the controlled area, the facilities are divided into separate hermetic rooms, which provides physical protection in the event of a fire. The ventilation systems are built depending on the nature of the premises, the regime and the layout of the technological equipment and have a specific purpose that meets the requirements for the area they serve and is carried out by supply and suction fans.

Fresh air is supplied from the serviced corridors through overpressure passive valves in the non-serviced rooms at the expense of the discharge created by the suction ventilation systems. This way of supplying air excludes backflow of contaminated air from the semi-serviced to the serviced premises. The air extracted from the suction ventilation systems goes for cleaning of aerosols and iodine filters.

General purpose of the ventilation:

- maintaining the radiation environment by creating negative pressure in the non-serviced and semi-serviced hermetic rooms to prevent the spread of radioactivity in the neighboring rooms through possible leaks;
- creation of conditions for normal operation of the equipment;
- ventilation of the premises after an accident;
- removal of excess heat;
- creating normal sanitary and hygienic conditions for the personnel during the repair operations;
- air conditioning.

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

In accordance with the study carried out under Measure 21111 of the Program for the modernization of units 5 and 6 for some selected premises, the fire resistance was calculated, using the methodology according to the German Standard for Nuclear Safety KTA 2101.2 "Fire protection of nuclear power plants. Part 2: Fire protection of building structures". This methodology takes into account the following factors:

- The geometry of the room;
- The type, quantity and location of fire loads;
- The influence of ventilation conditions (both natural and forced ventilation);
- Impact of firefighting capabilities (manual, automatic, fire brigade);
- Impact of wrong human actions (opening fire doors);
- Influence of heat-absorbing volumes.

In order to fulfill these requirements, within the framework of measure 21111, a "Fire Risk Analysis" was carried out. This analysis contains:

- Deterministic fire hazard analysis;
- Probabilistic analysis based on the Probabilistic Fire Vulnerability Assessment Method.

The following parts are included in the analysis:

- Reactor Compartment: Reactor Containment, Systems relevant to safety rooms, Electrical Rooms, Main Control Room (MCR) and Emergency Control Room (ECR);
- Diesel Generating Stations (DGS);
- Turbine hall and electrical rooms;
- Special water treatment systems.

A possible common cause failure analysis was performed. As a result of this study, the volume of work on the measures related to the modernization of the fire extinguishing systems was determined:

- Measure 18111 Improving the fire resistance of fire doors;
- Measure 18121 Limiting the spread of fire through ventilation ducts;
- Measure 18122 Modification of gas fire extinguishing system;
- Measure 18131 Qualification of fire alarm devices according to the required seismic level.

Periodically, Kozloduy NPP issues a report that assesses the current state of the fire alarm systems, including an assessment of the possibilities of supplying spare parts to ensure the systems' normal operability.

The report is prepared by the organization that designed, delivered, and installed the equipment at the site. The documentation contains a detailed inventory list of the main constituent hardware components of the architecture of fire alarm systems and number of installed components in the site.

Based on information from the equipment manufacturer, each component in the inventory is assigned a current market life cycle phase at the time of review of the report:

- Introduction
- Growth
- Maturity
- Decline
- Phase-out (Last orders)
- Obsolescence (Termination)

with a specific future year of product discontinuation indicated.

For reporting purposes, the "Introduction", "Growth", "Maturity" and "Decline" phases have been combined into one common "Commercial Availability" phase.

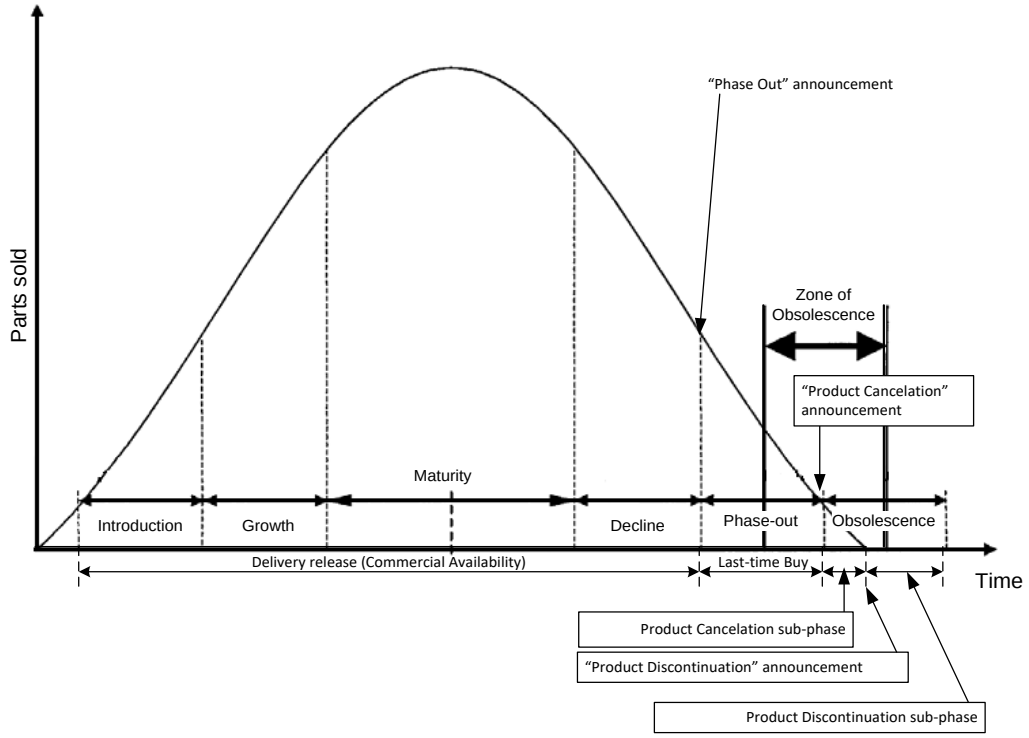

Fig 7. Equipment market life cycle phases

The information allows the personnel maintaining the systems to determine the repairability of the operated systems in future periods at an early stage.

Based on the presented results, the delivery of the necessary components for maintenance and planned modernization of the fire alarm systems is planned.

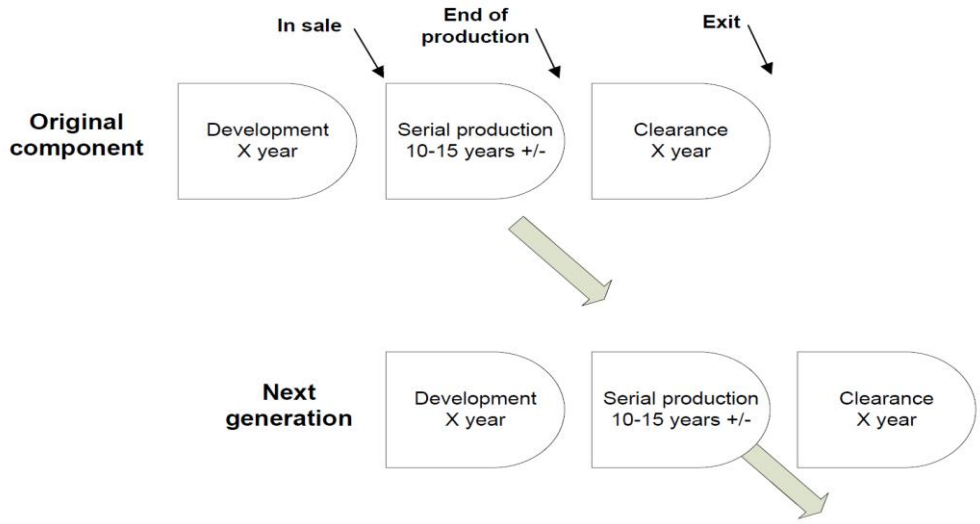

Fig 8. Modernization strategy

Following on the "Report on the results of the complex survey of the actual condition and assessment of the residual resource of the electrotechnical equipment of unit 5 of the Kozloduy NPP", the following recommendations are implemented:

- After 2020, fire alarm control panels type AlgoRex CS1140 (CT1142-Algorex) to be replaced with new generation Sinteso FC20**. The recommendation is filled with Technical decision for "Replacement of fire alarm stations of SS-1,-2,-3 and the adjacent operating panel" and for "Implementation of a detailed design for replacement of stations and peripheral elements of gas fire extinguishing systems in RC and TB on unit 5 ."
- After 2020, the existing detectors for the AlgoRex CS1140 Modular Fire Detection System to be gradually replaced with the detectors type FDOOT241- A5 (Interactive – Sinteso protocol). The replacement is planned to take place in the period until 2026.

As a result of the above, a number of modernizations of fire alarm systems have been carried out in recent years.

Table 4. Modernization of fire alarm systems of Unit 5

№	Topic	Effect of modernization	Implemented
1.	Replacement of a fire alarm station - TB unit 5	Improving the reliability of the systems by implementing high-end equipment of the latest generation - fire alarm center Sinteso FC2060. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2018
2.	Replacement of fire alarm stations in SS-1,-2,-3 and related control panel	The fire alarm systems of the unit's safety systems have been completely replaced - a total of 3 new fire alarm panels Sinteso FC2080 have been installed. Improving the reliability of systems by implementing high-end equipment of the latest generation. Trouble-free provision of	2019

		spare parts is guaranteed to ensure the reliable operation of the equipment.	
3.	Replacement of stations and peripheral elements of gas fire extinguishing systems in RC and TB of unit 5.	All the fire alarm systems of the unit involved in the management of the gas fire extinguishing systems have been completely replaced - a total of 10 units. Fire alarm centers Sinteso FC2020 with adjacent fire extinguishing panels for control and management of fire extinguishing have been implemented. The reliability of the systems has been improved by implementing high-end equipment of the latest generation. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2020
4.	Output of generalized signal "Fire in section 0" on panel in MCR of unit 5 when a fire occurs in the protected spaces with gas fire extinguishing.	Improves the response time of MCR senior operational personnel to take action when a fire occurs quickly and efficiently in the protected spaces with gas fire extinguishing of the unit.	2021
5.	Implementation of an alarm in the event of a main power failure of the fire alarm systems.	It allows operational personnel to promptly receive information about the failure of the main power supply of the fire alarm systems. The possibility of loss of fire alarm operation due to lack of power is practically eliminated.	2022

Table 5. Modernization of fire alarm systems of Unit 6

№	Topic	Effect of modernization	Implemented
1.	Replacement of a fire alarm station - TB unit 6	Improving the reliability of the systems by implementing high-end equipment of the latest generation - fire alarm center Sinteso FC2060. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2017
2.	Replacement of fire alarm stations in SS-1,-2,-3 and related control panel	The fire alarm systems of the unit's safety systems have been completely replaced - a total of 3 new fire alarm panels Sinteso FC2080 have been implemented. Improving the reliability of systems by implementing high-end equipment of the latest generation. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2018

3.	Replacement of stations and peripheral elements of gas fire extinguishing systems in RC and TB of unit 6.	All the fire alarm systems of the unit involved in the management of the gas fire extinguishing systems have been completely replaced - a total of 10 units. Fire alarm centers Sinteso FC2020 with adjacent fire extinguishing panels for control and management of fire extinguishing have been implemented. The reliability of the systems has been improved by implementing high-end equipment of the latest generation. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2019
4.	Output of generalized signal "Fire in section 0" on panel in MCR of unit 6 when a fire occurs in the protected spaces with gas fire extinguishing	Improves the response time of MCR senior operational personnel to quickly and efficiently take action when a fire occurs in the protected spaces with gas fire extinguishing of the unit.	2021
5.	Implementation of an alarm in the event of a main power failure of the fire alarm systems.	It allows operational personnel to promptly receive information about the failure of the main power supply of the fire alarm systems. The possibility of loss of fire alarm operation due to lack of power is practically eliminated.	2022

Table 6. Modernization of fire alarm systems of CSF (Common station facilities) on the site of EP-2.

№	Topic	Effect of modernization	Implemented
1.	Construction of a new Fire Alarm system in SRSB-3	Designed and built a new fire alarm system in SRSB-3 in accordance with modern requirements. The system is the latest high-end generation built on the basis of Sinteso FC2040 equipment and Sinteso FDO, FDT, FDM, FDL221 series sensors.	2016
2.	Software update of existing system MM8000 with Desigo CC, EP-2 site fire alarm systems at OFPS of units 5 and 6 and at dispatcher RSFSPP-NPP.	Software on workstations for visual control of the state of the fire alarm systems at the site of EP-2 at OFPS of units 5 and 6 and at dispatcher RSFSPP-NPP has been updated. It guarantees trouble-free migration to modern computer stations with modern	2020

		operating systems installed on them. Support and updates provided by the equipment manufacturer.	
3.	Implementation of an alarm in the event of a main power failure of the aspiration systems for fire detection of SRSB-3.	Enables operational personnel to promptly receive information about a loss of main power supply to the SRSB-3 aspiration fire alarm systems.	2022
4.	Implementation of an alarm in the event of a main power failure of the aspiration fire alarm systems in WTP and UAB buildings.	Enables operational personnel to promptly receive information about lost main power to aspiration fire alarm systems in WTP and UAB buildings.	2022

Table 7. Modernization of fire alarm systems in general plant facilities of "Kozloduy NPP" EAD since 2016

№	Topic	Effect of modernization	Implemented
1.	Replacement of the existing FAS in TQC.	Implemented modern high-class fire alarm system meeting all the requirements of the standards. Fire alarm system Esser by Honeywell inc. IQ8Control with IQ8Cuad sensors. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2017
2.	Replacement of the existing FAS in PSFSF.	Implemented modern high-class fire alarm system meeting all the requirements of the standards. Fire alarm system Esser by Honeywell inc. IQ8Control with IQ8Cuad sensors. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2017
3.	Replacement of the existing FAS in OSY.	Implemented modern high-class fire alarm system meeting all the requirements of the standards. Esser IQ8Control fire alarm system with IQ8Cuad sensors. A new control of fire extinguishing of transformers 1AT, 2AT, 3AT was built. Control and management of the process is carried out by specialized high-end fire extinguishing panels, model 8010, manufactured by Esser by Honeywell inc. Trouble-free provision of spare parts is guaranteed to	2017

		ensure the reliable operation of the equipment.	
4.	Replacement of the existing FAS in BPS.	Implemented modern high-class fire alarm system meeting all the requirements of the standards. Esser IQ8Control fire alarm system with IQ8Cuad sensors. A new fire control of the BPS cable sections has been built. Control and management of the process is carried out by specialized high-end fire extinguishing panels, model 8010, manufactured by Esser by Honeywell inc. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2017
5.	Replacement of the existing FAS in the Central Archive premises and in the Warehouse	Implemented modern high-class fire alarm system meeting all the requirements of the standards. Fire alarm system Esser by Honeywell inc. IQ8Control with IQ8Cuad sensors. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2018
6.	Implementation of FAS in the EP-2 Administrative building.	Implemented modern high-class fire alarm system meeting all the requirements of the standards. Fire alarm system Esser by Honeywell inc. IQ8Control with IQ8Cuad sensors. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2019
7.	Implementation of FAS in the Emergency management centre of “Kozloduy NPP” EAD.	Implemented modern high-class fire alarm system meeting all the requirements of the standards. Fire alarm system Esser by Honeywell inc. IQ8Control with IQ8Cuad sensors. Trouble-free provision of spare parts is guaranteed to ensure the reliable operation of the equipment.	2019

Lifetime management of structures, systems, and components (SSCs) of safety systems and systems important to safety in a nuclear power plant is essential to ensure safety and quality of operation throughout the design life. The programs for the survey and assessment of the residual lifetime of the equipment (pumps, valves and tanks) for the safety systems have been implemented. As a result of the implementation of the programs, an assessment of the technical condition and the residual lifetime was made, with the

relevant justifications and recommendations for implementing the necessary control over the equipment.

The scope of the aging management process also includes the components of fire extinguishing systems, fire alarm systems and fire dampers.

In order to assess the condition of the valves during the period of long-term operation, a mandatory periodic visual and measurement inspection is implemented. It is carried out during the planned annual outages.

Periodic technical inspection is carried out to assess the condition of the pipelines and tanks, through which the conditions of operation are established, and the necessary measures are determined to ensure their design lifetime. Control is carried out during planned annual outages.

In order to assess the condition of the pumps during the period of long-term operation, the repair documentation stipulates a mandatory periodic control of the internal surfaces.

An annual non-destructive inspection is carried out on the pipelines of the fire extinguishing systems, by conducting an ultrasonic examination. The control is carried out in accordance with the "Long-term schedule for carrying out non-destructive control of equipment and pipelines from the fire extinguishing system of unit 5, respectively of unit 6". The schedules cover pipelines, electrical and manual valves and tanks from the water fire extinguishing systems. Control of pipelines is carried out in the interval before the planned annual outages. The identified problem areas are included in the volumes for repair or replacement during the planned annual outages.

The frequency and scope of the types of activities performed are planned in accordance with the requirements of the manufacturer's operating instructions and current standards. A "Long-term schedule for preventive maintenance and repair of SSCs from safety systems and systems important to safety of units 5 and 6 and CSF" and "Schedule of preventive maintenance and repair of SSCs, when units 5 and 6 are operating at a rated power level for the relevant year" for the FPSE department are developed.

In order to increase the level of fire safety in the plant, the following assessments were developed to assess the compliance with the current mandatory standards:

- "Conformity assessment of the existing fire alarm systems, evacuation and emergency lighting, smoke protection doors, doors, shutters, windows, flaps and seals with the corresponding classes of reaction to fire and fire resistance, with the requirements of Regulation No. Iz-1971";
- "Assessment of the effectiveness of the automatic water fire extinguishing system in cable rooms of the controlled area and hermetic compartment of units 5 and 6, SRSB-3, UAB-2, BPS and OSY".

Independent evaluations were also carried out for the compliance of the design layout and design density of the drain sprinklers with the newly effected SD CEN/TS 14816:2009 "Stationary fire extinguishing installations. Installations for spraying water. Design, installation, and maintenance" and the effectiveness of automatic water fire extinguishing systems in cable rooms.

The following was performed to evaluate the effectiveness:

- analysis of the combustible load in cable rooms;

- deterministic analysis of the expected development of an independent fire in the existing situation in the cable rooms;
- review of the current condition of drainage sprinklers, supply and distribution pipelines, etc. elements of the existing system;
- the compliance of the design layout of the drainage sprinklers with the requirements of SD CEN/TS 14816:2009;
- the efficiency of the individual drainage sprinklers not meeting the requirements of SD CEN/TS 14816:2009;
- the effectiveness of the existing system for each individual room (compartment);
- recommendations with specific corrective measures to achieve effective firefighting.

The calculations reflected at least:

- pressure losses in supply and distribution pipelines, taking into account frictional pressure losses, differences in static pressures and losses in connecting parts and valves;
- the density of water distribution in the existing condition of the drainage sprinklers and the location of the cable bundles.

From the performed analysis, a density of the dispersed water of 13 mm/min was established, with a required minimum design density of dispersion of 10 mm/min.

Based on the independent assessment, recommendations were made for the identified non-conformities. The necessary modernizations were implemented in a timely manner to bring systems in line with the current regulatory requirements.

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

The concept of fire protection is within the scope of all stages of regulatory control carried out by the NRA. Preventive control is carried out in the process of issuing permits for changes in the SSCs, related to safety and performing functions related to the implementation of the fire protection concept. The ongoing and subsequent regulatory control consists of control of the fulfillment of the conditions contained in the issued permits for making changes and the licenses for the operation of the facilities, including the inspections conducted by the NRA.

Inspections are planned in advance and include various aspects related to the implementation of the fire protection concept (topical inspections). In addition, the NRA annually performs an inspection to establish the readiness for start-up and operation of units 5 and 6 of the Kozloduy NPP after carrying out planned annual outage and refueling. The scope of these inspections also includes the readiness of the facilities ensuring the fire protection of the units. The results of the inspections, as well as the conclusions about the condition of the facilities, are documented in the issued protocols.

The control carried out by the General Directorate "Fire Safety and Protection of the Population" covers the following aspects:

- compliance with the rules and regulations for fire safety in the design, construction and operation of the facilities, during their reconstruction, major renovation, major repair or change of purpose;
- the conformity of the products used in constructions and facilities with the legislative requirements for fire safety;
- compliance with the requirements for fire safety, determined by the regulatory framework in the Republic of Bulgaria.

The General Directorate "Fire Safety and Protection of the Population" performs the following types of inspections:

- complex inspections - carried out at least once every four years with the aim to determine the compliance of the technical condition of the Kozloduy NPP with the fire safety rules and regulations in force at the time of the inspection;
- control inspections - carried out no less often than once a year with the aim to determine the compliance of the facilities with the requirements of Regulation No. 8121z-647 [8], their compliance with the applicable construction and technical rules and norms for ensuring fire safety.

The results of the inspections are reported in protocols and provided to the licensees. In case of established non-conformities with the existing requirements, the licensee must take actions to eliminate them in a timely manner.

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

The organization and management of fire risk at “Kozloduy NPP” EAD and SE RAW meets the requirements of the International Standards and Guides for fire protection.

The corporate documents set the organizational framework that licensees follow. The management documents of the companies define the Program for fire protection and assign the responsibilities for the implementation of the program in the enterprise. Also, these documents contain instructions on the design, operation, availability, and maintenance of fire protection equipment. Documents have been created that effectively organize and outline the basics of the Fire Protection Program, which clearly define the responsibilities of personnel for fire prevention activities and describe best practice in fire safety management.

A major focus is ensuring fire safety by controlling fuels and ignition sources. This is achieved through fire safety management systems and adherence to activities which include but are not limited to the following:

- Fire safety is constantly reviewed through daily drills and periodic self-assessments, and independent supervision;
- All activities are planned, determined and carried out so as to maximize the level of fire safety;
- The maintenance approach and practice focuses on maintaining or repairing equipment so that it functions in full accordance with the design intent.

The fire zones are well separated, and the fire resistance of the walls, floors and ceilings is in accordance with the regulatory documents. The ventilation ducts have automatic fire dampers. Routes for the passage of cables, pipes and ventilation ducts are

sealed with the required degree of fire resistance. All fire areas and firefighting equipment are provided with clear markings including doors, valves, etc. The fire zones are equipped with an independent fire alarm system.

On the basis of the self-assessment, it can be concluded that the licensees adequately apply the concept of fire protection, corresponding to the regulatory requirements and the safety guidelines.

4. OVERALL ASSESSMENT AND GENERAL CONCLUSIONS

The National Report presents the approaches to ensuring fire protection during the operation of nuclear facilities applied by the licensees responsible for these facilities as follows:

- "Kozloduy NPP" EAD, holder of licenses for the operation of nuclear power units 5 and 6 and the spent fuel storage facilities located on the Kozloduy NPP site;
- State Enterprise "Radioactive Waste", holder of licenses for the implementation of the decommissioning activities of units 1-4 of the Kozloduy NPP and for the operation of the storage for conditioned radioactive waste located on the same site.

4.1. Conclusions regarding "Kozloduy NPP" EAD

Regarding nuclear reactors in operation and spent fuel storages, licensee “Kozloduy NPP” EAD adequately applies the concept of defence-in-depth to protect against internal hazards. This includes preventing events caused by internal hazards from occurring, detecting these events, controlling and/or mitigating their consequences.

The fire hazard analysis at the “Kozloduy NPP” EAD was prepared on the basis of a deterministic approach according to the national requirements in the field of fire protection, harmonized with the IAEA specific guides and the WENRA reference levels. The fire hazard analysis covers:

- all operational states of the plant - normal operation, shutdown reactor, single fire and subsequent spread, fires whose potential spread is determined by the occurrence of dependent and multiple failures in the SSCs and the protection means;
- the activities associated with an increased risk of fire generation as a result of human actions, including those undertaken during emergency situations;
- conditions in which the impact of the fire threatens the SSCs and the safety functions they perform and an assessment of the possible threats to these safety functions due to the development of a fire;
- the defined places on the NPP site where there is stationary or mobile combustible material;
- possible combinations of fire and other events (including external hazards).

The fire hazard analysis model is a detailed, integrated and realistic model of the nuclear units, including the procedures and actions of operational and professional fire protection service personnel at the site for a wide range of initiating events and hazards, external and internal fires, the combination of extreme climate conditions and the consideration of seismic hazards specific to the NPP site.

Deterministic analysis is complemented by probabilistic safety analysis to determine the effect of fire protection measures and to assess the risks caused by fire.

In accordance with the requirements of the Safety Regulation [2], the scope of the PSA level 1 includes an analysis of the current configuration of the units, taking into account all internal and external events and hazards specific to the site of the Kozloduy NPP, which individually or in combination could lead to nuclear fuel damage.

The analysis covers all possible operational states – full power, low power, and shutdown unit as well as the full range of internal initiating events (including internal fires, internal floods) and possible external hazards (natural and anthropogenic).

The performed review of these analyses confirms their adequacy and compliance with the applicable requirements and good practices. The comparison of the results of the PSA level 1 update shows that the frequency of fuel damage from internal fires has been reduced by 76%, compared to the previous evaluation model which is the result of the licensee's efforts to continuously improve the application of the DiD regarding fire protection.

The practical application of the fire protection concept by the licensee is considered in detail within the framework of the self-assessment presented in this report in all elements, including:

- procedures and measures to control and minimize the amount of flammable materials and to minimize potential sources of ignition that may affect elements important to safety;
- the implemented fire alarm systems, their scope and procedures for maintenance and response to their activation including fire detection and alarm systems, with detailed disclosure of the location of the fire to control room personnel, installed in the plant and their adequacy;
- the presence of suitable fire extinguishing means in accordance with the fire hazard assessment, designed and located so that their activation or unintended action does not unacceptably deteriorate the functions of the SSCs important to safety;
- the existence of written procedures that clearly define the responsibility and actions of personnel in response to each fire and of a common fire strategy and appropriate training covering any area where a fire may affect the SSCs important to safety;
- the established system for effective support of the plant's own firefighting capacity by the resources of the national service for fire safety and protection of the population available on site, the presence of the necessary coordination and an effective system of training, exercises and drills;
- the implementation of passive fire protection achieved by building the necessary fire barriers with the appropriate degree of fire resistance so that the complete burning of the fire load in the compartment does not lead to a breach of the barriers as demonstrated by the fire hazard analysis;
- the arrangement of the ventilation systems in a way that ensures that each firefighting compartment fulfills its purpose of isolation in the event of a fire and that the ventilation of other firefighting sectors that contain other channels of the safety system preserve their operability to fulfill their safety functions.

Compliance with these and all other elements of the implementation of the fire protection concept is subject to preventive, ongoing and subsequent control by the Nuclear Regulatory Agency, which also includes conducting inspections of the readiness for start-up of the units after the planned annual outage.

In addition, according to national legislation, specialized control of "Kozloduy NPP" EAD is carried out by the General Directorate "Fire Safety and Protection of the Population" of the Ministry of Internal Affairs, whose activity includes control of:

- compliance with the rules and regulations for fire safety in the design, construction and operation of the facilities, during reconstruction, major renovation, major repair or change of purpose;
- the conformity of the products used in constructions and facilities with the legislative requirements for fire safety;
- compliance with the requirements for fire safety, determined by the regulatory framework in the Republic of Bulgaria.

The control carried out by NRA and the General Directorate "Fire Safety and Protection of the Population" of the Ministry of Internal Affairs contributes to maintaining a high level of fire protection by the licensee " Kozloduy NPP" EAD.

The licensee's open policy for the systematic application of good international practices, through active participation in safety inspections by the IAEA and WANO, and the application of lifetime management measures to the elements of the fire safety program should be noted as strengths.

Activities that are not fully completed at the time of the topical peer review are the upcoming FHA updates (regarding PSFSF) commented on in the national report and the ongoing replacement of equipment in connection with the obsolescent equipment replacement program (e.g., the replacement of detectors for the AlgoRex CS1140 Modular Fire Detection System).

4.2. Conclusions regarding State Enterprise "Radioactive Waste"

Within the framework of the National Report, the Licensee SE RAW has adequately presented the approaches and strategies applied by it to ensure fire safety in the activities within the scope of the licenses:

- Temporary storage of conditioned RAW in SFCRAW;
- Decommissioning of units 1-4 of the Kozloduy NPP.

The FHA carried out within the safety analysis reports adequately determine the main hazards in the implementation of the relevant activities and the comparatively lower degree of potential danger in events related to the occurrence of fire:

- In relation to SFCRAW, the fire hazard during the performance of the activity is very low due to the nature of the activity, the absence of a combustible load, and the foreseen passive and active fire protection measures.
- For units 1-4, in terms of fire safety, a positive factor is the achieved high degree of fire resistance during the phase of their operation as nuclear units. The specific risks arising for a certain stage of the decommissioning activities are analysed as a basis for their authorisation.

In the presented self-assessment, SE RAW demonstrates compliance with the applicable safety requirements and standards, which determines the necessary basis for the implementation of activities in accordance with the issued licenses. No deviations were found that would serve as a basis for regulatory measures.

In addition, according to national legislation, specialized control of the site of the Kozloduy NPP is carried out by the General Directorate "Fire Safety and Protection of the Population" of the Ministry of Internal Affairs, whose activity covers the control already mentioned above. This contributes to maintaining a high level of fire protection by the licensee SE RAW.

The physical location of the sites of SE RAW within the same site with "Kozloduy NPP" EAD should be attributed among the strengths in terms of fire protection, which allows:

- Sharing of common resources such as external fire rings, RSFSPP-NPP located at the site, joint training and exercises;
- The possibility that all firefighting means and systems of SE RAW will be maintained on the basis of contractual relations by the specialists from "Kozloduy NPP" EAD.

Among the activities that have not yet been completed, it should be mentioned the analysis and justification of the subsequent decommissioning activities, which are not included in the "Report on safety analysis during the decommissioning of units 3 and 4 of the NPP Kozloduy", developed in 2015.

4.3. General conclusions

The conduct of the topical peer review allows licensees and regulators to focus their efforts on presenting their strategies and practical measures within a structured approach based on the application of the concept of defence in depth.

The general conclusion that can be made is that the concept of fire protection of the facilities presented in the report is subject to special attention and systematic efforts are made to demonstrate compliance with both the regulations of NRA and with the applicable fire protection and safety regulations which are also subject to constant improvement.

The effective use of the opportunities for peer reviews and for comparison with good international practices is a proven approach especially in relation to the operation of nuclear units where these mechanisms are most strongly developed.

The self-assessment results presented in this report are not without some imperfect elements such as possible repetitions of information, going into details or using equipment identifications, citing local norms and standards or classification categories. To some extent, this is inevitable due to the broad scope of the topical review sought.

During the review of the self-assessment and the preparation of the national report by the NRA, efforts were made to reduce imperfections of the nature indicated above. At the same time, as a result of these efforts, it is possible that some of the information may require additional clarification when reviewed by external experts.

5. REFERENCES TO THE NAR

[1] Report Topical Peer Review 2023 Fire Protection, Technical Specification for the National Assessment Reports, WENRA, 2022

[2] Regulation on Ensuring the Safety of Nuclear Power Plants, 2016

[3] Regulatory Guide „Protection against internal fires in nuclear power plants“ (RG-1/2023)

[4] Regulatory Guide "Probabilistic safety analyses of NPPs" (RG-7/2010)

[5] Regulation on Ensuring the Safety in Spent Fuel Management, 2004

[6] Regulation on Safety During Decommissioning of Nuclear Facilities, 2004

[7] Regulation on Safe Management of Radioactive Waste, 2013

[8] Regulation No. Iz-1971 of 29.10.2009 on Construction and Technical Rules and Regulations for Ensuring Fire Safety, 2009

[9] Regulation No. 8121z-647 on the Rules and Norms for Fire Safety during Operation of the facilities, 2014

APPENDIX 1: Defining the scope of the national report (selection and rationale)

The selection of the installations that are included in the National Report of the Republic of Bulgaria was carried out in accordance with the recommendations given in Appendix 4 of the WENRA Technical Specification for the National Self-Assessment Reports [1], as follows:

- The national selection includes at least one installation from each category addressed in the Directive that is likely to present a significant radiation risk in the event of a fire;
- The selection is representative of different types of facilities and technologies;
- The candidate facilities were selected taking into account the similarities in terms of the applied fire safety concept.

As a result of the selection, the following candidate facilities are included in the National Report:

- Power units in operation - unit 5 of the Kozloduy NPP is selected, unit 6 is represented;
- Power units under decommissioning - unit 4 of the Kozloduy NPP is selected, units 1, 2 and 3 are represented;
- Wet storage facility for SNF at the Kozloduy NPP site - included in the report;
- Dry storage facility for SNF at the Kozloduy NPP site - included in the report;
- Storage facility for conditioned RAW at the Kozloduy NPP site - included in the report.

Units 5 and 6 with VVER-1000 (B-320) reactors have an identical design and fire protection concept. The results and conclusions of the TPR will also be applicable to the represented unit 6.

Units 1-4 with VVER-440 reactors are being decommissioned and dismantled; the nuclear fuel has been removed from their facilities. The units have a similar fire protection concept, and unit 4, which was the latest to be decommissioned, was chosen as a candidate. Units 1-3 are represented installations and the results and conclusions of the TPR will be applicable to them.

The pool-type storage facility for SNF and the dry storage facility for SNF - at the Kozloduy NPP site - are candidates and are included separately in the National Report, as they have different storage technology. There are no represented SNF storage facilities.

The conditioned RAW storage facility at the Kozloduy NPP site is considered in the National Report separately from the power units in operation and in the process of decommissioning, although it does not represent a significant radiation risk in the event of a fire. There are no represented RAW storage facilities.

All nuclear facilities that are within the scope of the Directive are included in the National Report as candidates. There are no facilities excluded from consideration in the National Report.

APPENDIX 2: List of acronyms

BPS	Bank Pumping Station
CCF	Common Cause Failure
CSF	Common Station Facilities
CWPS	Cooling Water Pumping Station
DGS	Diesel Generating Station
DiD	Defence-in-depth
DSFSF	Dry Spent Fuel Storage Facility
ECR	Emergency Control Room
EER	Electrical Equipment Rack
EFR	External Fire Ring
ELB	Engineering & Laboratory Building
ENSREG	European Nuclear Safety Regulators Group
EP-2	Electricity Production-2
FAMSIV	Fast Acting Main Steam Isolation Valve
FAS	Fire Alarm Systems
FES	Fire Extinguishing Systems
FHA	Fire Hazard Analysis
FSP	Fire Service Pumps (of units 1-4)
FPP	Fire Protection Pump
FPS-2	Fire Protection Station-2
FPSE	Organizational unit "Fire protection systems and equipment"
HDF	Heat Distribution Facility
IFH	Indoor Fire Hydrant
IS OOA	Plant Information System "Organization of Operational Activities"
I&C	Instrumentation and Control
MCR	Main Control Room
MCP	Main Circulating Pump
MOV	Motor Operated Valve
MSL	Main Steam Lines
NAR	National Assessment Report
NPP	Nuclear Power Plant
NRA	Nuclear Regulatory Agency
OSY	Open Switch Yard
PAO	Planned Annual Outage
PSA	Probabilistic Safety Analysis
PSFSF	Pool-type Spent Fuel Storage Facility
PSR	Periodic Safety Review
RAW	Radioactive Waste
RC	Reactor Compartment

RCC	Reinforced Concrete Containers
RDFSPP-Vratsa	Regional Directorate of "Fire Safety and Protection of the Population"
RSB	Repair and Service Building
RSFSPP-NPP	Regional Service "Fire Safety and Protection of the Population" at the NPP site
SAR	Safety Analysis Report
SD-AV	Steam Dump to the Atmosphere Valve
SD-CV	Steam Dump to the Condenser Valve
SDD Kozloduy 1-4	SE RAW Specialized Division Decommissioning of Kozloduy NPP units 1-4
SDRAW Kozloduy	SE RAW Specialized Division Radioactive Waste – Kozloduy
SE RAW	State Enterprise "Radioactive Waste"
SFCRAW	Storage Facility for Conditioned RAW
SFP	Spent Fuel Pool
SG	Steam Generator
SRSB-1, -2, -3	Special Radwaste Storage Buildings numbered as follows: - 1 for units 1 and 2; - 2 for units 3 and 4; and - 3 for units 5 and 6
SNF	Spent Nuclear Fuel
OFPS	Operator of Fire Protection Systems (for units 1-4)
SS-1 (-2;-3)	Safety Systems -1(-2,-3) train
SSC s	Systems, Structures and Components
TB	Turbine Building
TPR	Topical Peer Review
TQC	Training & Qualification Centre
UAB	United Auxiliary Building
WENRA	Western European Nuclear Regulators Association
WTP	Water Treatment Plant