NATIONAL ASSESSMENT REPORT OF THE SLOVAK REPUBLIC

For the Topical Peer Review of Fire Protection under Council Directive 2014/87/EURATOM

October 2023

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Abbreviations used

AKOBOJE	Automated Nuclear Power Plant Security Complex
APB	Auxiliary plan building
ASME	American Society of Mechanical Engineers
ATD	Accompanying technical documentation
BD	Unit control room
BL	Bituminisation line
BTC RAW TSU RAO	Technology for treatment and conditioning of RAW
CaPP	Correction and prevention program
CCR	Common control room
CCW	Circulating cooling water
CDF	Core Damage Frequency
CFD	Computational Fluid Dynamics
COM	Central oil management
CPS	Central pumping station
ČSN	Czechoslovak State Standard
DBL	Discontinuous bituminisation line
DCS	Control system
DG	Diesel generator
DGS	Diesel generator station
ECR	Emergency control room
ENSREG	European Nuclear Safety Regulators Group
ESW	Essential service water
ESW PS	Essential service water pumping station
ETAG	European technical approval
EU	European Union
FaRC	Fire and Rescue Corps
FC	Fire-fighting compartment

FCC	Fibre-concrete container
FDPS	Fire detection and protection system
FD	Fire damper
FE	Fire equipment
FEE	Fixed extinguishing equipment
FES	Fixed extinguishing system
FP	Fire protection
FSB	Fire safety of the building
FLRAWT	Final Liquid Radioactive Waste Treatment facility
FSK RAO	
FTE	Fire-technical equipment (FDPS, FEE, HCPE)
GO	General outage
HCČ	Main circulation pump
HCPE	Heat and combustion products extraction system
HMI	Human Machine Interface
HNČ	Emergency feed water pump
HV	High voltage
HVAC	Heating, ventilation and air-conditioning systems
HWGCR	Heavy water and gas cooled reactor
HZ	Hermetic zone
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Control
IRAWS	Integral RAW Storage facility
IS RAO	
IRS	Integrated rescue system
ISFS	Interim Spent Fuel Storage facility
MSVP	
JAVYS, a.s.	Jadrová a vyraďovacia spoločnosť, a.s. /Nuclear decommissioning company
LLRAW	Low-level RAW
LOCA	Loss Of Coolant Accident
L&C	Limits and Conditions for safe operation
MNA	Methodological guide
MOD V2	Modernization of NPP EBO3&4
MoI SR	Ministry of Interior of the Slovak Republic
MOT	Main oil tank
NA	Guide
NAR	National Assessment Report
NEI	Nuclear Energy Institute
NESW	Non-essential service water
NFPA	National Fire Protection Association
NG	Notification General
NI	Nuclear installation
NOS	Independent assessment of nuclear safety, OHS and FP
NPP	Nuclear power plant
NPP EBO3&4	NPP Bohunice
NPP MO1&2	NPP Mochovce (Units 1&2)
NPP MO3&4	NPP Mochovce (Units 3&4)
NRA SR	Nuclear Regulatory Authority of the Slovak Republic
NRAWR	National RAW Repository
RU RAO	
NSD	Nuclear Safety Directive

OC/WS	Operations Centre/Warden Service
OER	Operational experience report
OHS	Occupational Health & Safety
OPC	Ole for process Control
OSART	Operational Safety Review Team
PER	Protected escape route
PSA	Probabilistic Safety Assessment
PFB	Plant fire brigade
PPE	Persona protective equipment
PSR	Periodic safety review
PVC	Polyvinylchloride
QAV	Quick action valve
RAW	Radioactive waste
RB	Reactor building
RUS	Reactor unit supervisor
SEP	Super-emergency power supply
SE, a. s.	Slovenské elektrárne, a. s.
SG	Steam generator
SC	Safety class
SNF	Spent nuclear fuel
SPSA	Seismic PSA
SR	Slovak Republic
SSC	System, structure, component
STN	Slovak technical standard
STS	Security technical service
TCS	Turbine control system
TG	Turbo-generator
TPR	Topical Peer Review
US NRC	US Nuclear Regulatory Commission
VHV	Very high voltage
WANO	World Association of Nuclear Operators
WENRA	Western Nuclear Regulators Association
WENRA RHWG	WENRA Reactor Harmonisation Working Group
WWER	Water-water energy reactor

Preamble

Slovakia is a country with more than 60 years of experience in the construction and operation of nuclear power plants (NPPs). Currently, four WWER 440/V213 Units are in operation in Slovakia – two at the Bohunice site and two at the Mochovce site. There are also two WWER 440/V213 units under construction at Mochovce, one of which is in the commissioning phase. Three other nuclear units at the Bohunice site are under decommissioning – the first Czechoslovak gas-cooled and heavy-water moderated A1 Unit and two older WWER 440/V230 Units. In addition, the Bohunice site contains an intermediate spent fuel storage facility, a radioactive waste treatment and conditioning facility and an integral radioactive waste storage facility. The Mochovce site also contains a facility for the final treatment of liquid radioactive waste and the National Radioactive Waste Repository.

The owner and holder of the operating licence for all nuclear units in operation and units under construction is the joint stock company Slovenské elektrárne, a.s. (SE). The holder of the licence for decommissioning of nuclear power plants and for the operation of radioactive waste management facilities is the state-owned company JAVYS. The regulatory authority exercising state supervision over the nuclear safety of nuclear installations is the Nuclear Regulatory Authority of the Slovak Republic (NRA SR).

The Topical Peer Review (TPR) follows from the European Union Directive 2014/87/Euratom amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, Article 8e, as well as Section 4(1)(o) of Act No. 541/2004 Coll. on the peaceful uses of nuclear energy (Atomic Act) and on amendment and supplementation of certain acts, as amended.

At the ENSREG meeting held in November 2020, it was decided that the subject of the next (second) Topical Peer Review (TPR II) would be fire protection for the following nuclear installations: nuclear power plants, research reactors, spent fuel storage facilities, fuel cycle facilities and radioactive waste storage facilities that are on the same site and are strictly related to the type of nuclear installation mentioned above. All phases of the life cycle of a nuclear installation are to be considered. The scope of the assessment is to cover nuclear installations under construction, operation and decommissioning and to focus on those nuclear installations which pose a significant radiation risk in the event of a fire.

The NRA SR has determined that a representative nuclear installation - Unit 3 of the Mochovce NPP – will be subject to assessment as part of the Topical Peer Review. In case of significant differences compared to other operating units (MO1&2 and EBO3&4), these differences are indicated in the National Assessment Report. Furthermore, the NRA SR has determined that a nuclear installation – the Interim Spent Fuel Storage facility (ISFS), where spent nuclear fuel with significant activity is disposed, will be subjected to an assessment within the framework of the Topical Peer Review. Fire at the nuclear installation in question cannot be ruled out. A possible fire may result in the release of ionising radiation or radioactive substances outside their protective barriers with a non-negligible adverse effect on the personnel of the nuclear installation and the surroundings of the nuclear installation.

This National Assessment Report describes the results of the assessment of fire protection at selected representative nuclear installations in Slovakia – Unit 3 of the Mochovce nuclear power plant and the Bohunice Interim Spent Fuel Storage facility. The National Assessment Report was prepared by the UJD SR with the contribution of the Ministry of the Interior of the SR, the Presidium of the Fire and Rescue Corps, based on documents from and in close cooperation with SE and JAVYS, as well as their technical support organisations.

Executive Summary

There are currently four WWER 440/V213 nuclear units in operation in Slovakia, two units at the Bohunice site and two units at the Mochovce site. In addition, two more WWER 440/V213 units are under construction at the Mochovce site, one of which is in the commissioning phase. The total installed capacity of the units in operation is 1,950 MWe. Slovenské elektrárne, a.s. is the owner and holder of the operating licence for all the above units in Slovakia. The licensee for decommissioning of nuclear power plants and for the operation of radioactive waste management facilities is the state-owned company JAVYS.

State supervision over nuclear safety of nuclear installations is exercised by the Nuclear Regulatory Authority of the Slovak Republic (NRA SR) within the meaning of Act No. 541/2004 Coll. on the peaceful uses of nuclear energy (Atomic Act) and the related decrees. The whole set of this legislative framework is regularly updated in line with IAEA safety standards and WENRA reference levels. State fire supervision is exercised by the Ministry of the Interior of the SR (MoI SR) and regional headquarters of the Fire and Rescue Corps (FaRC) in accordance with Act No. 314/2001 Coll. on Fire Protection and the related decrees.

All nuclear installations (NIs) have safety analysis reports that are updated in accordance with the Regulator´s requirements and are verified by the NRA SR. In accordance with national legislation, the safety analysis report is currently updated continuously at nuclear installations in Slovakia. The existing probabilistic safety assessments (PSA Level 1 and Level 2) prepared in accordance with the NRA SR Safety Guide, WENRA reference levels (Item O) and IAEA Standards No. SSG-3 and No. SSG-4 confirm that NPPs comply with internationally recognised safety objectives. PSA studies are full-scale studies and are regularly updated. The last update of the PSA for EBO3&4 NPP was in 2015, for MO1&2 NPP in 2017 (the next update to be completed in 2023) and for MO3&4 NPP in 2019. The PSA for the ISFS was prepared in 2005. Based on the results from the EU Stress Tests, hardware modifications have been made to the nuclear facilities in Slovakia and some specific parts of the safety documentation have been updated related to the assessment of rare extreme external hazards and the implementation of severe accident management measures.

In accordance with the requirements of national legislation (the Atomic Act), all nuclear installations in Slovakia are subject to periodic nuclear safety reviews, which are carried out at periodic 10-year intervals. The last periodic safety review for NPP EBO3&4 was in 2016 and for NPP MO1&2 in 2017. Based on the results of the verification of these reviews, the NRA SR approves further safety improvement programmes aimed at achieving even closer compliance with current safety standards and best practice. The approved programmes also include the implementation of comprehensive measures to mitigate the consequences of severe accidents.

All operating units in Slovakia have been subject to independent reviews by a number of international missions. Since 1991, there have been more than 20 IAEA missions in total (site, design, operational safety (OSART), probabilistic safety assessment (IPSART)) and several WANO missions. The regulatory framework is also regularly subjected to international review. The last integrated review of the regulatory framework, the IRRS Mission, was conducted by the IAEA in 2022 and the ARTEMIS mission in 2023.

Nuclear installations in the Slovak Republic have implemented multi-level fire protection according to the relevant national general binding legislation, international standards and norms. Fire protection is subjected to periodic safety reviews. The level of fire protection achieved meets national requirements and is in line with international standards and norms. It contributes significantly to the overall safety of NIs in Slovakia.

1 General Information

There are currently four WWER 440/V213 nuclear units in operation in Slovakia, two units at the Bohunice site and two units at the Mochovce site. In addition, two more WWER 440/V213 units of a significantly improved design are under construction at Mochovce, while Unit 3 is in the commissioning phase. The total installed capacity of the units in operation is 1,950 MWe. The owner and holder of the operating licence for all these units in Slovakia is Slovenské elektrárne, a.s. (SE). The holder of the licence for decommissioning of nuclear power plants and for the operation of radioactive waste management facilities is the state-owned company, JAVYS.

1.1 Identification of Nuclear Installations

Slovakia is a landlocked country located in a temperate climate zone in central Europe. There are two nuclear sites in Slovakia: Jaslovské Bohunice with two operating units of NPP EBO3&4 and Mochovce with two operating units of NPP MO1&2 and another two units under construction – NPP MO3&4, which together form the Mochovce NPP (see the location of the sites on the map and a view of the individual sites in Figure 1-1, 1-2 and 1-3).

The licensee for all these Units is the joint stock company, Slovenské elektrárne, a. s., with its registered office at: Mlynské nivy 47, 821 09 Bratislava.

Fig. 1-1 Location of NPPs in Slovakia
Note: At the Mochovce NPP site, Unit 3 is in the commissioning phase.

The Bohunice site is located in western Slovakia; the nearest towns are Trnava, Hlohovec and Piešt'any. Cooling water is fed from the Váh River. The Sĺňava reservoir with a total water volume of 12.3 million m3 is built on the Váh River. Water from the Sĺňava reservoir is supplied to the EBO3&4 NPP via the Drahovce pumping station, from where the water flows by gravity to the Pečeňady pumping station. From the pumping station, water is supplied by discharge pumps to the chemical water treatment plant of NPP EBO3&4.

Fig. 1-2 General view of the V2 Bohunice NPP site

The Mochovce NPP is located approximately 90 km east of Bratislava. The nearest towns are Tlmače, Levice and Zlaté Moravce. The cooling water for the Mochovce NPP is supplied from the Hron River. A water reservoir with a total volume of 2.6 million m3 is built on the Hron River. The reservoir supplies water to the Mochovce NPP. The water is pumped from the pumping station by pipeline to the water storage tanks and from there it flows by gravity to the chemical water treatment facilities of the Mochovce NPP.

Fig. 1-3 General view of the Mochovce site

The sites are connected to the grid by redundant power lines. In both cases there are two independent lines from the 400 kV distribution network and two independent lines to the 110 kV substation backup transformers. Similarly, in both cases there is the possibility of connecting the NPPs to diversified hydroelectric power sources (different for each site).

The basic data on operating NPPs are summarised in Table 1-1. All nuclear units in Slovakia are equipped with WWER 440/V213 pressurised water reactors manufactured by Škoda in the former Czechoslovakia, with a reactor thermal capacity of 1,471 MWt. The reactor cooling system is located in a large pressure-suppressed containment. Six loops are connected to the reactor, each equipped with isolating valve isolation valves and horizontal steam generators with a large volume of coolant on the secondary side of the steam generators. The reactor core consists of 349 hexagonal fuel assemblies; each assembly contains 126 fuel rods. 37 automatic control assemblies (ACA) have fuel rods below the neutron absorption part, so that the effectiveness of emergency shutdown of the reactor is increased by ejecting a portion of the fuel from the core at the same time as the control rods are inserted. Each unit uses two steam turbines. Electricity is generated in synchronous generators on a common shaft with the turbine and excitation generator. The power from each reactor unit is fed to the grid via two parallel power lines, each from the main generator through the respective unit transformer and its auxiliaries. Both branches are connected in the outlet substation to a single 400 kV line.

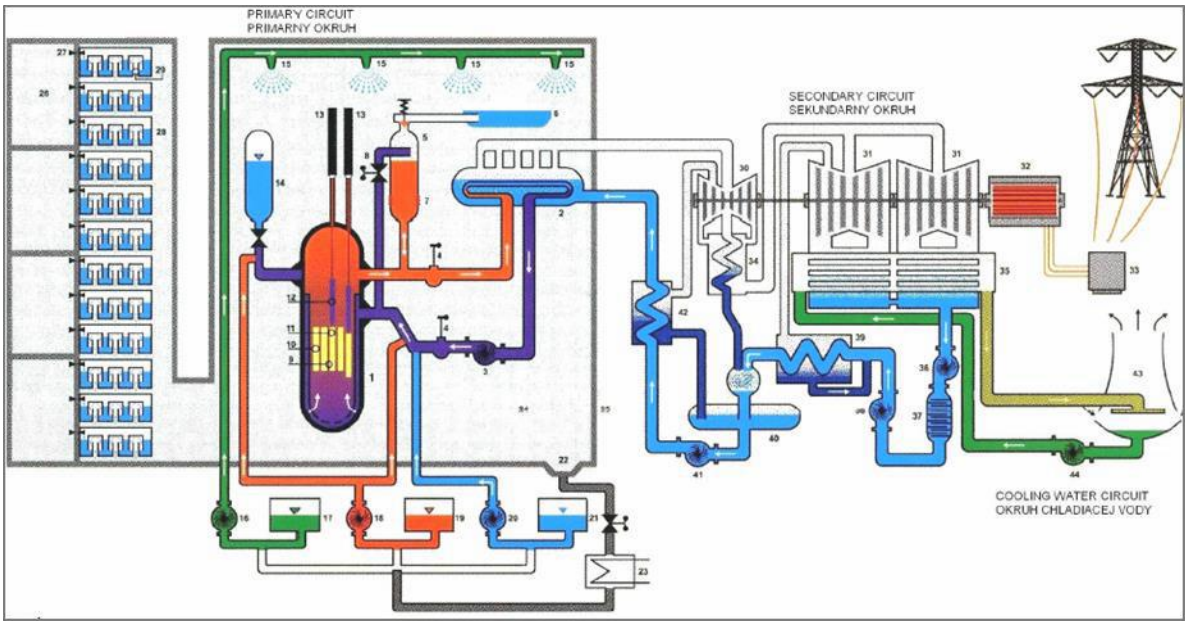

Fig. 1-4 WWER 440/V213 scheme

1 – Reactor, 2 – Steam generator, 3 – Main circulating pump, 4 – Main shut-off valve, 5 – Pressurizer, 6 – Barbotage tank, 7 – Pressurizer , 8 – Injection to pressurizer, 9 – Reactor core, 10 – Fuel assembly, 11 – Automatic control assembly (ARK), fuel part, 12 – Automatic control assembly (ACA), absorption part, 13 – ACA drives, 14 – Hydro-accumulators, 15 – Spray system, 16 – Spray pump, 17 – Spray system storage tank, 18 – Low-pressure spray pump, 19 – Low-pressure emergency system storage tank, 20 – High-pressure emergency pump, 21 – High-pressure emergency system, 22 – Suction from the hermetic zone, 23 – Spray system cooler, 25 – Containment, 26 – Air traps of barbotage tower, 27– Check valve, 28 – Bubbling tower, 29 – Barbotage tower flumes, 30 – HP part of the steam turbine, 31 – LP part of the steam turbine, 32 – Electric generator, 33 – Unit transformer, 34 – Steam separator and superheater, 35 – Condenser, 36 – Condensate pump, 38 – Condensate pump I°, 37 – Chemical treatment of condensate, 38 – Condensate pump I°° ,39 – LP regeneration, 40 Feeding tank, 41 – Main electric feeding pump, 42 – HP regeneration , 43 – CCW Cooling tower, 44 – CCW pumps.

The WWER 440 units were designed as twin units with a mirrored spatial arrangement. Most of the systems and equipment belong to one Unit; some of the equipment and systems are common to both units. The common parts of the systems and structures include the loading machine, spent fuel transfer, radioactive waste handling, fresh fuel reception and storage, stack, access to the control area demineralised water treatment system, service water system and cooling water system. Each Unit is equipped with its own spent fuel storage pool, which is located near the reactor pressure vessel. The spent fuel is cooled in the spent fuel storage pool (in a compact storage grid in a pool filled with boron-containing water) for approximately 4 to 7 years.

Table 1-1 Basic data

Nuclear Power Plant	EBO3&4 NPP	MO1&2 NPP	MO3&4 (Unit 3)
Site	Bohunice	Mochovce	Mochovce
Reactor type	WWER 440/V213	WWER 440/V213	WWER 440/V213
Thermal reactor output, MWt	1,471	1,471	1,375
Total electric power, MWe	505	470	470
State of the NPP	in operation	In operation	in operation
First criticality date	1984-85	1998-99	2022
Last Periodic Safety Review	2016	2017	-

In terms of fire protection, the WWER 440/V213 units were originally designed in accordance with Soviet design rules, but adapted to the conditions of the former Czechoslovakia and gradually adapted to international standards and currently applicable national legislation as part of programmes to improve the level of nuclear safety.

The NPP civil structures are divided into fire compartments or fire cells, with fire compartmentation structures usually made of reinforced concrete. At the boundaries of the fire compartments, fire closures are incorporated, whether they are fire doors, hatches or fire dampers on the ventilation systems with the required fire resistance. The fire resistance of the fire-resistant partition structures in the nuclear island of the NPP was defined in the basic design by the supplier of the WWER440/V213 technology as 90 minutes. At present, all civil structures in the NPP have the fire resistance of fire structures reassessed in accordance with the Decree of the MoI SR No. 94/2004 Coll., and subsequently the series of standards STN 73 0802, STN 73 0804, STN 92 0201-1, STN 92 0201-2, STN 92 0201-3, STN 92 0201-4 based on the determined degree of fire safety of the structure for the given fire compartment.

All areas of the NPP are detected by an automatic electrical fire alarm system.

Nuclear power plants are supplied with water for firefighting, which is distributed within the site through a looped network with external hydrants and internal hose installations in the buildings. Technology and areas with a higher fire risk are equipped with fixed fire extinguishers of various types.

Both NPP sites are equipped with a plant fire brigade (PFB), with the number of firefighters per shift and the forces/resources determined by the fire hazard analysis. Members of the PFB as well as firefighting equipment are stationed directly at the sites. In the case of the Mochovce NPP, the PFB is designated for all four units. The PFB units at Bohunice NPP and Mochovce NPP are separate units and due to the distance of several tens of kilometres they are not shared. In the event of a need for a major intervention, support is provided from external sources, in particular from the state firefighting units of the FaRC.

Nuclear power plants have a system of fire protection documentation at each level, which is subject to regular review and updating.

V1 Nuclear Power Plant – under decommissioning

The nuclear power plant V1 (NPP V1) in Bohunice, 2 units of WWER 440/V230, were commissioned in 1978/1980 and shut down after standard operation in 2006/2008. Fuel removal from the NPP was completed in 2011. The first phase of decommissioning took place between 2011and 2014. NPP V1 is currently in the final - 2nd phase of decommissioning. The decommissioning activities are planned to be completed in 2027, when the site will be released from administrative control after the final inspection. The licensee is JAVYS. A large part of the NPP equipment has already been dismantled and is being treated, with fragmentation and decontamination being the prevailing material treatment. In this phase of decommissioning, the production of metallic materials and materials from demolition activities predominates.

The fire protection of NPP V1 is maintained at the level of the operating NPP by means of contracts with the professional PFB of SE (NPP EBO3&4), which is located on the same site as NPP V1.

There are no significant quantities of flammable liquids and gases available or in use in NPP V1 that could cause a fire and consequent release of radioactive substances into the environment. There is a significantly lower risk of fire compared to operating NPPs and a negligible radiation risk due to fire (radioactive materials are in solid non-flammable form).

A1 Nuclear Power Plant – under decommissioning

The 150 MWe heavy water and gas cooled reactor (HWGCR) of NPP A1, located at the Bohunice site, was commissioned in 1972, shut down in 1977 after an operational accident and decommissioned in 1999. The decommissioning of NPP A1 has been underway since 1999 and is divided into five separately permitted phases with a scheduled completion in 2033. Decommissioning, consisting mainly of decontamination and dismantling activities, shall be carried out in a stepwise manner, starting with low contaminated facilities and areas and ending with facilities and areas with the highest contamination. The decommissioning process is influenced by the need to address the management of atypical radioactive waste containing sludge and organic compounds.

JAVYS, as a licensee, is currently carrying out activities related to the decommissioning of original, non-functional and unused technology of external equipment and technological equipment of the main production units of the reactor hall. The decommissioning of highly contaminated components such as the primary circuit and the reactor is under preparation, for which the use of remotely controlled equipment is envisaged.

In terms of fire protection, the buildings of NPP A1 are constructed of non-combustible and fire-resistant materials. Fire protection procedures and functional automatic fire detection systems are in place.

The fire protection of NPP A1 is maintained at the level of the operating NPP through contracts with the PFB of SE (NPP EBO3&4), which is located on the same site as NPP A1 and persons with professional competence in an employment relationship.

NPP A1 is characterised by a significantly lower risk of fire compared to operating NPPs. The radiation risk due to fire is negligible. The calculated values of the annual effective dose at the boundary of the protection zone for the reference accident are ~3 orders of magnitude lower than the established acceptance criteria (1 mSv/year).

Interim Spent Fuel Storage Facility

The Interim Spent Fuel Storage facility (ISFS) is located at the Bohunice site. The ISFS is operated by JAVYS. The ISFS (wet part) was put into operation in 1987. The following upgrades were carried out during its operation:

- increasing its seismic resistance and increasing its storage capacity (1997-1999),

- changing the geometry of the stored assemblies (2007).

The ISFS is interconnected by a railway siding and a roadway with the internal roads of the JAVYS premises. These are connected to the external roads. The actual area of the ISFS is fenced and forms a separate sector within the AKOBOJE security system. According to the safety analysis report, the planned lifetime of the ISFS is 50 years.

The civil structure part of the ISFS has 4 main floors, 2 intermediate floors and one platform. The floor plan of the building: is 47×70 m. The building structure is a combination of monolithic reinforced concrete and steel structure. The foundations, basement below ground level and storage pools with accessories, are made of monolithic reinforced concrete. The two interconnecting halls and the skeleton extension are made of steel. Roof structure - purlins. The envelope is made of switched aerated concrete panels and lightweight panels.

The ISFS is used for long-term storage of spent nuclear fuel (SNF) from NPP production in the Slovak Republic. This intermediate storage facility is a wet storage with four pools, three of which are operational and one is spare. The fuel is stored in storage tanks containing boron, which ensures the sub-criticality of the fuel. The maximum amount of heat developed is 1,990 kW. The water in the pool serves to remove residual heat and also as shielding from ionising radiation. The volume of water in the pools is sufficient to ensure the safety of the stored SNF for several days even in the event of a complete loss of power, cooling and water supply.

The ISFS cooling system consists of redundant, separate and independent systems, including the electricity supply. The power supply to the ISFS is provided by two independent feeders. In the event of a power failure on one supply, an automatic switch to the back-up supply takes place. In the event of a power failure on both feeders, there is an automatic backup to the diesel generator set (DG), which provides sufficient power for the long-term operation of the ISFS. In case of failure of the DG, the power supply is provided from the main DG located in the JAVYS premises. The maximum cooling capacity of the ISFS is 2,533 kW (when 3 of the 4 pumps are operating).

Combustible materials in ISFS are PVC cable insulation, PVC in switchgear, PVC in floor coverings and oil in pumps. Electrical equipment located in fire compartments may be a fire initiator.

Fire-fighting intervention of the fire brigade at the ISFS is ensured through a contract with the PFB of the SE (NPP EBO3&4) based at the same location as the ISFS.

The fire-resistant dry part of the ISFS is under construction (spent nuclear fuel from the wet part of the facility will be moved to its dry part). The SNF in the dry storage will be stored in special storage tanks cooled by natural air circulation. This method of cooling the fuel is independent of electricity.

RAW Treatment and Conditioning Technology

The NI of the RAW Treatment and Conditioning technology (BTC RAW) is located in Bohunice. The BTC RAW was commissioned in 2000 and is operated by JAVYS. According to the safety analysis report, the expected lifetime is 50 years. The BTC RAW includes technological units intended for the treatment and conditioning of RAW produced from the operation of NPPs, decommissioning of NPPs, institutional RAW and RAW whose originator is unknown.

The BTC RAW NI includes the following technological units:

- The Bohunice RAW Treatment Centre (BTC RAW) treats various types of RAW – combustible solid and liquid wastes, compactable solid wastes, incombustible and non-compactable wastes, concentrates, ion exchange resins and other contaminated liquids and sludge. It uses the following technologies/ treatment facilities for the treatment of these RAW: a cementation line for cementation of treated RAW, an incinerator for incineration of RAW, a compactor for high-pressure compaction of RAW, a sorting box and a fragmentation plant for sorting and fragmentation of RAW.
- Bituminization line (BL) and discontinuous bituminization line (DBL) for fixation of RAW into bitumen, which ensures low leaching of radioactive substances by water and significant volumetric reduction of wastes.

The BTC RAW also includes other technological facilities: an active water treatment plant, a fragmentation line, a large capacity decontamination line, a line for pre-treatment of fixed RAW, a FCC production plant, and a currently under construction facility for re-melting of metallic RAW and a new incinerator for RAW. This includes the solid RAW storage facilities and the NPP A1 premises where the certified storage facilities are located.

Not qualified – BTC RAW is not a nuclear installation within the meaning of the NSD.

Final Treatment of Liquid RAW

The Final Liquid Radioactive Waste Treatment facility (FLRAWT) is located at the Mochovce site. The FLRAWT was commissioned in 2007 and is operated by JAVYS. According to the safety analysis report, the expected operating lifetime is 50 years.

The different lines of the technological equipment are intended primarily for the treatment and conditioning of liquid RAW into a form suitable for disposal at the National RAW Repository in Mochovce. The basic technology of the plant is the treatment of radioactive concentrates, ion exchange resins and sludge into a bitumen matrix and their disposal in drums. The drums are then placed in fibre-concrete containers (FCCs). Using cementation – with active grout the barrels in the FCC are topped with cement grout. In addition to the treatment of liquid RAW, the handling facilities of the FLRAWT in Mochovce also allow the handling of solid RAW from the production of the Mochovce NPP and Bohunice NPP, which are fixed in a solid container (cask). The drums with solid RAW are transported to the FLRAWT, where they are placed in a FCC container and further treated by cementation until they are disposed in the Mochovce National RAW Repository.

Not qualified – FLRAWT is not a nuclear installation within the meaning of the NSD.

Integral RAW Storage Facility

The Integral RAW Storage facility (IRAWS) is located at the Bohunice site. The IRAWS was commissioned in December 2017 and is operated by JAVYS. According to the safety analysis report, the expected lifetime is 70 years. The IRAWS nuclear installation is intended for the storage of RAW from the decommissioning of NPP V1 and NPP A1:

- solid or solidified RAW before further treatment at plants within the JAVYS, a.s. premises,
- RAW conditioned by various technologies into solidified (solid) form originating from the decommissioning of NPP V1 and NPP A1 at the site until such time as it can be transported to a permanent disposal site,
- solid RAW for a period during which their activity falls below the limit level and then released into the environment.

RAW containing explosive substances, Class I combustibles and residual heat producing materials are excluded from this storage. This significantly reduces the impact of fire on the radiological risk to personnel, the population and the environment.

In the event of a fire, the IRAWS does not present a potentially significant radiological risk beyond the boundaries of the NI.

National RAW Repository

The National RAW Repository (NRAWR) Mochovce is a multi-barrier surface-type repository designed for the final disposal of solid and solidified low-level and very low-level radioactive waste generated from the operation and decommissioning of nuclear installations, in research institutes, laboratories and hospitals in the Slovak Republic. The National RAW Repository was put into operation in 2000 and is operated by JAVYS.

Protective barriers against the release of radioactivity into the environment are all structures, both man-made and natural, which are used to separate the disposed RAW from the environment and to prevent the penetration of radionuclides into the environment. In a repository for the disposal of low-level radioactive waste, the various barriers consist of: the matrix in which the waste is fixed, the wall of the fibre-concrete containers (FCCs), the reinforced concrete structure of the repository, the filling of the intermediate space of the repository box, the multi-layered final overlay and the clay pit. The last barrier is a low permeability geological formation. In case of extremely adverse conditions with water ingress into the interior of the storage boxes, the repository is equipped with a drainage system designed to collect and control water. The drainage system is one of the engineered barriers that prevents the repository from having a negative impact on the environment.

The Low-Level RAW Repository (LLRW repository) consists of a system of storage boxes arranged in rows and double rows. Treated low-level radioactive waste (LLRW) is transported to the repository, coated with a cement mixture in fibre-concrete containers from the Bohunice treatment centre and also from the FL RAW treatment facility in Mochovce. The marked containers are transferred from the transport vehicle to a storage box at a pre-determined location after an entry check. No liquid, gaseous or explosive waste can be, or shall be accepted at the repository.

The NRAWR is resistant to fire hazard.

1.1.1 Qualifying Nuclear Installations

The list of NIs in the Slovak Republic subject to EU Directive 2014/87/Euratom amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations includes the following nuclear installations:

- EBO3&4 NPP, Bohunice site,
- MO1&2 NPP, Mochovce site,
- MO3&4 NPP, Mochovce site,
- Interim Spent Fuel Storage facility (ISFS), Bohunice site,
- V1 NPP (under decommissioning), Bohunice site,
- A1 NPP (under decommissioning), Bohunice site,
- Integral RAW Storage facility (IRAWS), Bohunice site; and
- National RAW Repository (NRAWR), Mochovce site.

1.1.2 National selection of installations for TPR II with rationale (brief summary)

The selection of nuclear installations for the purposes of the Topical Peer Review of Fire Protection (TPR II) was carried out according to the criteria set out in the European Union Directive 2014/87/Euratom amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, the ENSREG Terms of Reference for TPR II [131] and the WENRA Technical Specification for the preparation of the National Assessment Report [132]. The selection of nuclear installations for the purpose of TPR II is summarised below. More detailed information on the selection made, including the rationale for the selection, is provided in Annex 1.

The NRA SR has determined that the Topical Peer Review will be conducted at the NI – Unit 3 of the Mochovce NPP. The nuclear installation under completion, Unit 3 of the Mochovce NPP, is a representative NI and the results of its TPR are applicable to all NPPs operating in the Slovak Republic. After commissioning, spent fuel will be stored in the spent fuel pool next to the reactor at the Mochovce NPP Unit 3. A fire at the nuclear installations in question cannot be ruled out. A possible fire may cause a release of ionising radiation or radioactive substances outside their protective barriers with a non-negligible adverse effect on the personnel of the nuclear installation and its surroundings.

The NRA SR further determined that the NI – Interim Spent Fuel Storage – will be subjected to TPR. The interim storage facility contains spent nuclear fuel. A fire at the nuclear installation cannot be ruled out. A potential fire may cause a release of ionising radiation or radioactive substances outside their protective barrier with a non-negligible adverse effect on the nuclear installation´s personnel and its surroundings. The decommissioning license is held by JAVYS.

No spent nuclear fuel or significant quantities of liquid or gaseous radioactive substances are present at the decommissioned V1 and A1 NPPs. The risk of fire is low and the possible release of radioactive substances into the vicinity of the decommissioned nuclear power plants is very small. NPP V1 and NPP A1 are excluded from TPR II. The results of the TPR of Interim Spent Fuel Storage are reasonably applicable to both NPP V1 and NPP A1.

The Integrated Radioactive Waste Storage Facility (IRAWS) is designed for the storage of solid RAW from the decommissioning of NIs in Slovakia. RAW containing explosive substances, Class I combustibles and residual heat producing materials are excluded from storage. This significantly reduces the fire risk, and the radiological risk to personnel, the public and the environment. IRAWS is excluded from the TPR II.

The National RAW Repository is considered to be fire resistant and is excluded from this TPR II.

1.1.3 Key parameters

The key parameters of the NIs qualified for the TPR II are given in the previous chapter 1.1 of this Report.

1.1.4 Approach to developing a NAR for national selection

The selection of nuclear installations for TPR II, the self-assessment of fire protection at representative nuclear installations and the preparation of the National Assessment Report (NAR) followed the methodology and criteria set out in the ENSREG Terms of Reference for TPR II [131] and the WENRA Technical Specification for the preparation of the NAR [132]. The main steps of the process are briefly described in the following text.

The NRA SR drafted and issued an internal management act – the Chairperson's Order. The Chairperson's Order provides basic information on the TPR II, the objective, purpose and expected outcomes of the peer review, the scope and content of the review, the review schedule, the establishment of the working group, the requirements for the NAR, the estimated resources of the NRA SR needed to carry out the review, etc. Roles and responsibilities for the preparation of the NAR are assigned.

The selection and rationale for the selection of nuclear installations in the Slovak Republic for the Topical Peer Review was carried out. Communication with licensees and the TPR II Steering Committee was ongoing.

The NRA SR issued Decisions No. 235/2022 and No. 236/2022, in which the obligation is imposed on the licensees to carry out a self-assessment of fire protection at the NPP MO3&4, Unit 3 and at the Interim Spent Fuel Storage facility according to the prescribed methodology and to deliver the documents to NRA SR for the preparation of the NAR.

SE and JAVYS carried out a self-assessments of fire protection and prepared documents for NAR according to the prescribed methodology within their Quality Management System.

Preparation of the NAR was at the UJD SR from documents supplied by the licensees. During the process of drafting the NAR, communication between the ÚJD SR and the licensees was ongoing. Subsequently, the Report was supplemented by an assessment of the state of fire protection at NIs in the Slovak Republic carried out by the NRA SR and the MoI SR, the FaRC Presidium. The Report was commented on, and the content, scope and technical accuracy of the information presented was checked. Furthermore, the NAR was approved by the NRA SR, translated into English, published and sent to ENSREG within the deadline.

The National Assessment Report describes the results of the fire protection assessment for the NI, Unit 3 of MO3&4 and the Interim Spent Fuel Storage facility for the TPR II. The Mochovce Unit 3 is a representative nuclear installation, therefore the NAR describes the fire protection of this Unit. In the case of major differences in fire protection compared to other operating units (NPP MO1&2 and NPP EBO3&4), the NAR highlights these differences. The NAR is prepared according to ENSREG and WENRA requirements. A graded approach has been used in the preparation of the NAR, i.e. the focus of the NAR is on those NIs that have a potentially significant radiological risk in the event of a fire.

The results of TPR II for Unit 3 of MO3&4 and Interim Spent Fuel Storage facility will be assessed in terms of relevance and practicality of their application to other NIs in the Slovak Republic and subsequently applied.

1.2 National Regulatory Framework

State supervision over nuclear safety of nuclear installations is exercised by the Nuclear Regulatory Authority of the Slovak Republic (NRA SR) within the meaning of Act No. 541/2004 Coll. on the Peaceful Uses of Nuclear Energy (Atomic Act) and on amendments to certain laws, as amended [1] and the related set of decrees. The whole set of this legislative framework is regularly updated in line with IAEA safety standards and WENRA reference levels. Although the NRA SR is not a state administration body authorised to carry out state fire supervision, Article 31(1) of the Atomic Act authorises and enables the NRA SR to carry out procedures and inspections for assessing the actual state of nuclear safety while also inspecting and assessing the state of fire protection (also in the context of the inspection and implementation of international obligations).

State fire supervision is carried out by the Ministry of the Interior of the SR (MoI SR) and regional headquarters of the Fire and Rescue Corps (FaRC) according to Act No. 314/2001 Coll. on Fire Protection as amended [6] and the related set of decrees [7] to [16]. The MoI SR, as the central body of state administration, also manages the performance of state administration in the field of fire protection and issues generally binding legal regulations to ensure fire protection. The organisational unit of the MoI SR is the Presidium of the Fire and Rescue Corps of the SR (MoI SR, Presidium of FaRC).

State supervision over radiation protection is exercised by the Public Health Authority of the Slovak Republic pursuant to Act No. 355/2007 Coll. on the Protection, Promotion and Development of Public Health, and Act No. 87/2018 Coll. on Radiation Protection and the related set of decrees.

1.2.1 National Regulatory Requirements and Norms

The basic requirements of the NRA SR for fire protection are based on Section 3(5) of the Atomic Act [1], the related Decree No. 430/2011 Coll. on requirements for nuclear safety [2], the safety guide [32] and the Act on Fire Protection [6]. In relation to the Fire Protection Act, the decrees of the MoI SR with technical content [7] to [16], which set out requirements for a specific area related to fire protection or fire equipment, are applied. (The WENRA reference levels, item SV (internal hazards) are transposed into the UJD SR Decree on the requirements for nuclear safety [2] and the safety guide [32], which are related to the fire protection. [24].)

Decrees with technical content deal with the following:

- technical requirements for fire safety in construction and use of buildings [7],
- provision of buildings with water for fire-fighting [9],
- the characteristics of a fixed fire-extinguishing equipment and a semi-fixed fire-extinguishing equipment and the conditions for their operation and for ensuring their regular inspection [10],
- the characteristics of the electrical fire alarm system, the conditions of its operation and its regular inspection [11],
- the characteristics, operating conditions and regular inspection of portable fire extinguishers and mobile fire extinguishers [12],
- the characteristics, specific operating conditions and regular inspection of the fire closure [13],
- fire safety principles for the handling and storage of flammable liquids, heavy fuel oils and vegetable and animal fats and oils [14],
- fire safety principles for activities with flammable gases and combustible gases [15],
- fire prevention [16].

Fire-technical equipment shall be operated and regularly inspected in accordance with the above-mentioned legislation applicable to the type of fire-technical installation concerned.

The general requirements and principles for fire protection of the NI do not differ from the general requirements and principles applied to other industrial, storage, administrative and production buildings. They are laid down in Sections 4 and 5 of the Fire Protection Act [6] and in the Construction Products Act [18].

In relation to firefighting units, the Decree of the MoI SR on firefighting units [19] applies. At the sites of Mochovce and Bohunice, there are plant fire brigades (PFB).

One of the main principles applied in the design of Unit 3 of the Mochovce NPP was the implementation of the requirements of the generally binding legal regulations, in particular the requirements of the Decree of the MoI SR No. 94/2004 Coll. [7] and the relevant technical standards.

Nuclear safety, radiation safety and technical safety requirements are applied concurrently to the existing civil structures and technology of the NIs, and for these reasons the fire safety requirements have been applied in deviation from the legislation in force. As part of the basic design, a procedure for dealing with deviations (engineering solution) was proposed in the given cases, which was submitted to the relevant central government authority for approval and subsequently approved by the MoI SR, the FaRC Presidium). The detailed design shall include technical solutions for fire protection, giving the highest priority to nuclear safety and radiation protection requirements in the event of such cumulative requirements. All identified legislative discrepancies between nuclear safety/radiation protection and fire protection requirements were communicated with the FaRC Presidium and subsequently submitted for approval.

The analyses and fire safety assessments are carried out in accordance with generally binding legislation (a set of laws and decrees) and the UJD SR Safety Guides. (Legislation requires a fire hazard analysis, a probabilistic fire risk assessment and a deterministic fire hazard analysis). The periodicity of analyses, their updating and safety assessment is determined by legislation or is carried out within the framework of a change in the current situation with an impact on fire safety. The methodology of analyses is mainly based on the WENRA reference levels, the SV item (internal threats), IAEA standards (e.g. No. SSG-3, No. SSG-64), instructions of the MoI SR, the FaRC Presidium. US NRC guidelines, ASME standards and others are also used.

The fire designs at the time of the design of NPP EBO3&4 and NPP MO1&2 were prepared in accordance with the legislation in force at that time. At NPP EBO3&4, for the modified civil structure of the main production unit (MOD V2 – 2001-2008), partial fire protection projects (FPPs) were prepared according to the then valid Decree [8] and standards [38] and [39]. Later changes were implemented in accordance with the currently valid version of the Decree of the MoI SR No. 94/2004 Coll. [7]. At present, the FP design documentation is being updated for MO1&2 NPP according to the actual state for selected civil structures.

1.2.2 Implementation/application of international standards and guidelines

The design concept of the MO3&4 NPP units and the overall design was developed in the former Soviet Union according to the safety criteria, technical regulations and standards in force in the Soviet Union at that time, as well as the standards in force in the former Czechoslovak Federal Republic.

In terms of international standards, the design was initially developed in accordance with the recommendations of the IAEA Safety Guide on Fire Protection [25] and later WENRA [24]. The IAEA recommendations were extended in the revision of the MO3&4 NPP design to include additional recommendations from the IAEA Safety Guides on Protection against Internal Fires and Explosions [26], Fire Protection in NPP Operation [27] and other [29], [30].

In the approved design for the construction permit for NPP MO3&4 of 2008, the application of international standards is proposed in the individual parts of the design. These include, for example, the series of standards for the design of the fixed fire extinguishing equipment [40], [41], [42] and [43], heat and flue gas extraction [52] and electrical fire alarm system [53].

Based on recommendations resulting from insurance company audits, insurance company standards [31] have been applied in NPP EBO3&4, NPP MO1&2 and NPP MO3&4 to improve the fire protection of selected civil structures.

1.3 Improving fire safety as a result of feedback and lessons learned

The area of fire safety of NI structures in the Slovak Republic has undergone a gradual implementation of safety improvements. The source of improvements were recommendations of international organisations, feedback from domestic and foreign experience in the implementation of the fire protection concept and from operational experience, as well as adaptation to evolving standards.

The NPP MO1&2 has substantially improved its fire safety by implementing safety measures according to the IAEA-EBP-WWER-03 document before the NPP MO1&2 was put into operation.

In the case of the MO3&4 NPP design, this is a significant shift in safety as a result of the implementation of the current legal requirements compared to the operating units in Mochovce and Bohunice. The design of the MO3&4 NPP has been developed in accordance with legal requirements [6], [7] to [19], requirements of regulatory authorities [1], [2], [32], IAEA safety standards [25], [26], [27], WENRA reference levels [24], as well as in accordance with national and international standards for the design and certification of fire protection equipment (e.g. STN ISO 6183, STN EN 15004, STN EN 54, NFPA 16, BFPA 750, VdS 2108, VdS 2109). In addition, the experience of the operator of NPP MO1&2 and NPP EBO3&4 as well as the recommendations of the insurance companies have been applied. All these aspects were developed in the safety concept [60] and subsequently reflected in the basic design of NPP MO3&4 [60].

The most significant improvements to NPP fire safety include, for example:
- reducing fire hazard by selecting appropriate building materials,
- fire-retardant cabling,
- more efficient fire extinguishing equipment,
- accurate fire detection in all buildings,
- improvement of smoke and heat extraction in the turbine-generator room (TG),
- protected escape routes with fire ventilation and others.

Also during the construction of the MO3&4 NPP itself, inputs from operating NPPs (at home and abroad) and Operational Experience (OER) were continuously evaluated and, when positively evaluated, applied to the design.

The fire resistance of fire-resistant structures and fire-fighting equipment is documented in accordance with national legislation, national and international standards. The achieved fire performance of fire-resistance structures certified in accordance with [7] shall be recorded in database form for all building structures [113].

The level of fire safety achieved has significantly reduced the overall fire hazard and the risk of compromise to safety-critical systems, structures and components, thus contributing to the overall high level of nuclear safety.

At MO3&4 NPP, as a result of prolonged construction, there were changes in legislation, the implementation of which was not required retrospectively, but ultimately there was a conflict between the legislation in force and the obligations of the contractors for fire structures arising from the design and, for example, the certificates relating to the date of purchase of materials and equipment. Furthermore, it can be mentioned that the part of the national legislation aimed at industrial sectors does not contain specificities of nuclear installations. In the event of such a conflict or absence of a rule within the legislation, nuclear safety requirements have taken precedence and deviating fire safety solutions have also been agreed with the relevant supervisory authorities.

In the case of the ISFS, there has been a significant improvement in fire safety in remedying the deficiencies identified following the deterministic analysis, e.g.:

- increasing the fire resistance of vertical and horizontal load-bearing steel structures of the ceiling,
- verification and increase of the fire resistance of the load bearing steel system ensuring the stability of the building and the roof structure,
- verification and documenting of the fire resistance of the building envelope,
- separation of free-running ducts that do not serve as protected escape routes (PER) from the PER by structural elements of D1 type with a fire resistance of at least 30 minutes on the side away from the CUC EI-S-30 with special limitation of smoke penetration,
- addition of fire closures for fire separation of individual fire compartments with the required fire resistance,
- provision of PER ventilation in accordance with the requirements for the FSB solution,
- addition of emergency lighting to the PER,
- construction of an exit from at least one protected escape route to the roof of the building,
- ensuring the protection of air handling systems (HVAC) in accordance with the FSB solution – creation of a separate fire compartment for the HVAC machine rooms, installation of fire dampers on the HVAC piping when the piping passes through the fire division structure or fire insulation of the HVAC, sealing of spaces at the point of penetration of the HVAC piping with defined fire resistance,
- sealing and marking of penetrations of wiring and installations through fire partition structures and others.

An important role in the development and improvement of fire safety is played by the verification of the conceptual design of fire safety and functionality of the most important fire safety equipment at the NPPs and ISFS by full-scale fire tests in accredited laboratories. These activities are provided and financed by the licensees.

2 Fire Safety Analyses

Fire Safety Objectives

The fire protection concept is based on the requirements of the NRA SR Decree No. 430/2011 Coll. [2], the Fire Protection Act [6], the IAEA recommendations [29] and WENRA reference levels [24]. This includes nuclear safety and radiation protection requirements (for individual NPP operating conditions) as well as fire protection requirements (FP).

The fire protection design shall include solutions where it is demonstrated that a fire at any location in the NPP (despite the precautions taken), will not become a cause of non-compliance with the general safety conditions, the essential safety functions of the NPP will not be compromised and at the same time the fire protection requirements set out in the generally applicable legislation and relevant technical standards will be met.

The basic safety functions of the NPP are:
- ensuring the safe shutdown of the reactor and maintaining it in a safe shutdown condition,
- ensuring the removal of residual heat from the reactor core after shutdown,
- ensuring that releases of radioactive substances are limited so that any releases do not exceed the limits set.

The provision of fire protection is based on the consistent application of the 'defence in depth' principle which, in relation to the above requirements, creates the following three levels of 'barrier':

Barrier 1 – Prevention – Measures to prevent the fire as far as possible,

Barrier 2 – Detection and suppression – fire identification, reporting and suppression systems - to ensure that a fire that occurs despite preventive measures (barrier 1) is identified and reported immediately after it was found and that the means are available to extinguish it quickly or to suppress it,

Barrier 3 – Preventing the spread of fire - the use of fire separation structures that prevent the spread of unextinguished fire (despite the 1st and 2nd barrier) outside the fire compartment so that the basic safety functions of the NPP listed above are not compromised.

The NPP fire protection design provides a balance between these three levels of defence in depth. This shall be based on the following considerations:
- it is assumed that a fire can start in a NPP at any location. In addition to the permanent fire loads, the presence of transient fire loads at any location in the NPP shall be taken into account. The ignition and subsequent flashover of the occurring fire loads shall be considered,
- when applying the single failure criterion, the fire itself shall be considered as a single failure,
- two or more fires are not anticipated at the same time at Units 1, 2, 3 or 4 of the Mochovce NPP,
- the occurrence of a fire and another event (e.g. LOCA) at the same time is not postulated, except where it is clear from the analysis that a fire is likely to cause an accident, or vice versa, where an examination of the other risks gives rise to such a risk,
- in general, in the event of a fire, a maximum of one system is allowed to fail (3 times 100% backup), unless there are no other requirements of the basic design for the safety measure in question (e.g. 2 times 100 %).

The following principles were followed in the fire protection concept:
- fire prevention - minimizing the fire load, establishing appropriate fire protection principles, technical conditions and criteria for design, implementation and operation, using technological equipment

ensuring its fire safety,

- identification of the equipment and components of the safety systems providing the safety functions of the NPP defined by the design: their location and the identification of their distribution routes,
- identification of equipment and components of systems related to nuclear safety: their location and the identification of their distribution routes,
- the fire safety solution for each civil structure [61] was developed according to the legislative requirements of the Slovak Republic. All planned changes were evaluated as a change of the construction before completion in accordance with the requirements [6], [7], [16] and submitted for approval and approved by the relevant central state administration authority (MoI SR, FaRC Presidium),
- division into fire compartments:
  - in accordance with IAEA recommendations [26], or legal requirements/recommendations of the NRA SR [2] and [32], fire separation of areas where redundant equipment and components of safety and nuclear safety related systems are located,
  - in accordance with the legal requirements of MoI SR [6], [7], [10] and the requirements of related technical standards [35],
  - ensuring the timely and safe evacuation of persons from each fire compartment,
  - ensuring the rapid and effective intervention of fire brigades,
  - separation of high fire risk operations, or operations with a higher probability of fire and spread of fire from other operations,
  - limiting the number of penetrations in fire separation structures,
  - possibility of exhausting combustion products inside the building,
  - limiting the extent of damage and any consequential damage following a fire,
- in cases where it is not possible for redundant equipment and components of safety or safety-related systems to be located in separate fire compartments (reactor building, unit control room, emergency control room, cable room under the unit control room, or emergency control room, etc.), fire protection systems have been designed to limit the spread of fire in these fire compartments and to exclude unacceptable effects of fire or the fire protection systems themselves on redundant safety systems [2] a [32],
- use of fire cells in accordance with [32] and [26],
- passive fire protection systems were designed preferably, i.e. systems whose functionality is not dependent on energy supply [32],
- the use of combustible materials and fire-hazardous materials was (as far as possible) excluded or minimally limited in the civil and technological parts of the project; in cases where it was not possible to apply this principle, such combustible (or fire-hazardous substances) with more favourable fire-technical characteristics were chosen and their quantity was limited to the necessary minimum [26],
- for each fire compartment the fire hazard was determined, according to which the requirements for the type and fire resistance of individual types of structures and the degree of fire safety of the building for the fire compartment were determined [59],
- devices for fast, reliable and automatic fire detection have been designed [74],
- fire-technical equipment was designed - fixed fire extinguishing equipment (gas, foam and water), fixed cooling equipment (water-based) [75], [76], [77], [78], [79], [80] and [81],
- as part of the fire safety solution for individual civil structures, the types, numbers and locations of fire extinguishers as the primary means for extinguishing fires have been determined [7] and [36],
- the project addresses the minimum number of firefighters and the material and technical equipment of the fire brigade [82],
- devices and measures have been designed to eliminate or limit the secondary effects of fires or extinguishing and cooling systems on both operating personnel and NPP safety systems and other systems; devices and measures have been designed to limit the accidental or unwanted activation of

extinguishing and cooling equipment,
- equipment and components of fire protection systems designed to limit the consequences of failures of components and structures of safety systems classified in safety classes have been included among the classified equipment in accordance with Decree No 430/2011 Coll. [2],
- fire-technical equipment and civil structures, which are construction products in accordance with Act No. 133/2013 Coll. (or Act No. 90/1998 Coll.) [18], are documented by fire structure certificates in accordance with Decree No. 94/2004 Coll. [7], which are part of the accompanying technical documentation (ATD),
- a probabilistic safety assessment (PSA) has been prepared for internal hazards, which includes an assessment of internal fires [64].

In terms of the design of individual technological systems, as well as civil structures, the maximum elimination of combustible materials is required. This general requirement has been applied in:
- the building part – using construction materials of reaction to fire classes A1 and A2,
- the technological part – minimizing the possibility of leakage of flammable liquids from technology by increasing their seismic resistance, minimizing the spillage of flammable liquids by equipping them with containment and emergency tanks, using flammable liquids with a higher ignition temperature,
- the organisational measures described in section 3.2.1.3, based on which preventive controls and measures aimed at eliminating potential sources of fire are carried out.

Of the above assumptions, the following barriers have been applied within each barrier:

Barrier 1 – Prevention

Fire protection (FP) is governed by Directive [98], which imposes duties and responsibilities primarily aimed at the prevention of fires in areas of increased fire hazard and in places of increased fire hazard. At the same time, measures are taken to control the entry of flammable liquids and gases and their storage, and monitoring of the technology and its possible leaks is in place. Activities with an increased risk of fire are carried out on PO-order and any shutdown of fire technical equipment (FTE) is replaced by a suitable temporary measure (determined by the fire protection technician). Staff are regularly trained every 12 months. The FP area is subject to regular inspections. These activities and measures effectively eliminate the conditions for a fire.

Barrier 2 – Detection and Suppression

Fire detection – electrical fire detection and protection system (FDPS) is installed in each building in accordance with the requirements of the basic design, which is designed and constructed in accordance with the applicable legislation and related standards, thus meeting the basic requirements for reliability and redundancy of the required parts of the system (e.g. power supply). The system is seismically resistant and in terms of diversity the detectors incorporate multiple detection methods based on different physical principles. The wiring of the FDPS system shall be designed in accordance with the principles of separation for cabling generally applied in the design.

Thanks to the early detection of the fire, a quick reaction of downstream systems (fire extinguishing, ventilation, etc.) is ensured, which are automatically activated from the FDPS and followed by the departure of the firefighters (verification of the location of the FDPS "FIRE" signalling by the intervention of the PFB, even if the intervening unit of the PFB finds out that it is a false alarm after conducting a survey of the location of the alarm).

The fire detection system is a certified system, it falls under the scope of national legislation, which requires periodic inspections.

Fire extinguishing in spaces and of equipment is described in section 3.2.1.2. Extinguishing system is designed and constructed in accordance with applicable legislation and related international and national design standards. Part of the fixed fire extinguishing system (FES) is seismically resistant. Redundancy is applied in part to the number of pumps, sources of fire water and its replenishment. In the case of earthquake-resistant systems, the supply of fire water has been diversified from different sources. Independence, physical and functional separation is ensured by separate FES machine rooms, electrical cables are pulled in accordance with the principles of cabling separation.

In the event of failure of the first barrier, the FDPS minimises the fire detection time and then automatically activates the FES, thus significantly reducing the fire response time to a minimum. In this way, active systems ensure effective and rapid fire spread suppression.

Fire suppression systems are certified systems, they fall under the scope of national legislation, which requires regular inspections.

In accordance with the NPP fire suppression strategy ("defence in depth"), the elimination of each fire is executed by the PFB within the standardised performance of the PFB's response activities according to the controlled firefighting documentation by deploying the predefined composition of the PFB's forces and resources to the most complex fire scenario in the respective civil construction.

Barrier 3 – Preventing the spread of fire

All civil structures are divided into fire compartments or fire cells based on the analysis. Fire separation structures consisting of materials of reaction to fire class A1 and A2 are designed based on a fire safety analysis for the required fire resistance, thus maintaining their stability, load-bearing capacity and preventing the spread of fire between the fire compartments. Openings in fire separation structures are fitted with certified fire closures. Redundant systems and equipment relevant to nuclear safety shall be physically separated by fire separation structures.

Failure of the first and second barrier shall not cause the spread of fire between fire compartments due to certified fire separation structures.

In accordance with the fire suppression strategy of the NPP, another barrier to the protection of adjacent fire compartments is presented by the PFB unit carrying out response activities in the respective civil construction according to the controlled firefighting documentation, section "Recommendations for the Intervention Commander “.

The provision of fire protection in the ISFS is based on the consistent application of a 'defence in depth' approach which, in relation to the above requirements, creates the following three levels of barrier:

- Barrier 1 – Prevention - Measures to prevent the fire as far as possible,
- Barrier 2 – Detection and suppression – fire identification, reporting and extinguishing equipment - to ensure that a fire that occurs despite preventive measures (barrier 1) is detected and reported immediately after its occurrence and that the means are available to extinguish it quickly or to suppress it,
- Barrier 3 – Preventing the spread of fire – The use of fire separation structures that prevent the spread of un-extinguished fire (despite barriers 1 and 2) outside the fire compartment so that the performance of essential safety functions is not compromised – leakage of radioactivity.

2.1 Nuclear Power Plants

2.1.1 Type and scope of fire safety analyses

Under the applicable Slovak legislation and related regulations - Annex 3, Part B, II. letter I, paragraph 1 of the NRA SR Decree No. 430/2011 [2], Decrees of the MoI SR No. 94/2004 [7], No. 121/2002 [16] and No. 611/2006 [19], Section 20 (1) and par. 58/2016 [5] of the NRA SR Decree and the safety guide of the NRA SR [32], the NPPs are obliged to prepare the following types of analyses: fire hazard analysis, probabilistic fire risk assessment and deterministic fire hazard analysis.

A. Deterministic fire hazard analysis

The analysis was prepared at the design stage and subsequently updated for all NPP civil structures so that the requirements for the related disciplines (civil, electrical, FTE, etc.) emerged from the analysis. In the civil structures housing safety-critical equipment, the principles described below to ensure nuclear safety are applied in the analysis.

Deterministic fire hazard analysis covers the following:

- a single postulated fire at any location where combustibles are permanently or temporarily present and its subsequent spread, if necessary,
- all operational states and modes of operation, including NPP shutdown (during NPP shutdown some safety systems and fire protection equipment/measures may be temporarily inoperative/ineffective e.g. due to maintenance, inspection or operational activities),
- appropriate combinations of fire and other events, including external hazards (e.g. earthquake and subsequent fire interactions).

B. Probabilistic fire risk assessment

The Level 1 probabilistic safety assessment covers all operating modes of NPP Unit 3, the reactor equipment and the spent fuel storage pool. It contains information on systems and elements whose failure in response to an initiating event may lead to fuel damage in both the core and the spent fuel pool. The PSA analyses fire scenarios at selected buildings that may be significant contributors to such risk. The analysis considers the combination of a fire with a seismic event, where small localised fires are assumed.

C. Fire Hazard Analysis

The analysis assesses the risk of fires in selected buildings, the conditions for effective intervention and evacuation of persons, the equipment of NPPs with fire-technical equipment (FTE) and the capacity of water sources for extinguishing. At the same time it determines the largest area of the fire, the verified time of arrival of the reinforced fire brigades, the necessary quantity and type of extinguishing agents (suppressant) for fire-fighting and cooling, the minimum number of the fire brigades necessary for effective fire-fighting and its material and technical equipment and the shortest time for effective intervention. The fire hazard analysis may only be carried out by a person with professional competence.

Nuclear Safety-Related Buildings

The above analyses refer to different scales of civil structures. The Mochovce NPP facilities are divided in terms of fire protection into buildings with a direct or indirect connection to nuclear safety. Priority is given to buildings directly related to nuclear safety.

In view of the increased requirements for nuclear safety and operational reliability, and therefore also the related requirements for fire protection, the NPP MO3&4 civil structures are divided into the following groups:

- Group A – selected civil structures where enhanced nuclear safety requirements apply. Thus, these are civil structures where equipment relevant to nuclear safety is located,
- Group B – all production buildings which are significant in particular in terms of operation or contain certain fire hazards and which are not among the structures listed in Group A,
- Group C – these are all buildings of non-production type, except those listed in Groups A and B.

A list of NPP facilities and their classification is provided in Table 2-1. Group A facilities must comply with the requirements defined for Group B facilities and the requirements defined in NRA SR Decree No 430/2011 [2].

Table 2-1 Groups of civil structures of Units 3&4 of Mochovce NPP

Name	Group
Grooves and channels of power cables Part II.	A
Power cable lines Part II.	B
Drinking water supply	B
Fire and service water supply	B
Pipe ducts Part II.	A
Common DG station	A
DG station II. RB	A
High-pressure compressor station II. RB	A
Oil management for DG station II. RB	B
Turbine hall II. RB	A
Bases of transformers with oil tanks II. RB	B
External substation 110 kV and 400 kV – II. RB	B
Diesel and oil filling – II. RB	B
Diesel management II. RB	A
Natural draft cooling tower II/1, II/2, II/3	A
Forced draft cooling tower 31, 32	B
Cooling water piping in the tower circuit II. RB	B
Cooling water ducts in tower circuit II. RB	B
Central pumping station for non-essential service water and non-system fire water II. RB	A
Pumping station of essential service water and system fire water II. RB	A
Sludge piping from cooling towers II. RB	B
Secondary gatehouse	C
Simulator	B
Reactor building II. RB	A
Auxiliary plant building II. RB	A
Connecting bridge between II. RB and SO 801/1-02	A
Ventilation stack II. RB	A
Air duct to ventilation stack II. RB	A
Electrical equipment spaces of transverse intermediate electrical building – Unit 3 II. RB	A
Super-emergency power supply – Unit 3	A
Backup water supply - II. RB	A
Intermediate sludge storage – shelter	C

2.1.2 Key assumptions and methodology

A. Deterministic fire hazard analysis

Deterministic fire hazard analysis [59] was prepared during the preparation stage of the MO3&4 NPP design. The analysis is based on the NRA SR Decree No. 430/2011 [2], Decrees of the MoI SR Nos. 94/2004 [7] and 121/2002 [16], safety guide of the NRA SR [32], international recommendations [26]. The basic principles for the development of the deterministic fire hazard analysis are based on the nuclear safety requirements laid down in the NRA SR Decree No. 430/2011 [2]:

- prevent fires,
- identify, signal and extinguish fires,
- locate fires that have not been extinguished.

In addition to that:

- non-combustible materials, fire-retardant materials and fire-resistant structures shall be proposed in the design,
- fire-fighting equipment must be provided in the nuclear installation and must be designed in such a way that, in the event of its failure or incorrect activation, the functional capability of equipment relevant to nuclear safety is not affected,
- fire-fighting equipment must be qualified,
- an explosion or fire hazard analysis must be carried out in the design to determine the required fire resistance of the fire separation structures,
- the design must be such that a fire at any location will not prevent the safe shutdown of the nuclear reactor, its maintenance in a safe condition and not cause the release of radioactive materials or the exposure of persons to radioactive materials in excess of specified limits.

At the same time, the principle of defence in depth as described in Chapter 2.1.1 has been applied.

The analysis was carried out in accordance with the Decree of the MoI SR No. 121/2002 [16], Decree No. 94/2004 [7] and the relevant standards STN 92 0201-4, STN 73 0802 and STN 73 0804. The analysis is part of the fire safety solution for the civil structure.

In preparation for the deterministic analysis, the following principles were followed:

- identification of safety system equipment and components providing safety functions of NPP as defined by the design,
    - safety systems equipment and components, including redundancy and belonging to divisions of safety systems,
    - equipment and components of systems relevant to nuclear safety.
- division into fire compartments; the spaces (rooms) in the buildings were divided into fire compartments – the purpose of the division into fire compartments:
    - fire protection separation of areas where redundant parts of safety systems are located (to the extent appropriate this rule also applies to systems related to nuclear safety) [32], [26],
    - fire separation of areas that are exhaustively listed in legislation and technical standards [7],
    - protected escape routes,
    - shafts and engine rooms of evacuation and fire lifts,
    - lift, installation and rope shafts, rope rooms, cable ducts,
    - HVAC machine rooms, except those serving only one fire compartment,
    - control and computing centres with an area of more than 100 m^2,
    - power substations with an area of more than 100 m^2, transformer chambers,
    - equipment and spaces that must form separate fire compartments according to materially relevant

standards (e.g., flammable liquids according to STN 92 0800),

- Furthermore, the following conditions have been applied:
  - the creation of technical conditions for the timely and safe evacuation of persons from each fire compartment, and the effective and rapid intervention of the fire brigade,
  - separation of activities with a high fire hazard, or operations with a higher probability of fire and spread of fire, from other operations,
  - limiting the number of penetrations through fire-separation structures,
  - removal of combustion products outside the building,
  - limiting the extent of damage or reducing economic losses caused by fire,
  - in cases where it is not possible for the partitioning structures of the safety systems to be located in separate fire compartments (hermetic space, unit control room and emergency control room, cable space under the control room of the unit, etc.), fire protection measures shall be designed to limit the spread of fire in these fire compartments, to preclude unacceptable fire or fire protection system effects on more than one division of the safety systems, or to fulfil the safety functions of equipment located in other fire compartments where it will not be significantly affected in securing safety-related systems [26],
  - preference shall be given to passive fire protection systems, i.e. systems whose function (operation, action) is not dependent on energy supply [26],
  - the use of combustible materials and fire-hazardous substances is limited in the design of the construction and technological part; flammable and fire-hazardous substances will be used only in the necessary quantities and those with the most favourable fire-technical properties will be selected (at the same time, the requirements for ensuring nuclear safety and radiation protection will be maintained) [26],
  - for each fire compartment the requirements for classification of each type of structure are specified according to the Decree [7],
  - designed system for rapid and reliable fire detection [7],
  - fire-fighting shall be carried out with portable or mobile fire extinguishers and fixed extinguishing equipment (water, gas and foam) [12], [9] and [10],
  - the types, numbers and locations of fire extinguishers required for the first response to a fire are determined according to the conditions of the individual fire compartments [12] and [36],
  - equipment and measures are designed to prevent or limit the secondary effects of fires and/or fire-extinguishing systems on personnel and safety systems; equipment and measures are designed to limit accidental or unwanted actuation of fire-extinguishing systems [26],
  - equipment and components of fire protection systems intended to limit the consequences of failures of components and structures of safety systems classified in safety classes are categorised as classified equipment and their design, manufacture, installation and operation are subject to a specific quality assurance system [3],
  - the consequences of the fire for the safe shutdown of the nuclear reactor, its maintenance in a safe condition and compliance with the limits set for the release of radioactive material or the exposure of persons shall be assessed.

B. Probabilistic fire risk assessment

The probabilistic safety assessment (PSA) of operation level 1 for Unit 3 of Mochovce NPP [65] and [66] is developed based on legal requirements (Atomic Act [1] and Section 20 of Decree No. 58/2016 [5]). All PSAs have been prepared by a reputable company involved in domestic and international projects aimed at assessing and improving the safety of NPPs in the European Union (EU). The reports were subject to independent external and internal assessment. The company that prepares the PSA has an integrated management system in place. The objective of the Level 1 fire PSA was to evaluate the impact of fires and safety and to determine the potential contribution of internal fires to the overall core (fuel) damage frequency. The analysis uses the results of deterministic fire hazard analyses.

The methodology for preparing the fire PSA, is based on the assessment approach and methodology described in IAEA Safety Standards No. SSG-3 [28], No. SSG-64 [29], No. SSG-77 [30], US NRC guides/documents, and the ASME standard.

All NPP structures shall be constructed in such a way that the following conditions are met in the event of any fire:

- ensuring nuclear safety and radiation protection,
- safe evacuation of persons from a burning or fire-threatened object or part thereof, to an open space or to other areas that are not threatened by fire,
- preventing the transfer of fire to another building,
- preventing the spread of fire between fire compartments inside the building,
- ensuring effective intervention by the PFB unit, in defined cases also by other external fire brigades involved in the fire-fighting and rescue works.

Basic principles and assumptions:

- it is postulated that a fire can start at any place in the NPP,
- only a single fire can occur at the same time in the NPP MO1&2 and MO3&4 (Mochovce NPP),
- a fire and another event (e.g. LOCA) at the same time is not postulated, except where it is clear from the analysis that a fire is likely to cause an accident, or conversely, where a review of other internal risks indicates such a risk,
- in addition to permanent fire loads, the presence of temporary fire loads at any location in the plant shall be taken into account. The ignition and subsequent flashover of the occurring fire loads shall be considered.

C. Fire Hazard Analysis

The fire hazard analysis for NPP Bohunice and NPP Mochovce [71] and [72] was prepared according to the Decree of the MoI SR No. 611/2006 [19] and its preparation was based on the fire safety solution of the construction. The analysis for Mochovce NPP considered the following:

- the risk of fires in selected buildings or areas of the NPP, which form a set of buildings or areas interconnected by technological equipment,
- conditions for effective intervention and evacuation of persons and property in NPP buildings or premises,
- equipping fire compartments, buildings or premises with the latest fire systems,
- the capacity of water sources for fire extinguishing and cooling in the NPP buildings or premises, or in the whole intervention perimeter of the PFB shall be determined for:
    - the largest area of the anticipated fire,
    - verified arrival time of the first reinforcement fire-fighting units,
    - the quantity and type of extinguishing agent required for fire-fighting and for cooling,
    - the minimum number of the PFB members necessary for the effective fighting of the expected fire according to the largest area of the expected fire by calculation, as well as the requirements for its material-technical equipment, i.e. fire-fighting equipment, means and other material-technical equipment (referred to in Section 6 (4) to (6) of the Decree on fire brigades [19]),
    - the shortest time to take effective action on a predicted fire according to the largest area of the calculated predicted fire.

The fire hazard analysis shall include:

- description of the fire hazard, detection and extinguishing of fire in selected NPP facilities with significant fire load,
- a description of the most complex fire scenario in the NPP, for which the numbers of firefighting equipment, extinguishing agents and the number of firefighters required to carry out an effective response to this reference fire are determined,
- conclusions and recommendations for the NPP management,
- NPP layout plan showing the fire-fighting intervention in case of turbine oil fire; functional composition and minimum number of the types of fire-fighting equipment, material means and other material-technical equipment of the PFB; emergency stock of each type of extinguishing agents and ion exchange resins necessary for ensuring the fulfilment of the PFB's tasks.

The aim of this analysis is to fulfil the content, scope and procedure of the Decree of the MoI SR No. 611/2006 [19] required by the legislation, although to achieve this aim the fire safety design solutions of several civil structures of the Mochovce NPP had to be verified, while the results of this analysis can also be used to demonstrate the fulfilment of the design objectives and requirements of the fire protection and also the IAEA recommendations, i.e. to demonstrate that a possible fire:

- will be localized in a pre-defined fire compartment,
- will not cause common cause failures in more than one safety system,
- will not prevent the performance of tasks related to nuclear safety and the safety of NPP operators,
- will not prevent safe shutdown of NPP, the safe maintenance in a shutdown condition and the removal of a residual thermal power for the required period,
- will not cause an unwanted release of radioactive material or combustion products (has not caused a release of radioactive materials or exposure of persons above the established limits – Annex 3, Part B of NRA SR Decree No. 430/2011 [2]).

The objectives of the analysis are considered to be met if the requirements of the OPP design of the assessed facility are met, i.e. if it is determined that a potential fire occurring anywhere in the assessed facility will:

- be confined in a predefined area (fire compartment),
- not cause threat (damage) to the load bearing building structures,
- not cause threat to adjacent building structures,
- not prevent a safe escape (evacuation) of persons from the building, nor the fire-fighting intervention by fire brigades.

The methodology of the analysis is specified in the "Instruction of the President of the Fire and Rescue Corps on the content and the procedure for the preparation of the fire-fighting documentation", issued in the "Collection of Instructions" of the Presidium of the Fire and Rescue Corps [23]. The method includes:

- determination of the time of free development/spread of the fire,
- determination of the time of arrival of the fire brigade to the fire,
- determination of the estimated time of locating the fire,
- determination of the area of the fire (circular, angular, direct-angular form of spread),
- determination of the area to be extinguished,
- determination of the parameters of the fire and the deployment of the necessary forces and resources,
- determination of the necessary supply of extinguishing agents for extinguishing and protection,
- determining the number of streams required,
- determining the number of firefighters required,
- determination of the number of fire engines required, including the number of water tankers.

2.1.3 Analyses of fire phenomena: an overview of models, data and implications

A. Deterministic fire hazard analysis

In the deterministic analysis or fire safety design of a building, the primary task is to determine the fire hazard in the premises under consideration. Fire hazard is the probable intensity of a potential fire in the building or part of the building under assessment (fire compartment). It is determined by the probable duration of the fire, the probable temperatures of the gases in the burning space or the equivalent duration of the fire and the corresponding standard temperatures of the gases in the burning space. It depends on the quantity and type of combustible substances in the fire compartment under assessment and on their rate of combustion.

- Probable fire duration – is the period of a fully developed fire (without fire brigade or FES intervention) during which 80% of the combustible materials constituting the fire load are expected to burn.
- Probable gas temperature – is the temperature of the gases in the burning space at the time of a fully developed fire (without intervention of fire brigades or FES).
- Equivalent fire duration – is the notional fire duration during which a fire in the fire compartment under assessment would follow the standard temperature curve and produce the same (equivalent) effects in a representative structure (e.g. reinforced concrete slab) as an actual developed fire.

The analysis procedure is as follows:
- determination of the fire load:
    - accidental fire load (includes the mass and calorific value of all combustible materials delivered to or in the fire compartment during normal operation)
        - based on table values,
        - by accurate determination and conversion to wood weight,
    - permanent fire load (includes the mass and calorific value of combustibles in the structures of fire compartment) – e.g. doors, windows, floors
        - based on table values [35],
        - by accurate determination and conversion to wood weight [35],
          Note: Under nuclear power plant conditions, in most cases the floor finish is included in the permanent fire load. Other building materials are of reaction to fire class A1 or A2.
- determination of the surface area factor
    - this factor is determined according to the equation and expresses the ratio between the surface area of fire compartment structures and the floor area of fire compartment,
- determination of the venting parameter
    - for a fire compartment or part thereof shall be determined according to the size of the area, position and height of openings in the envelope or roof structures and according to the surface area of the structures of the fire compartment or part thereof. It shall be determined by calculation,
- from these three values expressing the quantity of combustible materials, the effect of the structures on the temperature in the fire compartment and the air supply in the event of a fire in the fire compartment, the fire hazard is then determined,
- based on the determined fire hazard, the requirements for fire-separation and load-bearing structures (fire resistance) are determined in accordance with the decree [7] and the technical standard [35]),
- in terms of legal requirements [7] or based on calculations included in related standards [35] or international regulations and recommendations, the requirements for fire technical equipment are determined (FTE).

The main outcome of the deterministic analysis [59] is the solution of the fire safety of the construction of all civil structures prepared in accordance with the requirements of the Decree of the MoI SR No. 94/2004 [7], which includes:

- division into fire compartments,
- classification of building products and fire structures,
- determination of the fire load (fire hazard),
- determination of requirements for civil structures,
  - assessing the fire resistance of existing structures,
  - requirements for products and their reaction class to fire,
  - requirements for fire resistance of fire-separation structures,
  - methods of increasing fire resistance of steel structures,
- requirements for escape routes,
- clearance distance requirements,
- requirements for technological equipment,
  - HVAC systems,
  - Fire dampers,
  - equipment and distribution systems with flammable liquids or gases,
  - cable distributions, requirements for their installation (separation, etc.),
- requirements for fire-fighting intervention and fire-fighting equipment
  - intervention facilities (roads, access areas, intervention routes),
  - electrical fire alarm system,
  - fixed fire-extinguishing systems,
  - facilities for heat removal and combustion products extraction,
  - fire extinguishers,
  - supply, distribution and consumption of fire water,
- marking requirements,
- fire protection (FP) requirements with regard to seismic hazards.

The requirements thus defined, resulting from the FP solution, have been reflected in the implementation design of all disciplines and in all civil structures. As a result, each civil structure has a separate design documentation describing the above-mentioned parts. It is divided into a text part, including calculations, and a graphic part with graphically marked boundaries of fire compartments, spacing distances, fire installations and other markings required by the Decree of MoI SR No. 94/2004 [7].

The fire structures at the building and the compliance of the achieved fire resistance with the results of the deterministic analysis or FSB was the subject of inspections carried out by the relevant central government body (MoI SR, FaRC Presidium). All fire structures are registered in the fire database [113], where there are documents on the fire resistance achieved.

Currently, the deterministic analysis [59] and [60] represents the current state of fire protection at MO3&4 NPP, Unit 3.

For both NPP MO1&2 and NPP EBO3&4 a supplementary deterministic fire hazard analysis was also performed [68] and [69]. The methodology for the preparation of the supplementary fire hazard analysis, which also includes an assessment of the potential impact of a fire on nuclear safety, is based on the assessment approach and methodology described in the WENRA reference levels [24], IAEA, US NRC and Nuclear Energy Institute (NEI) documents. The fire characteristics in the fire compartment and fire spread were calculated using the US COMPBRN IIIe computational program.

B. Probabilistic fire risk assessment (Fire PSA)

The main steps in the PSA include:
- identification of fire sources, systems and elements that may be rendered inoperative by fire,
- determination of the frequency of fire in fire compartments,
- Modification of the PSA model to consider significant fire events and quantify the contribution of fires to the frequency of core/fuel damage.

The purpose of the PSA fire analysis was to ensure that the following actions were taken: Identification of nuclear unit fire sections, selection of equipment for analysis, selection of cables and determination of cable routes, qualitative triage, analysis of unit response to fire, selection and analysis of accident chains, calculation of fire ignition frequency, quantitative triage, control circuit fault analysis, human factor reliability analysis under fire conditions, fire hazard quantification, uncertainty and sensitivity analysis of results, determination of the potential contribution of internal fires to the overall frequency of core/fuel damage. The PSA model of internal events contains information on systems and elements whose failure in response to an initiating event may lead to core/fuel damage.

These are systems that provide the following safety functions:
- reactivity control,
- residual heat removal,
- maintenance of primary circuit integrity, coolant supply and containment integrity,

Fire initiated incidents are categorized as follows:
- events leading to a controlled shutdown of the reactor,
- operator shutdown of the reactor,
- transients leading to reactor scram,
- leakage of coolant from the primary circuit.

The PSA analyses fire scenarios that may be significant contributors to risk, taking into account the existence of safety-critical elements and cables in the affected fire compartment that are considered in the fire scenarios, the fire load on the fire compartments and the effectiveness of barriers between fire compartments.

In the first step for the fire compartment it is assumed that all equipment and cables that are exposed to the effects of the fire will be damaged, i.e. the assumption is made that detection and extinguishing systems are ineffective, fire protection coatings or casings are not considered.

A fire compartment cannot be excluded from the analysis if it meets at least one of the following conditions:
- after a fire occurs in the fire compartment, a requirement for safety functions arises because the unit cannot be maintained at full capacity, limits and conditions are also taken into account,
- there are elements or cables in the fire compartment which are required in the emergency response.

In the case of significant changes in the design with an impact on fire safety, these changes are assessed through separate analyses. As an example, an analysis of the probability of start-up of a seismic-resistant and a seismically non-resistant fixed fire-extinguishing system [112].

Combinations of incidents

The simultaneous occurrence of two or more initiating events is not considered in the PSA of internal incidents due to the low frequency (< 1.0×10-7/year). However, multiple initiating events are considered in the seismic PSA (SPSA) because an earthquake, as an initiator of common-cause failures, may lead to simultaneous initiating events considered in the internal events PSA.

The possibility of small localised fires is anticipated in connection with the seismic event. For this situation, the NPP MO3&4 licensee has developed organisational and working procedures for their liquidation and elimination of their consequences in the relevant fire liquidation documentation, such as operational cards and operational plans and, where applicable, in the on-site emergency plan [102].

The basic measures to eliminate the occurrence and prevent the spread of fire after a seismic event are:

- fire compartmentation structures enclosing fire compartments containing equipment or components of safety systems,
- Seismically qualified fire dampers for HVAC systems in seismic-resistant buildings or fireproof insulation of HVAC ducts,
- fixed fire extinguishing systems activated by a seismic-resistant electrical fire alarm for fire identification,
- seismic resistant fixed fire extinguishing equipment in protected areas with relation to nuclear safety,
- equipment containing flammable liquids (especially oil systems) is seismically qualified in order to maintain its integrity after a seismic event,
- Common equipment located in a fire compartment (or fire cell) that is intended to remain operational after a seismic event with equipment that is not required to be operational after a seismic event is seismically resistant so that it cannot become a source of fire following a seismic event.

A detailed analysis was carried out for the turbine hall. The other buildings were excluded from further analysis due to the low risk of fire and spreading of fire.

The turbine hall has spaces that are sufficiently separated from other areas to prevent the fire from spreading to the whole building. For fire compartments separated by large spaces free of combustibles, it is conservatively assumed that the fire will not spread to the next fire compartment (areas where an insignificant layer of hot gas may be formed). A 20-foot (about 6.5 m) clear space is considered a fire barrier. The fire frequency was taken for the entire building. It is converted to areas of fire that directly result in the loss of all EFWPs and electric feeding pumps or all after-cooling pumps. Three main contributions to fire frequency are considered: fire from transient (secondary) or imported combustibles, cables and pumps. The analysis proved that the physical separation and distribution of fire in the turbine hall cannot lead to the loss of the external network. The turbine hall fire frequency is based on the turbine hall fire frequency at full power.

At Mochovce NPP, a well-trained, exercised and fully operable plant fire brigade (PFB) is always on standby, which has a controlled documentation of fire-fighting and is able to intervene in any object of the plant in a very short time (i.e. within five minutes from the fire notification to the fire control room or the PFB operating station). Considering the thermal loads, the existing fire barriers and the continuous presence of a fire brigade capable of extinguishing most fires before they spread, the possibility of fires spreading to adjacent fire compartments is not considered in the following analysis.

Screening by frequency

The frequency of fire was calculated for each fire compartment based on NUREG/CR-6144. A quantitative triage analysis was performed for all spaces not triaged in the qualitative triage analysis (by impact). Based on the frequency of fire, those rooms with a frequency of less than 1×10-7/year were excluded from further analysis.

Core/fuel Damage Frequency

Subsequently, the PSA model was used. For each fire compartment with a fire frequency greater than 1×10-7/year, the core damage frequency was calculated by the PSA model, taking into account the impact of the fire on equipment and cables located in the fire-affected fire compartment. In order to maintain a conservative triage approach, the following assumptions were used:

- the fire disables all elements (including cables) of the safety systems and auxiliary security systems located in the affected fire compartment,
- no manual or automatic fire extinguishing is foreseen.

Several additional assumptions are made to determine the impact of fire on the operability of equipment:

- ground connection is assumed for switches and cables. If the switchboard cannot be protected against cable short-circuit by an undamaged contactor, then its loss is assumed,
- hot connection is considered in control circuits and single-phase control cables,
- hot connection in three-phase power cables is not considered,
- passive elements such as pipes, heat exchangers, check valves, etc. cannot be damaged by fire,
- false fire signal generation is assumed only for electrical valves that can cause accidents with loss of coolant. False signals are not considered for other fittings, e.g. if an electrical valve of a safety system is normally open (closed), its false closing (opening) due to fire is not considered,
- repair of fire-damaged equipment is not foreseen,
- personnel are not considered to enter the fire affected fire compartment to manually adjust valves or other equipment,
- manual opening or closing of a valve or manual starting of a pump (whose cables are destroyed by fire) is considered when the valve or pump is not located in the affected fire compartment and can be reached via unaffected fire compartments. This assumption is used for secondary circuit components.

The calculation was performed by the Risk Spectrum PSA program such that the unavailability of components located in the affected fire compartment is equal to one. The possibility of recovery is not considered. A fire compartment was excluded from further analysis when its contribution to the core damage frequency is less than 1×10^{-8}/year.

C. Fire Hazard Analysis

A turbine oil fire in the oil system of HON TG 22 in the turbine hall was selected as the most complex NPP fire scenario. The reason for the selection is the large scale of the fire, the relatively long time of the fire brigade's arrival and its deployment and the complexity of the manual intervention. The response to the turbine oil fire of the other TGs is equally complex.

The calculation of forces and means for fire-fighting is prepared according to the Collection of Instructions of the Presidium of the HaZZ [23], which determines the content and procedure for the preparation of documentation on fire fighting. The following assessments are also included in the descriptive and verification part:

- the size of the legal entity and its importance to the national economy,
- the location of the legal entity in relation to the deployment of fire-fighting units,
- the quantities and fire-technical characteristics of combustible materials,

- the nature of technological equipment and processes,
- the initiating sources and the potential for damage to technological equipment,
- the nature of buildings, the type of civil structures and the size of fire compartments,
- the possibilities of fire spread inside and outside the buildings,
- the possibilities and times of evacuation of persons or material,
- the provision of fire-fighting equipment in buildings,
- the quantity of extinguishing agents, forces and means required to fight the fire,
- the possibilities of intervention and the equipment of the units to be relied upon in fire-fighting.

Minimum numbers are determined from the results of fire hazard analysis:
- fire development assumptions due to the presence of combustibles and the possibility of its spread to adjacent fire compartments or objects,
- the largest area of the anticipated fire in the fire compartment,
- the shortest expected time of free spread of the fire,
- the type and quantity of extinguishing agents needed to fight the fire,
- the minimum number of firefighting unit personnel required to carry out an effective response,
- minimum equipment with basic and special fire-fighting equipment and fire protection means ensuring the supply of the required type and quantity of extinguishing agents to fight the fire,
- the capacity of water sources usable for fire-fighting and cooling,
- the estimated number of evacuees and the conditions for their evacuation,
- the necessary personal protective equipment to ensure the highest possible protection of the intervening PFB personnel,
- the possibilities of providing assistance by external fire-fighting units and other components of the integrated rescue system.

The results of the analysis are valid for the turbine oil fire of all 8 TGs of the turbine hall. The simultaneous occurrence of fire on more than one TG is not expected.

The analysis also revealed the organisational and technical conditions that will provide control of the most complex fire scenario on the site.

2.1.4 Main results/prevailing events (experience of the licensee)

The deterministic analysis established the basic requirements for all areas and disciplines of the overall design. Nuclear safety requirements played a key role in its elaboration and, in the event of a conflict of requirements between nuclear and fire safety, nuclear safety requirements were paramount. Any changes arising within other disciplines were transferred to the design from the fire safety design of the building and vice versa, the requirements arising from the fire safety design were applied in the design of other disciplines (building, electrical, instrumentation, control, etc.). The deterministic analysis results in the fire safety design itself reflecting the current state.

Comparison of the fire loads in the fire compartments calculated by the different methods does not show any significant differences in the calculated results. The fire load results given in the supplementary deterministic analysis and in the deterministic analysis, support each other.

Probabilistic safety assessment (PSA) of on-site fires shows that among the internal hazards, fire in the TG turbine hall has the most significant contribution to the core damage frequency (CDF). The calculated mean CDF is 3.06×10-6/year. The core damage frequency from internal fires is 2.81×10-8/year, which is a minor contribution at 0.92 %. Of these, the largest contribution is from internal fires at full reactor power. The most significant chain of events contributing to the PSA of internal fires is shown in Table 2-2.

Table 2-2 Peak minimum critical section for fire in the turbine hall at full reactor power

Frequency	%	Parameter	Commentary
1.49E-08	0.49	Fire in the turbine hall	After a fire in the turbine hall is not extinguished, the operator does not restore the supply of feed water to the SG, does not start primary feed and bleed, and personnel do not restore the supply of feed water to the SG using a mobile source.
		Fire in the turbine hall not extinguished (probability of failure 1.00E-01)	
		Operator fails to start primary feed and bleed after unextinguished fire in the turbine hall (dependent fault) (probability 5.89E-02)	
		Operator fails to restore power supply to SG after loss of turbine hall after unextinguished fire (probability of 3.60E-02)	
		Personnel fail to restore power supply to SG using mobile source after fire in the turbine hall (probability of 3.00E-03)	

No actions to be taken emerged from the results of the probabilistic assessment.

The fire hazard analysis verified the fire risks, fire spread patterns, fire characteristics of the structures, and determined the requirements for extinguishing agent quantities, forces, and resources. Analyses on the most complex fire scenario evaluated the responsiveness of the PFB. The measures proposed are not remedial in nature to address the deficiency, but rather to improve or enhance the existing situation.

2.1.5 Periodical assessment and change management

Each type of analysis is subject to the requirements of the relevant legislation, which also defines the requirements for its updating.

According to Decree of MoI SR No. 94/2004 [7], deterministic analysis is part of solution of the fire safety of the building, the update of which is required when making design modification. This means that part of the design documentation of most major changes (depending on the scope and individual impacts on the building or technological part) is also a part of the fire safety solution of the building (FSB). The analysis or fire safety design solution for NPP MO3&4 was issued in 2008 and updated several times in the form of amendments and approved by the MoI SR, the FaRC Presidium.

The conditions for revising the PSA are laid down in Annex 4 of NRA SR Decree No. 430/2011 [2] and specified in the safety guides of NRA SR [33] and [34]. During the lifetime of the NI, the PSA is periodically reviewed as part of the periodic safety review and whenever there has been a significant change in the design of the NI, a significant change in the operating procedures, or a new significant risk has been identified. The reassessment shall take into account new data, changes in methodology, design and operating procedures, changes affecting human factor reliability, or other new information that affects the results of the PSA. The last update of the PSA for MO3&4 NPP was performed in 2020 [65] and [66].

The fire hazard analysis must be updated according to the actual situation and subsequently approved by the Regional Fire and Rescue Corps Headquarters in accordance with the Decree of the MoI SR No.

611/2006 [19]. The analysis from 2013 for the commissioning of Unit 3 of NPP MO3&4 was updated in 2022 [71].

2.1.6 Overview of measures

A. Deterministic fire hazard analysis

Deterministic analysis, as part of the building fire safety design, is an integral part of any major design change. The requirements defined in the fire safety design are reflected in other parts of the design (construction, electrical part, instrumentation and control, etc.) and are thus approved by the MoI SR, the FaRC Presidium and become binding requirements, the fulfilment of which is subject to inspections.

B. Probabilistic fire risk assessment

No measures resulted from the probabilistic assessment.

C. Fire Hazard Analysis

The fire hazard analysis determined the following:

- the largest area of the expected fire,
- verified the time of arrival of the emergency unit of the PFB to the fire under assessment and the time of arrival of the reinforcement fire-fighting units,
- the quantity and type of extinguishing agent required to fight the fire and the level of actual stock,
- the minimum numbers of the PFB needed to effectively fight the expected most complex fire, as well as the requirements for its material and technical provision.

In addition, the following recommendations/ measures resulted from the analysis:

- to increase the number of cylinders for self-contained breathing devices according to the normative; to procure a sufficient number of fixed and portable gauges, detectors and other technical means for identification of the type and size of ionizing radiation and contamination of persons, equipment, working conditions or environment at the Mochovce NPP, including the provision of a sufficient number of specific PPE for intervening PFB members, fire and rescue corps officers, employees and members of external firefighting units and other rescue services of the integrated rescue system (IRS),
- to complete fire-fighting documentation (FD) – in accordance with Sections 34 and 35 of Decree No. 611/2006 [19] (operational sheets and operational plans) also for other selected areas of NPP Mochovce and also locations with increased fire hazard,
- modify or update the existing firefighting documentation, especially in the part on the activities of the intervention unit of the PFB, so that it corresponds to the real requirements for this activity and is in accordance with the legally required documentation in the meaning of the MoI SR Decree No. 611/2006 [19].

2.1.7 Status of implementation of modifications/changes

A. Deterministic fire hazard analysis

As part of the MO3&4 NPP design, approximately 40 design modifications have been implemented since 2008 with an impact on the original fire safety design. The results of the fire safety design are used as inputs for other disciplines. All modifications are incorporated into the detailed design, are implemented and have been subject to inspection by the MoI SR and the FaRC Presidium.

B. Probabilistic fire risk assessment

No measures resulted from the probabilistic assessment.

C. Fire Hazard Analysis

Recommendations/measures resulting from the fire hazard analysis are summarized in Chapter 2.1.6 (C).

2.2 Research reactors

Not applicable

There are no nuclear installations in the category research reactors that have been or are being constructed, commissioned, in operation or decommissioned in Slovakia.

2.3 Fuel cycle facilities

Not applicable

There are no nuclear installations in the category fuel cycle installations that have been or are being constructed, commissioned, in operation or decommissioned in Slovakia.

2.4 Dedicated spent fuel storage facilities

2.4.1 Type and scope of fire safety analysis

As part of the fire safety assessment of the Interim Spent Fuel Storage facility (ISFS), the following analyses were carried out: fire hazard analysis, probabilistic fire risk assessment and deterministic fire hazard analysis.

A. Fire Hazard Analysis

The fire hazard analysis [73] has been developed for the whole premises and buildings of JAVYS in Bohunice. This analysis:

- assessed:
  - the risk of fires in selected buildings or premises which form a set of buildings or premises interconnected by technology,
  - conditions for effective intervention and evacuation of persons and property,
  - equipping fire sections, objects or premises with fire-technical equipment,
  - the capacity of water sources for fire-fighting and cooling,
- determined:
  - the largest area of the expected fire,
  - verified arrival time of the first reinforcement fire-fighting units,
  - the quantity and type of extinguishing agent necessary to fight the fire and for cooling,
  - the minimum number of the fire brigade members required to effectively fight the anticipated fire according to the largest area of the anticipated fire by calculation, as well as the requirements for its material and technical equipment,
  - the shortest time needed to take effective intervention in a predicted fire according to the largest area of the predicted fire by calculation.

The following facilities belonging to JAVYS with a significant fire load in terms of fire hazard, detection and extinguishing, were under assessment:

- Bohunice RAW Treatment Centre,
- bituminisation plant,
- Interim Spent Fuel Storage facility,
- gas management,
- A1 NPP (reactor building, intermediate building and turbine hall),
- radioactive water treatment plant,
- liquid RAW storage facility,
- V1 NPP,
- other buildings have negligible fire load and are not related to nuclear safety.

A bituminous line fire was identified as the most complex fire scenario (reference fire) for the need to determine fire-fighting equipment, extinguishing agents and the number of firefighters to carry out an effective intervention. The need for fire-fighting equipment, extinguishing agents and the number of fire-fighters required to take effective action to fight this reference fire is calculated.

B. Probabilistic fire risk assessment

A probabilistic fire risk assessment (hereafter referred to as the Fire PSA) [67] has been prepared for the ISFS as part of the overall probabilistic fire risk assessment for non-reactor nuclear installations of JAVYS. The Fire PSA considers fires in fire compartments, the spread of fires, the detection and suppression of fires, and the impact of fires on nuclear safety. The risk of release of RAW to the working environment and the external environment shall be assessed.

C. Deterministic fire hazard analysis

Deterministic fire hazard analysis was prepared as part of the fire safety documentation of the building fire safety design [70].

Fire safety of buildings is the ability of civil structures – in the event of fire – to maintain load-bearing capacity and stability for the time specified by technical specifications, to prevent loss of life and health of persons, animals and loss of property, to enable effective intervention of fire brigades in fire-fighting and rescue work. It is achieved by appropriate urban, layout, structural and material design of the civil structures or by fire safety measures.

In terms of fire safety, the building must be designed and constructed so that in the event of fire:

- the load-bearing capacity and stability of the supporting structure of the building is maintained for a specified time period,
- the formation and spread of fire and smoke from a fire outbreak in the building is limited,
- the possibility of fire spreading from the fire outbreak to adjacent structures is limited,
- people are able to leave the building on time or to save themselves by other means,
- the safety of fire protection units is ensured.

Deterministic fire safety analysis covers:

- single postulated fire at any location where combustibles are permanently or temporarily present and its subsequent spread, if necessary,
- all modes of operation,

- appropriate combinations of fire and other events, including external hazards (e.g. earthquake and subsequent fire interactions).

2.4.2 Key assumptions and methodology

A. Fire Hazard Analysis

The fire hazard analysis [73] was prepared in accordance with the requirements of the Decree of the MoI SR No. 611/2006 [19]. The analysis took into account:
- two or more fires at the same time in different buildings on the JAVYS site is not postulated,
- selected the most complex fire scenario (reference fire) among all buildings located in the JAVYS premises.

The method of analysis is specified in the "Instruction of the President of the Fire and Rescue Corps on the content and procedure for preparing documentation on fire-fighting" [23] issued in the Collection of Instructions of the Presidium of the Fire and Rescue Corps.

B. Probabilistic Fire Risk Assessment

The methodology for preparing the Fire PSA, is based on the assessment approach and methodology described in the relevant IAEA safety standards/documents, US NRC guides/documents, and the ASME standard that were in effect at the time the analysis was prepared. The Fire PSA was prepared in accordance with the IAEA guides and documents in effect at the time the fire PSA was prepared.

The PSA methodology for internal fires, applied to a non-reactor nuclear installation – ISFS, consists of the following steps:
- data collection and evaluation
  - data from deterministic analysis (fire load of individual rooms, fire-technical properties of structures and elements of passive fire protection; elements of active fire protection - detection and alarm systems, fire water, fire extinguishers),
  - data for fire frequencies and reliability data for fire protection functions were used from the NUREG/CR-6144 database and from the fire analysis performed for NPP V1,
- designation of fire compartments
  - data from deterministic analysis,
- getting to know the PSA model of on-site events
  - it is not necessary to have a PSA model of on-site events,
  - location of storage for combustible RAW, technology that may release RAW into the environment due to fire,
  - determining initiating events that may be triggered by fire near spent fuel pools,
  - fire-induced loss of ventilation systems,
- inventory of cables and equipment
  - inventory of fire load - data from deterministic analysis,
  - identifying systems and features to suppress the impact of fire,
  - identifying contributors from human error,
  - identifying cables with consideration of the following fault conditions:
    - broken circuit – a circuit fault that causes a conductor to lose electrical connection,
    - ground fault – a circuit fault, when the cable conductors connect to the grounding element,
    - inter-phase short-circuit – a circuit fault, when the conductors of a cable connect to each other,
    - hot connection – a short-circuit, when a live conductor connects with an de-energized circuit, causing the de-energized circuit to become energized,

- screening by impact
  - rooms containing RAW, components or cables necessary for the elimination of an accident caused by fire; radioactive (non-flammable) materials are contained in the spent fuel that is placed in the ISFS storage pools; RAW is not contained in other rooms,
  - rooms with a fire load such that, in the event of a fire, the fire may spread through damaged fire barriers (fire separation structures), open fire doors into rooms with combustible RAW, components and cables performing safety functions,
- screening by frequency
  - NUREG/CR-6144 databases and fire analysis made for NPP V1,
  - room is excluded from the analysis, if the frequency fire is less than 1×10^{-5}/year,
  - room is excluded from the analysis, if the frequency of consequences is less than 1×10^{-5}/year,
- detailed analysis
  - for rooms that have not been excluded from analysis based on previous steps.

C. Deterministic fire hazard analysis

Deterministic fire hazard analysis [70] results from the NRA SR Decree No. 430/2011 [2], decrees of the MoI SR and the safety guide of the NRA SR [32]. The analysis was prepared according to the Decree of the MoI SR No. 121/2002 [16], Decree No. 94/2004 [7] and a number of relevant standards STN 92 0201-4, STN 73 0802 and STN 73 0804. It is part of the fire safety design of the building (FBS).

The basic principles for the development of a deterministic fire hazard analysis are based on the nuclear safety requirements set out in the NRA SR Decree No. 430/2011 [2]:
- prevent fires,
- identify, detect and extinguish the fire,
- locate fires that have not been extinguished.

The analysis was based on the following postulates:
- it is postulated that a fire can occur in the ISFS at any location where fire loads are present. The ignition and subsequent flashover of fire loads is considered,
- when applying the single failure criterion, the fire itself shall be considered as the single failure,
- two or more fires at the same time in different buildings on the JAVYS site are not postulated,
- a fire and another event at the same time is not postulated, except where it is clear from the analysis that a fire is likely to cause an accident or, conversely, where a review of other internal risks indicates such a risk,
- in general, in the event of a fire, a maximum failure of only one system (3×100 %) is allowed, unless there are no other requirements of the basic design for the safety measure in question (e.g. 2×100 %).

All implemented fire protection measures are consistent with the deterministic analysis and the analysis did not identify any other events that were not covered by the measures.

2.4.3 Analyses of fire phenomena: and overview of models, data and implications

The Fire PSA for the ISFS was developed with the following additional assumptions:
- only single fire may occur in any one fire compartment of the ISFS,
- the spread of a fire from a fire compartment to an adjacent fire compartment shall only be considered in cases where it is not demonstrable that the fire will be extinguished in the fire compartment where it originated,

- current occurrence of other initiating events - of natural phenomena - earthquake with fire is not foreseen,
- concurrence of internal initiating events, e.g. coolant leakage from a spent fuel storage pool with fire is not assumed, only analysed if it is a consequence of a fire.

The following incidents with nuclear safety implications were identified and subsequently analysed within the Fire PSA:
- fire may lead to loss of operability of the pool cooling system,
- fire may lead to loss of operability of the ISFS ventilation systems.

2.4.4 Main results/prevailing events (licensee´s experience)

The total calculated frequency of RAW release into the working environment due to fire is 2.68×10-7/year. For this event, according to the results of the analysis of the selected most serious accidents and their radiation consequences for the definition of the hazard area for the nuclear installations of JAVYS, the annual dose limit for an individual is not reached or exceeded (1 mSv).

2.4.5 Periodical assessment and change management

The evaluation and verification of the analyses shall be carried out periodically in the framework of the periodic nuclear safety assessment. The analyses are still considered valid as there have been no major changes in the methodology of the analyses or significant changes to the ISFS that would affect the results of the analyses. The last update of the deterministic fire hazard analysis is from 2005 [70] and the fire hazard analysis is from 2015 [73]. The analyses are currently being updated in connection with the expansion of the ISFS storage capacity to include dry spent fuel storage.

2.4.6 Overview of measures

An overview of the measures resulting from the fire risk analyses is given in Chapter 2.7.

2.4.7 Status of implementation of modifications/changes

The status of implementation of modifications/changes is contained in Chapter 2.7.

2.5 Waste storage facilities

Not applicable

The nuclear installations, Integral RAW Storage facility and National RAW Repository, are excluded from the review. The justification for the exclusion is given in Annex 1 to this report.

2.6 Installations under decommissioning

Not applicable

NPP V1 and NPP A1 nuclear installations are excluded from the review, the justification for exclusion is given in Annex 1 to this report. The results of the review of the ISFS nuclear installation can be transferred to the NPP V1 and NPP A1 under decommissioning.

2.7 Licensee´s experience of fire safety analyses

The original design of the MO3&4 NPP was reassessed as part of a detailed safety concept [60], where the fire hazard was evaluated in terms of meeting the specified criteria for defence-in-depth for each fire compartment in the safety-significant civil structures. In particular, the established fire resistance of civil structures and fire closures, the existence of safety systems and their possible redundancy, the safety principles of cabling and the overall fire protection assessment were evaluated.

A graded approach was applied in the division of civil structures into groups, where the principle of defence-in-depth was applied adequately.

The solution of fire safety of the building [60], thus already contains the safety assumptions of the original design, safety improvements coming from the reference NPP MO1&2 supported by deterministic and probabilistic analysis for the reference NPP, but also by its own analysis for internal hazards [64] developed for the design of NPP MO3&4.

In accordance with the national legislation in the field of fire protection, the following documents are prepared:

- the solution of fire safety of the building [61] contains for all civil structures:
  - division of the civil structure into fire compartments,
  - determination of fire hazard,
  - determination of the requirements for the structure of the building,
  - providing for the evacuation of persons and animals,
  - determination of the requirements for escape routes,
  - determination of spacing distances,
  - determination of fire safety measures,
  - determination of intervention equipment.
- the fire hazard analysis elaborated in the framework of the safety concept [59] is considered as a deterministic analysis and is elaborated in detail in the fire safety design of the building within the basic design [61]; for the reference NPP MO1&2 a supplementary deterministic fire hazard analysis has also been developed [68] and also for NPP EBO3&4 [69].
- probabilistic fire risk assessment [65] and [66] was developed in relation to internal hazard analysis [64].
- the fire risk analysis [71], in which the fire compartment is assessed:
  - with a high fire risk and with a complicated situation during intervention,
  - where flammable liquids or flammable gases predominate in the technological equipment of the fire compartment.

No major problems were identified within the individual analyses that would significantly affect the fire safety solution of the building. This is mainly due to the fact that this is a repetitive design of the same type for which substantial improvements in terms of fire safety have been made at the reference NPP MO1&2 under the Nuclear Safety Enhancement Programme. These were the basis for the design of NPP MO3&4, supplemented by additional requirements of current legislation or experience from the operating NPPs.

In the case of major design changes, the solution of fire safety of the building is an integral part of the design modification and with the implementation of the design modification, fire safety is also covered at the same time.

The current status of the MO3&4 NPP reflects the actual status on site and is in accordance with the legislative requirements at the date of preparation of the given part of the documentation.

2.7.1 Overview of strengths and weaknesses

The deterministic analysis, in the part related to the cable ducts, as part of the safety improvements at the reference NPP MO1&2, provided several alternatives to increase the level of safety, in the form of:

- fireproofing of the cabling,
- by replacing cables with fire retardant or fire resistant ones, or
- a more efficient fire extinguishing system.

The fire-proof spray coatings of cables were applied at the reference NPP MO1&2 before its commissioning.

In the deterministic analysis of NPP MO3&4, all alternatives were considered conservatively at the same time. Thus, the result is that the cabling used is fire-retardant or fire resistant, and the fire suppression system was replaced with a high efficiency mist system. The characteristics of the cabling used allow, in accordance with the applicable standards, to reduce the requirements for the division by cable fire partitions, which has remained unchanged, however, the premises are divided by cable fire partitions according to the original design. In addition, the fire risk of these spaces was calculated with the assumption that there are PVC cables present. These factors represent a strength of the design and have contributed significantly to the level of fire safety achieved.

As part of the safety precautions and analysis, safety-significant equipment was identified in the piping areas adjacent to the TG turbine hall. The proposed measure included the fire separation of these spaces by a fire separation structure and the addition of a water curtain over the unsealed openings. However, this solution turns out to be overestimated, because after its implementation, the subsequent verification of the heat and combustion products removal system by the CDF model [97] showed that the fire parameters in the TG turbine hall do not endanger the safety-relevant equipment in the adjacent building of the intermediate electrical building, even if these measures had not been implemented. This can again be considered as a strength of the design.

Some of the fixed fire-extinguishing equipment and FDPS are classified as safety-classified equipment under Decree No 430/2011 [2]. For these facilities, analyses of the impact of the lower safety classified facilities on the higher classified ones have been performed in accordance with the NRA SR Decree No 431/2011 [3] and show that their failure or non-functioning does not affect the safety-critical facilities.

The analyses identified the following deficiencies for the ISFS (deterministic analysis [70]:

- insufficient fire resistance of the supporting steel structures of the ceiling,
- to check the fire-resistance of the supporting steel system ensuring the stability of the building and the roof structure,
- verify and document the fire resistance of the building envelope,
- separate free-running ducts that do not serve as a protected escape routes from the protected escape route (PER) by structural elements of type D1 with a fire resistance of at least 30 minutes on the side facing away from the CUC EI-S-30 with special limitation of smoke penetration,
- add fire closures for fire separation of fire compartments with the required fire resistance,
- ensure ventilation of protected escape routes in accordance with the requirements for the FSB solution,
- add emergency lighting to protected escape routes,
- reconsider the possibility of controlling critical fire equipment (HVAC equipment, ventilation of PER, fire doors, power shutdown) by means of FDPS,

- build an exit from at least one PER to the roof of the building,
- ensure the protection of the HVAC system in accordance with the FSB solution – creation of a separate fire section for the HVAC machine rooms, installation of fire dampers on the HVAC piping when the piping passes through the fire separation structure or fire insulation of the HVAC system, sealing of gaps at the point of penetration of the air ducts with defined fire resistance,
- seal and mark penetrations of distribution lines and installations through fire partition structures,
- install voice alarm in the building (recommended).

Those deficiencies have been remedied. The method of elimination of the deficiencies is described and documented in the implemented design: Fire protection measures in the building – Interim Spent Fuel Storage facility within the as-built documentation [63].

2.7.2 Lessons learned from events, assessments, missions related to fire safety

The application of the results from the missions on Unit 3 of NPP MO3&4 during the construction phase did not have the nature of missions conducted on operating units (e.g. WANO in 2021), therefore they are not relevant for the evaluation of the fire safety analyses. This is mainly due to the fact that at the time of the current mission, finishing works were underway and many of the issues identified were already the subject of planned corrective actions, such as construction backlogs. However, all relevant improvements on the reference NPP coming from the missions have been reflected in the design solution. Thus the approach to mission conclusions is expected to be identical to that of the operating units and therefore we present the experience from the operating NPPs.

Design development on operating NPPs is also resulting from the recommendations from the missions. Examples are the insurance companies, based on their recommendations fire-technical equipment was installed in NPP EBO3&4 and NPP MO1&2:
- addition of fixed extinguishing system (FES) on the oil systems of make-up pumps,
- addition of FES with CO_2 in the area of storage of radioactive oils and oil systems of the control area,
- addition of FES for light and medium foam in the DGS building,
- addition of FES with CO_2 – Server room,
- addition of FDPS in the dirty laundry of NPP EBO3&4,
- addition of FES with light foam – Central oil management of NPP MO1&2,
- addition of FDPS in the storage facilities of NPP MO1&2,
- addition of FDPS in the building of auxiliary operations building,
- light foam hydrants were added to the wall-mounted fire hydrants.

No incident (fire, near-fire, smoke) with an impact on nuclear safety or fire protection has been recorded at the ISFS so far. This confirms sufficient fire prevention.

2.8 Regulator´s assessment and conclusions on fire safety analyses

The obligation to assess the documentation required for each type of authorisation or permit is imposed on the NRA SR by Section 4(2)(e) of the Atomic Act as amended [1]. The NRA SR has a process for assessing documentation within its management system, which includes safety analyses (deterministic/probabilistic). The review of fire safety analyses is based on an assessment of compliance with safety criteria. The safety assessment criteria are derived from the provisions of relevant generally binding legislation and best practice (NRA SR guides, IAEA, US NRC, WENRA reference levels). Specific inspection procedures are used for the reviews (e.g. PSA Quality Control, P 240 001:21, Fire Safety Assurance Control, P 350 0006:22). The depth of the review is determined by a graded approach, i.e. the review focuses on those nuclear installations, systems and structures or elements of analysis that are associated with a greater radiation risk. The fire safety analyses submitted to the NRA SR by licensees are usually reviewed by a multidisciplinary team with external support. When outsourcing external support, care shall be taken to ensure the expertise, independence of the external support and the avoidance of conflicts of interest. The review of fire safety analyses is combined with an on-site inspection. In some cases, the NRA SR requires an independent verification of the stated characteristics of fire-technical equipment with the participation of the NRA SR inspector and the FaRC Presidium. The results of the reviews are documented. Identified deficiencies in fire safety analyses or requests for additional information are communicated with licensees and resolved.

2.8.1 Overview of strengths and weaknesses identified by the Regulator

Three types of fire safety analyses are developed for operating NPPs: fire hazard analysis, deterministic fire hazard analysis and probabilistic fire risk assessment. The analyses are required by the MoI SR or the NRA SR and are related to each other. The analyses are prepared according to their specific methodology and serve different purposes. Deterministic fire hazard analysis is treated conservatively and has inherent modelling uncertainties. The probabilistic fire risk assessment is treated realistically and is complemented by an analysis of the uncertainties and sensitivity of the data used to the results of the calculation. The analyses are treated comprehensively and systematically according to the prescribed methodology and established practice.

The contribution of fires to the frequency of core/fuel damage at nuclear power plants is low (< 1% for an operating unit). The building that has the largest contribution to the risk of fires is the common turbine hall.

No incident (fire, near-fire, smoke) with an impact on nuclear safety or fire protection has been recorded at the ISFS so far. This confirms implementation of sufficient fire prevention.

The strength of fire protection can be considered to be the existence of a plant fire-fighting unit with adequate equipment and competent personnel on site, capable of intervening within minutes of receiving a call for action.

2.8.2 Lessons learned from inspection and assessment under regulatory oversight

Three types of fire safety analyses are prepared for operating NPPs: fire hazard analysis, deterministic fire hazard analysis and probabilistic fire risk assessment.

Fire hazard analysis is required by legislation in the decrees of the MoI SR and is developed to the design documentation of buildings to determine the possible need for the establishment of a plant fire brigade.

Deterministic fire hazard analysis results from the NRA SR Decree No. 430/2011 [2] and Decrees of the MoI SR No. 94/2004 [7] and No. 121/2002 [16]. It is part of the fire safety design of the building (FSB). The objective, recommended content, scope and procedure of this analysis is given in the NRA SR Safety Guide No. 2/2020 [32], which is based on the WENRA reference levels, item SV (internal hazards), IAEA Standard No. NS-G-1.7 (No. SSG-64), recommendations of nuclear insurance companies (NUIC) for the protection of NPPs against fires and other documents. The analysis shall cover a postulated fire at any location where combustibles are permanently or transiently present and its subsequent spread, all operating modes including shutdown NI, and appropriate combinations of fire and other events, including external hazards. The fire hazard analysis determines the requirements for fire resistance of fire partition structures and requirements for fire-fighting equipment, consideration and assessment of possible subsequent (secondary) effects of fire and the action of fire-fighting equipment. It further verifies that the safety systems required for the shutdown of the NI, the removal of residual heat and the containment of radioactive substances within the specified barriers are sufficiently protected against the effects and consequences of fires and that the safety systems are capable of fulfilling the safety functions even when a single failure is considered.

The development of probabilistic fire risk assessment for nuclear power plants is stipulated in the Atomic Act [1] and NRA SR Decree No. 58/2016 [5]. The impact of fire is analysed together with other internal and external initiating events to evaluate fire protection measures and to identify the risk of fire and its potential contributions to the frequency of core/fuel meltdowns, core/fuel meltdown failures and radioactive releases to the surroundings of the NI. The probabilistic fire risk assessment is limited to selected NI facilities and areas where the occurrence of a fire may have an impact on nuclear safety.

Fire safety analyses are performed according to a prescribed or recommended methodology by experienced analysts and using specific or generic data, if specific data are not available or are burdened by large uncertainties.

NPP fire safety analyses cover all operating modes of the NPP, the reactor equipment and the spent fuel storage pool.

The results of the reviews show that fire safety analyses are carried out in a comprehensive and systematic manner. The fire hazard analysis, fire risk analysis and probabilistic fire risk assessment are regularly updated to demonstrate that the fire safety design objectives and principles are met as stated in the fire protection documentation for each NI structure, the NI fire protection systems are properly designed and all necessary administrative measures are properly implemented. The analyses confirm compliance with the requirements of the general binding legislation on fire protection. They confirm that the protection of the NI against fires is sufficient or propose measures to improve fire safety where necessary.

2.8.3 Conclusions on the adequacy of licensee´s fire safety analyses

The scope and quality of the fire safety analyses of the licensee are in accordance with the legislative framework as well as with international standards and norms. The relevant analyses have been accepted by the supervisory authorities, the NRA SR and the FaRC Regional Headquarters. After the NPP MO3&4 is put into operation, it will be necessary to develop an update of the fire hazard analysis in order to evaluate the currentness of the PFB equipment.

3 Fire Protection Concept and its Implementation

3.1 Fire Prevention

3.1.1 Nuclear Power Plants

3.1.1.1 Design considerations and prevention

In accordance with Act No. 314/2001 Coll. on fire protection [6] and its implementing decrees, all civil structures are constructed in such a way that in the event of a fire:

- the load-bearing capacity and stability of the supporting structure of the building is maintained for a specified period of time,
- limit the occurrence and spread of fire and smoke from the fire outbreak in the building,
- limit the possibility of fire spreading from the fire outbreak to adjacent structures,
- persons were able to leave the structure in time or save themselves by other means,
- ensure the safety of fire brigades.

The following preventive fire protection measures are implemented at NPP MO3&4:

- minimize the amount of flammable substances and materials,
- prevent the spread of fire inside and outside the buildings by fire compartments created,
- using civil structures and materials, which correspond to fire hazard in the fire compartments,
- safe evacuation of persons from the building is ensured,
- the distance between the buildings and the design of fire open areas is such that the fire cannot spread between the civil structures,
- technical and technological equipment and distribution systems are designed, implemented and operated in such a way that the fire is limited as far as possible and the activities necessary to ensure nuclear safety, fire protection and radiation protection can be carried out at all times,
- the means and conditions are provided for effective fire-fighting intervention.

3.1.1.2 Overview of measures to manage and control fire loads and ignition sources

Minimising the use of flammable substances and materials

In accordance with the requirements of Decrees [2], [4], [16] and fire protection management [98], flammable substances and materials incorporated into the construction were used in the design of the MO3&4 NPP only in unavoidable cases. Where the use of flammable substances and materials could not be ruled out, measures were taken to limit or eliminate the possibility of fire occurrence and spread, or to limit the secondary effects of fire:

The basic obligations for minimising the fire load are described in Directive [98]. A description of the activities associated with increased fire risk is given in the Directive [100]. In accordance with fire protection legislation [16], a written permit (e.g. welding permit, PO-order) must be issued for these activities, for which an authorised person is responsible. Training of fire assistance patrols for activities involving increased fire risk is provided by a fire protection technician.

Minimising the use of flammable substances and materials is required in the development of work procedures, designs, upgrades, maintenance and operations.

Any change of use of the building, workplace, technology must be assessed in the documentation, which is prepared and confirmed by a fire protection specialist.

A. Cable distribution systems

Fire retardant cables are used for all cables in buildings critical to the safe and reliable operation of NPPs – civil structures group A, B (Table 2-1) [83].

Fire retardant cables are used:
- for all cables of the safety systems,
- for all equipment that must be operational in the event of fire (e.g. emergency lighting, FDPS, fixed fire-extinguishing equipment, etc.).

In NPP EBO3&4 and NPP MO1&2, within the framework of increasing the level of nuclear safety, spraying with fire protection coating was carried out on all system (critical in terms of nuclear safety) cable ducts, cables and structures located in fire sections with fire duration greater than EI 90 in accordance with the Decree of the MoI No. 94/2004 [7]. In the case of design modifications, existing cables are replaced in these areas with fire retardant cables.

At NPP MO1&2, the improvement of fire resistance was addressed in the framework of safety measures prior to the commissioning of the Units and subsequently mainly during general outages. At NPP EBO3&4, fire safety upgrade was and is implemented mainly during general outages.

B. Electrical and I&C cabinets equipment

In accordance with the requirements of the NRA SR Decree No. 430/2011 [2] and Decree No. 94/2004 [7], internal flammable wiring (cables) and flammable materials inside electrical and I&C cabinets have been minimised. When using the classical materials, i.e. in combustible form, measures are taken (division into fire compartments, design of the HVAC system) to prevent the negative effects of fire on these facilities. The electrical and I&C cabinets have been manufactured in accordance with IEC 60439-1. According to this standard, the insulation materials are to a certain extent resistant to abnormal heat and fire. Another example is the use of fire-resistant switchgear located in protected escape routes.

C. Flammable liquids

Where the use of flammable liquids is unavoidable, the use of flammable liquids of lower flammability classes is preferred in accordance with Decrees [2] and [14]. Storage facilities and areas containing process equipment with flammable liquids is designed and constructed in accordance with [14] in order to prevent the spread of flammable liquids, for example in the event of unintentional spillage. In structures with nuclear safety implications, piping systems and equipment are seismically resistant to maintain the integrity of equipment and piping routes during and after a seismic event to prevent the unwanted release of flammable liquids.

To eliminate the risk, where the process system allowed it, oil fillings with a higher flash point were selected. An example is the use of QUINTOLUBRIC 888-68 hydraulic oil, which is not a flammable liquid according to Decree [14] because its flash point is 275 °C, which is higher than 250 °C (classification as a flammable liquid), a burning point of 325 °C.

Furthermore, measures were implemented to capture the leaked flammable liquid under the process equipment [103] in accordance with the requirements of the Decree of the MoI SR No. 96/2004 [14]. An example is the TG machine room building, where the containment and drainage of leaking turbine oil into the emergency tank is designed, consisting of three open containment tanks for each of the four TGs located directly under the lubricating oil system equipment, which may cause uncontrolled leakages and spillage of lubricating oil. The bottom of the tanks is sloped to one of the corners, where an attached pipe will divert (by gravity) captured liquid spills to an atmospheric emergency oil tank (one for each TG) located at a lower elevation [84].

Another example is the oil management facility of DG Station II. RB, where all the requirements of the Decree [14] are met. The tanks are equipped with a containment tank consisting of the floor of the oil management room of the DG station, including the piping ducts. In all areas where flammable liquids are present, the floor is sloped and is made of materials of reaction to fire class A1 and A2. The flooring is impermeable and resistant to the chemical effects of flammable materials.

In terms of organisational measures, all locations with an increased risk of fire (especially those containing flammable liquids) have been identified and a Workplace Fire Code has been developed for these locations. [86]. Document [86] provides a brief description of the workplace, the fire-technical characteristics and sets out the requirements for ensuring protection against fire, the duties of persons and fire-fighting equipment.

D. Flammable gases

In areas where flammable gases are present, effective measures are designed to limit their negative effects (explosion, combustion) - sufficient ventilation and drainage outside the building, monitoring of their dangerous concentration, exhaust areas in accordance with the Decree of the MoI SR No. 124/2000 [15].

An example is the installation of a hydrogen concentration measurement in the TG machine room and subsequent shutdown of the cranes and provision of ventilation after an increased hydrogen concentration is signalled. At dangerous concentrations, all electrical equipment that could cause an explosion is switched off.

E. Flammable radioactive waste

Flammable radioactive waste is primarily (in most cases) low-level solids and liquids or air filters, which are stored and treated in the Active Auxiliary Plant Building. The storage of flammable radioactive waste is provided in reinforced concrete vaults forming separate fire compartments, which are equipped with fire detection and automatically activated gas fixed fire-extinguishing equipment with CO_2 extinguishing agent.

F. Technical and process equipment

All process equipment and piping inside and outside buildings containing or distributing flammable liquids or flammable gases, including their supporting structures, shall be made of non-combustible materials and shall be seismically resistant, retaining their integrity even after an earthquake.

Oil lines with flanged joints are designed to be tight, e.g. fitted with sleeves or covers to prevent oil splashing in the event of loss of joint tightness. The design of the sleeves allows easy indication of minor leaks. In the case of the TG oil system, the oil thus captured is led to a containment tank with a sensor and, when full, a signal is sent to the turbine control system (TCS). Areas with flammable liquids shall be equipped with containment and emergency tanks in accordance with Decree [14]. The drain pipe from the containment tank to the emergency tank shall have a permanently effective liquid stop or non-captive fuse and shall not have a shut-off valve.

Equipment and distribution pipelines with flammable gases are designed in accordance with the Decree of the MoI SR No. 124/2000 [15]. Areas where an increased concentration of hydrogen may occur are equipped with measuring instruments to measure the concentration of hydrogen and subsequently, the reduction of the said concentration and the disconnection of electrical equipment from the electrical voltage is ensured by appropriate technical means.

In general, technological systems and equipment containing flammable liquids or gases can generate an explosive atmosphere in their surroundings. In the Mochovce NPP, these are in particular the following process systems:

- TG turbine hall – TG oil systems, distribution of hydrogen for alternator, distribution of industrial gases,
- transverse and longitudinal intermediate electrical building – battery rooms,
- DG station building – oil and fuel management for DG,
- building of the mobile DG and common DG – DG fuel management,
- diesel and oil filling,
- diesel management of II. RB.

In accordance with the government regulation [22], calculation reports were prepared for the above-mentioned civil structures, based of applicable STN standards for explosive environments [47], [48], [49], [58] and [51], based on which the division into zones for electrical and mechanical equipment was determined. The explosion hazard zones thus identified determined the requirements for the electrical equipment in the electrical design. Equipment located in explosive atmospheres was supplied in Ex design and its characteristics are demonstrated in the relevant accompanying technical documentation (ATD).

In the case of machinery containing flammable liquids, potential leaks of flammable liquids or vapours have been eliminated by means of flame arresters or liquid seals.

The explosive environment in the vicinity of process equipment is marked with appropriate safety signs in accordance with [22].

The area of fire prevention in hot works or activities with increased fire risk is ensured by organizational and technical means. A more detailed description is given in 3.2.1.3.

3.1.2 Research reactors

Not applicable

There are no nuclear installations in the category of research reactors in the Slovak Republic that have been or are being constructed, commissioned, operated or decommissioned.

3.1.3 Fuel cycle facilities

Not applicable

There are no nuclear fuel cycle facilities in the Slovak Republic that have been or are being constructed, commissioned, operated or decommissioned.

3.1.4 Dedicated Spent Fuel Storage Facility

3.1.4.1 Design considerations and prevention

In the ISFS, the following flammable substances represent the fire load, in particular: PVC cable insulation, PVC in switchgear, PVC in floor coverings and oil in pumps. In particular, electrical equipment located in fire compartments may be fire initiators.

3.1.4.2 Overview of measures to manage and control fire load and ignition sources

The basic obligations in the field of fire load minimisation are described in Directive BZ/KB/SM-07 Fire Protection [127]. A description of the activities associated with increased fire risk is given in Directive BZ/KB/SM-07 Fire Protection [127]. According to the applicable fire protection legislation [16], a written permit (e.g. welding permit, PO-order) must be issued for these activities, for which an authorised person is responsible. Training of fire assistance patrols for activities involving increased fire risk is provided by a fire protection technician.

Minimizing the use of flammable substances and materials is required in work procedures, designs, upgrades, maintenance and operations. Any change in the use of the building, workplace, technology must be assessed in documentation that is prepared and confirmed by a fire protection specialist.

There are no storage facilities or areas containing technological equipment with flammable liquids at the ISFS.

3.1.5 Radioactive waste storage facilities

Not applicable

The nuclear installations – Integral RAW Storage and National RAW Repository are excluded from the review. The justification for the exclusion is given in Annex 1 to this report.

3.1.6 Facilities under decommissioning

Not applicable

The nuclear installations NPP V1 and NPP A1 are excluded from this review. The justification for the exclusion is given in Annex 1 to this Report.

3.2 Active Fire Protection

3.2.1 Nuclear Power Plants

3.2.1.1 Fire Detection and Alarm

3.2.1.1.1 Approach to design

Only natural persons who have undergone training in the scope and content stipulated by the manufacturer, have undergone knowledge verification and have been issued with a special certificate of professional competence in accordance with the Act [6] may design, install and repair electrical fire alarm systems (FDPS) and carry out their inspection.

The technical requirements for the new FDPS system are in particular:
- the FDPS equipment must be continuously operational; disabling of the equipment may only be carried out by a qualified operator under work permits for work that could affect the operation of the FDPS; the equipment failure must be signalled and rectified within the time limit specified in the FDPS operating rules for the equipment for the site being protected,
- the requirement for FDPS functionality during and after a seismic event is determined by the seismic scenario for Units 3&4 of the Mochovce NPP and the seismic qualification; the FDPS used to initiate a seismically qualified FES must be functional after a seismic event,
- FDPS functionality is not required during and after a LOCA accident,
- the main source of power supply for the FDPS will be provided from the NPP's unsecured self-consumption distribution system,
- the backup power supply for the FDPS is made up of dry rechargeable batteries,
- the FDPS system shall be such that a single cable fault in any single circuit cannot prevent the proper operation of more than one of the following functions:
    - automatic fire detection,
    - operation of push-button detectors,
    - acoustic fire alarm operation,
    - transmitting or receiving signals to or from input or output devices,
    - initiating the operation of additional equipment (fixed extinguishing equipment, fire dampers),
- the FDPS system must ensure reliable operation with a maximum degree of suppression of unjustified ("false") alarms. Reliability is one of the basic prerequisites for an effective design.

All fire protection equipment (i.e. including the FDPS) must be certified as construction products within the meaning of the Act [18], including those parts of the system that will carry out the control activities that are necessary for the operation of the certified fire technical equipment (FTE). The FDPS must have a conformity assessment within the meaning of the Act [21] on Technical Requirements for Products and Conformity Assessment.

3.2.1.1.2 Types, main characteristics and expected performance

For the NPP MO3&4 FDPS, a new system is used, supplemented by new technical requirements based on legislative and normative documents [2], [11] and [53]. The electrical fire alarm system is used for fire identification in the protected area (the area in which the electrical fire alarm detectors are located), acoustic or optical alarm signalling and controls via input/output interfaces the equipment connected to it, e.g. fire suppression devices, fire doors, etc. The electrical fire alarm system [85] is a common system, it also performs additional functions and consists of:
- electrical fire detection and protection system (FDPS),
- control system for fire protection.

In the MO3&4 NPP design, the electrical fire alarm system is also referred to as the fire detection and protection system (FDPS). The electrical fire alarm system must identify a physical or chemical phenomenon caused by a fire in the guarded area, acoustically or optically signal an alarm in or around the guarded area, and control the equipment connected to it. The FDPS is an integrated fire alarm, fire protection and warning system. The FDPS shall provide:
- control of fire dampers,
- control of interaction between FES and other technological systems (fire pumps, HVAC, doors).

FDPS directly activates the relevant fire-technical equipment (fire dampers – direct activation by interrupting the power supply in the electrical switchboard for the relevant fire damper) and indirectly transmits a signal to activate the relevant fire-technical equipment and related equipment (FEE, fire pumps, fans) through their control system.

FDPS contributes by early detection to the limitation of failures (initiating event – fire) and the prevention of the consequences of failures (by early detection of fire it is possible to extinguish early and prevent the spread of fire through FTE or fire intervention of the PFB) through direct activation of fire-technical equipment (e.g. fire dampers) and indirect activation of fire protection equipment and related equipment (heat removal and combustion products extraction, FEE, fire pumps, ventilation of protected escape routes, switching off fans of HVAC systems) via their own control system.

The function of the FDPS system is to provide fire detection by electrical fire alarm, execute fire protection commands and alerts in conjunction with the following systems:

- TELEPERM control system (master instrumentation and control system (I&C),
- HVAC for the reactor building,
- HVAC of the auxiliary operations building,
- HVAC for the intermediate machinery room,
- HVAC systems controlled by TELEPERM,
- fixed fire extinguishing equipment, controlled via control panels,
- pumping station of non-essential service water, controlled by TELEPERM (Unit 3) and by FDPS,
- pumping station of essential service water, controlled by TELEPERM (Unit 3) and by FDPS,
- electrical part,
- heat removal and combustion product extraction system,
- DG station,
- VHV and HV distribution equipment,
- machinery room.

The individual FDPS control panels are connected to the FCnet communication buses and then to the MM8000 superstructure system. Each change of the control panel status is displayed on the LCD-display control panel and then on the MM8000 superstructure system. Each line, group of detectors or even each detector has its own designation and a user text can be assigned to it.

Due to the obsolescence of the MM8000 system and unavailable support from the manufacturer, it was replaced with a more modern DesigoCC system from the same manufacturer. DesigoCC is a graphical superstructure system on top of EPS servers. DesigoCC is installed on the Windows SQL Server platform and works on the server-client principle. DesigoCC provides operators with a user-friendly overview of the connected Sinteso EPS system, increasing operator comfort and rapid response in the event of an alarm.

All events from the Sinteso system (from the FDPS control panels) are transmitted to the DesigoCC HMI. The FDPS functionality itself is stored/configured in the FDPS control panels, DesigoCC only visualizes (textually and graphically) the status on the FDPS control panels. From the DesigoCC-client workstation, the operator can operate/control individual parts of the FDPS system. There is no output control logic installed in the Desigo CC system, it is only used to display states. The control logic is installed in Sinteso. From the DesigoCC system, the information is also passed on via the OPC Server protocol to the PO-order management server and receives back commands to switch fire zones off/on according to the PO-orders. Sinteso and in the same way DesigoCC is divided into two separate systems in MO3&4 NPP, one for Unit 3 and common facilities, the other for Unit 4.

Sinteso™ of C-LINE and S-LINE, AlgoRex and VESDA VLF fire detectors are used in individual areas:

- multi-sensor detectors,
- optical-smoke detectors,
- flame detectors,
- suction smoke detectors,
- push button detectors,
- linear smoke detectors,
- heat detectors,
- gas detectors (in battery rooms – hydrogen detection).

The FDPS is primarily an automatic system. Manual activation is expected especially in escape routes where push-button detectors are placed which, in addition to triggering the alarm, also activate the fire ventilation of the stairwells.

The determination of the spaces where fire detection is required is based on the fire safety design of the building [61]. The FDPS system is designed for all NPP areas, the exception being the areas:

- common buildings that have already been equipped with detection within NPP MO1&2,
- outdoor areas,
- spaces filled with water,
- impassable trenches and channels,
- sewer and valve shafts, valve pits,
- natural draft cooling tower and forced draft cooling tower, including their pools,
- sanitary facilities,
- HVAC riser shafts.

Independence between the detection of adjacent fire compartments is ensured mainly by the looping of lines and directional detectors. This means that interruption of an FDPS line does not mean loss of its function. At the same time, each sensor and its activation or failure is precisely identified. In addition, in areas where the activation of the FES is based on a signal from the FDPS, the lines in these areas are duplicated to ensure reliability and independence.

In buildings, identifiable combination sirens with a beacon are used to sound the alarm in escape routes (corridors, stairwells). The devices are positioned to alert workers to potential danger and are connected to the alarm lines. All alarm devices are activated from a general alarm in the building. Acoustic and optical alarm devices are not fitted to buildings that are not permanently occupied (e.g. cable ducts, shelters).

FDPS control panels have their own spare backup power supplies (AKU batteries), which provide power to the devices for a minimum of 48 hours in the event of a 230 V AC mains voltage failure. Failure of the backup power supply is indicated on the control panel display. The electricity supply for the FDPS equipment can be considered as a 1st stage supply, i.e. in the event of a failure of the 230 V AC power supply, there will be an automatic immediate switchover to its own backup supply.

FDPS panels use the "Extended Networking" system architecture, which is based on the interconnection of FDPS panels into Subnets. Each FC2060 panel displays and controls all detectors and I/O modules connected to it [85].

Each SUBNET is a circular interconnection of FC2060 control panels with a metal cable via FC-net/SAFEDLINK communication. In each SUBNET, one control panel is designated as the master control panel and displays all information and controls all control panels of that SUBNET. The individual SUBNETs together with the Standalone control panels are connected by a circular FC-net/LAN data communication bus. FC-net/LAN is a multi-mode optical cable connection. The interface between FC-net/SAFEDLINK and FC-net/LAN consists of FN2008-A1 converters. Subnets 1-4 are connected by two FN2008-A1 converters, Standalone panels by one FN2008-A1 converter [85].

The FDPS system is fully digital (I/O – inputs, outputs, CPU – central processing units, CP – communication processors, standard and industrial bus systems for communication), modular, hierarchical, flexible, programmable and reliable. The FDPS is built on the DMS8000 superstructure system, which is designed for comfortable operation of the entire FDPS system. DMS8000 is a software application based on PC client-server architecture. It uses a graphical HMI interface and allows to fully receive information from the FDPS control panels, as well as to control the individual FDPS control panels.

The DMS8000 system consists of one server and 8 client stations. The DMS8000 SERVER is made up of two separate PCs, which will be interconnected by the Marathon application. This application will ensure redundant operation of the DMS8000 server in case of failure of one PC. DMS8000 client is formed by separate PCs together with one monitor located at the operator's workplace according to the user's requirements in:

- Unit Control Room – operational part,
- Emergency Control Room,
- Outside the Unit control room – operational part,
- Fire brigade building – fire reporting room.

The FDPS does not directly control any air handling system equipment (fans) except for fire dampers and selected gas-tight enclosures.

In terms of system resilience to external influences, in addition to meeting the requirements of a series of standards [53], the design requirements arising from the safety concept are also applied to the design of the FDPS. In terms of safety functions, the FDPS system is classified as SC IV safety class equipment in accordance with the NRA SR Decree No. 430/2011 [2]. The maintenance of the safety function is required in some areas even after a seismic event, and therefore the individual components are seismically qualified.

The requirements for periodic inspection of the FDPS are defined in the Decree of the MoI SR No. 726/2000 [11]. The Decree specifies the requirements for the scope of inspections: daily, monthly, quarterly and annual.

FDPS tests are carried out in accordance with this legislation and the manufacturer's regulations. The content of the inspections is defined by the Decree in question as follows:

- checking the functionality of the backup power supply, including test operation of the electrical fire alarm system on the backup power supply,
- checking the functionality of controls, status displays and additional surface and interior equipment, including cleaning,
- sealing, wiring, tightening connections, fuse inserts, terminals,
- individual device functions, including battery recharging,
- the voltage supplied by the individual power supply devices of the control and status display devices and the input voltage of the notification appliance lines at quiescent current,
- RAM back-up batteries and back-up batteries for out-of-service signalling,

- interconnection of individual devices,
- inspection of fire detectors,
- functional parameters of detectors,
- visual and mechanical inspection of the socket, including cleaning,
- visual and mechanical inspection of the detector sensor, including cleaning.

Tests are usually carried out in the following range: control panels, automatic and push-button detectors, acoustic alarm, other equipment, if included, and wiring. At the same time they are tested and a test record is made in the FDPS operating log-book.

3.2.1.1.3 Alternative and temporary measures

Activities associated with an increased risk of fire include, in particular:
- operation, shutdown and start-up of production in process equipment containing flammable substances,
- maintenance and repair of technical and process equipment containing flammable substances, or using hazardous substances, which -during the work- may reach a state where fire, explosion or the release of toxic substances in concentrations exceeding the limits permitted by the regulations may occur,
- welding, thermal cutting and other metalworking processes using welding, grinding or sparking equipment, independent of the degree of automation, in places where there is a risk of fire or explosion,
- gluing of combustible floor and roof coverings, wall and ceiling coverings using fire, thermal appliances and equipment or combustible adhesives and removal of old paint using thermal appliances and equipment,
- unavoidable handling of open flames in places where there is a possibility of fire or explosion,
- melting-on various materials in places where there is a risk of fire,
- other activities designated by the equipment operator, the fire department manager, or the fire protection technician,
- activities, for which a risk assessment is required in relation to the tripping of FDPS detectors,
- activities, for which a risk assessment is required in relation to active FDPS detectors.

Activities associated with increased fire hazards can only be carried out in SE-EBO/SE-EMO and MO3&4 based on a valid document - "PO-order" [100]. Work may only commence after all specified fire precautions in the PO-order have been complied with. The PO-order does not replace other documents for equipment clearance (Z-order, B-order) or documents for the actual performance of work on the equipment (Order), etc.

These principles and procedures also apply when shutting down fire detection on parts of the premises or shutting down fire extinguishing (see also 3.2.2.4).

According to the Decree of the MoI SR No. 726/2002 [11], if the FDPS is not operable, alternative measures are required. This fact is also carried over into internal regulations [98], [100] and [114], where FDPS shutdown is considered as a non-standard condition and the fire protection alternate measures are mentioned in the PO-Order. These include, for example:
- cleaning of flammable substances,
- filling the technology by inert gas,
- removal of flammable materials,
- airing of the space,
- covering flammable materials,
- sealing of openings and penetrations,

- avoiding explosive environments,
- maintaining clear escape routes,
- other.

Assistance fire patrol and premises walk-around are set up to assist at risk activities. In some cases, as an alternative measure, monitoring of selected areas by installed camera systems (example: the main circulation pump room).

3.2.1.2 Fire suppression

3.2.1.2.1 Approach to design

The basic requirements for fixed fire extinguishing systems are laid down in the Decree of the MoI SR No. 169/2006 [10]. Based on the Decree and at the same time on the safety concept, general requirements for a fixed extinguishing system (FES) have been established (an exception to the rules is given in section 3.2.1.2.3):

- only natural persons who have undergone training in the scope and content specified by the manufacturer, knowledge verification and have been issued with a special certificate of professional competence, may design, install and repair fixed and semi-fixed fire extinguishing systems and carry out their inspection [6],
- all FES installed within the Mochovce NPP must be equipped with a combined triggering device (Manual control and self-acting control. Self-actuation may be mechanical, hydraulic, pneumatic or electrical),
- FDPS will be used as the initiation of self-triggering for the FES (note: for FES of external transformers, a pressurized air system is used), which, based on the detection from the fire detectors, passes the information to the FES control system, which initiates the triggering. At the same time, the FDPS initiates the execution of other necessary actions for the start of extinguishing based on the algorithms for FES (e.g. start of fire pumps, closing of dampers, shutdown of HVAC, etc.) before starting the FES. The FES control system signals the status of the SHZ and selected components of the FES,
- the selection of a specific type of FES and extinguishing agent is based on the following:
  - the nature of the risk,
  - the impact of filling discharge, such as continuous operability, water damage, overpressure, thermal shock, cleaning, etc.; and
  - health risks.
- FES are installed in parts of the building or in whole buildings:
  - In accordance with the Decree [7],
  - In selected cable rooms of the main production unit,
  - Oil management of turbines, selected pumps and transformers,
  - In the DG station building in selected areas,
  - Storage facility for solid radioactive materials,
- in accordance with the change in the concept of using cables and minimizing the use of flammable materials in the equipment of cabinets and panels, FES are not installed in electrical distribution cabinets, panels in 0.4 kV and 6 kV substations, I&C panels with safety-critical equipment. In the case of the use of flammable materials in the equipment of cabinets, panels, engineering solutions are applied,
- each FES shall have an engine room located close to the protected area. The engine room shall form a separate fire compartment. Access to the engine room of a fixed fire-extinguishing system shall be from the open air or from a protected escape route,
- all FES parts must be marked in accordance with the MoI SR Decree No. 169/2006 [10],

- the alarm device shall signal the actuation of the fixed fire-extinguishing device by an audible alarm. The audible alarm shall sound at all times during the delay between the fire being signalled and the start of discharge and during discharge; this does not apply to a fixed sprinkler with volume extinguishing or to a fixed extinguishing system which may create a concentration hazardous to the health of persons, where the audible alarm shall sound until a safe concentration has been established in the protected space; the audible alarm shall be distinct from all other alarms,
- the control panel of the FES shall be capable of controlling the immediate downstream equipment related to the operation of the FES (e.g. light alarm, audible alarm),
- power supply requirements - the fixed fire-extinguishing system shall have an electrical supply for at least the duration of its operation; the power supply shall be made in accordance with the Decree [10],
- all manually operated FES valves must have their status signalled at the Unit Control Room.

3.2.1.2.2 Types, main characteristics and expected performance

Fire water

The fire water system for Mochovce NPP is connected to the raw water supply. Raw water for Mochovce NPP is provided from the Veľké Kozmálovce waterworks on the Hron River, but for industrial purposes and for the supply of water to buildings for fire-fighting, the water is treated. The water supply is provided by two separate feeders, which are fed by pumps located in the pumping station built at the dam of the water works. From the pumping station, the pumps transport water for the needs of the Mochovce NPP (service water and fire water). The pumps are connected to a system of secured power supply from two independent sources. The water source can be considered as inexhaustible in terms of the needs of Mochovce NPP.

Fire water for System 1 and System 2 (seismically non-resistant piping) connected to a circulating cooling water system that provides fire water supply in the event of an accidental feeder failure. The fire water system for the seismic resistant system and possibly the essential service water distribution system can also be replenished from the cooling system. The connection is made partly by means of dry pipes, which have to be supplemented by fire hoses and portable pumps. In this way, water can be replenished for the fire system (after the water supply in the ESW system tanks has been exhausted) and, if necessary, also for the ESW – natural draft tower pools. The supply of water for fire extinguishing to individual buildings is handled in the solution of the building – Fire and utility water supply.

At the MO3&4 NPP site, the fire water supply system is divided into three independent systems.

- The first system provides fire water supply in the II RB seismically non-resistant part of the FES, FES of external oil transformers, FES of TG oil tanks. The fire system is supplied with water from the cooling system of the 2nd double unit. The fire network is supplied with water from a fire water pumping station located in the cooling water pumping station. Two separate discharge lines lead from it directly to the II RB. Inside the RB, it is connected to the internal looped fire system (internal hydrants and FES).
- The second system provides fire water supply to both indoor hydrants and outdoor fire hydrants for all MO3&4 NPP facilities. This system is fed with water from the cooling circuit II of the RB. The fire network is supplied with water from a fire water pumping station, which is connected to a cooling water pumping station. There are two separate routes from this pumping station, which are connected to a looped external fire water supply system. The system runs around the two RBs, then around the water treatment plant, workshops, operations and office buildings and the Medical Centre. This basic circuit is subdivided into sub-circuits. Both hydrant systems are looped and fitted with shut-off valves along the route so that in the event of a failure of the piping system, it is possible to disable a certain part of the system and to operate the other parts of the fire hydrant system independently.

- The third system provides fire water supply to the seismic-resistant FES. The system is fed from the ESW cooling circuit (from the ESW pumping station). The distribution between the ESW pumping station and the II. RB is by three pipelines, which are interconnected. This system is connected by two pipes to the first system - increased fire safety. The water flow between the 1st and 3rd system is ensured by check valves in the direction from the seismically non-resistant to the seismically resistant areas (from the 1st to the 3rd) in case of loss of water in the pools of the ESW pumping station.

Fire water pumping station for the first fire water supply system

The pumping station is located at the cooling towers of II. RB. The fire pumps are located between the service water and cooling water pump station. Water is supplied to the system by 4 pumps. In addition to these main pumps, there are additional pumps in the PS I, which are triggered when the pressure in the network drops. There are shut-off valves on each discharge pipe from each pump, the two discharges are connected to each other via shut-off valves and an air compensator on the supply pipe. The standby fire pump starts automatically (within 20 seconds after the command is given) in case of a failure of the selected operating pump. Simultaneous operation of both pumps is not considered.

Fire water pumping station for the second fire water supply system

Pumping station has two pumps (1 + 1 spare). In addition to these pumps, there are additional pumps in PS II, which are triggered when the pressure in the network drops. There are 2 (1+1 spare) pumps. There are shut-off valves on each discharge pipe from each pump, the two discharges are connected to each other via shut-off valves and 2 air compensators on the supply pipe. The standby fire pump starts automatically (within 20 s after the command is given) in case of a failure of the selected operating pump. Simultaneous operation of both pumps is not considered.

Pumping unit with diesel engine

It is designed to supply water to the first FES of outdoor oil transformers, FES of TG oil tanks, water curtain). If necessary, this unit can also be used to supply the second system (supplying fire water to both indoor hydrants and outdoor fire hydrants for all MO3&4 NPP facilities). For this purpose, it is necessary to open the valves on the interconnecting pipe.

ESW pumping station

There are 3 (1 + 2 spare) fire water pumps installed in the ESW pumping station, each with a separate discharge to the II. RB. The importance of the supply to the pumps is Category II. One fire water pump is designed to provide 100 % of the fire water demand. The other two pumps work as automatic backup in case of insufficient pressure after a signal from the FDPS to start the working pump. After approx. 20 seconds, the 1st standby pump starts and in case of continued insufficient pressure after approx. 40 seconds, the 2nd standby pump starts. Pumps start automatically after FDPS alarm, manually from the Unit control room and ESW PS. After the extinguishing of the fire compartment is finished, the fire pump can be shut down manually from the Unit CR and ESW PS.

The system is permanently pressurised (1+2) by make-up water pumps. These pumps start up when the pressure in the system drops. In case of fire pump operation, their operation is blocked. The water source is the ESW circuit – the pools of the ESW PS and the pools of the natural draft towers.

Fire water distribution is provided by three steel pipes, routed underground in seismic-resistant ducts together with the ESW pipes. The pipelines are interconnected by a collector and in II. RB are routed as a pair. From here the branches are led to the FES switchboards in II. RB. A pair of DN 250 pipelines is connected to the FES pipelines of the seismically non-resistant areas by two pipelines, secured with isolation valves and check valves, so that the flow from the seismically non-resistant side to the seismically resistant part of the II. RB is ensured.

A water supply is created on each ESW system to serve the operation of the ESW or fire water in the event that water cannot be replenished from the main feeder. The supply is made up of the volume of water in the natural draft cooling tower pools, the supply pipe from the natural draft cooling tower to the ESW PS, and in the pump suction tanks.

Raw water for NPP EBO3&4 is secured from the water source Sĺňava Piešt'any. Fire water is provided from a single system that is looped within the site and is fed from a circulating cooling water source. The fire water pumping station is located in the Central Pumping Station and consists of 4 main fire water pumps and 6 fire water booster pumps.

Fixed fire extinguishing equipment

A fixed fire-extinguishing system (FES) is a fire-extinguishing system comprising, in particular, a fixed source of extinguishing agent, a distribution pipe, a discharge valve, a triggering mechanism and a signalling device.

A protected space is a technological installation, space, room or building in which the discharge valves of a FES or a semi-fixed fire-extinguishing system are located.

Fixed fire extinguishing systems can be divided according to the area to be extinguished into:
- local – Local FESs are used in areas where it is possible to provide the required extinguishing concentration and early detection in a well-defined area. The advantage of local fixed extinguishing systems is the early identification of the threatened equipment or space and the rapid transport of the extinguishing agent to the threatened location,
- volumetric – Volumetric (flooding) FES are used in areas where it is necessary to use an effective extinguishing concentration for the entire protected area and it is not possible to ensure a thorough separation of technological equipment and even spatially separate the places with the highest fire load.

Fixed fire-extinguishing system (FES) must extinguish or bring the fire under control, signal their operation and perform an auxiliary function. The basic requirements for FESs are defined in Decree [10] and in the relevant technical standards. The FESs used in NPP MO3&4 were designed on the basis of the fire safety design of the structure (deterministic analysis) in locations with an increased fire risk or with a possible impact on nuclear safety and are as follows:
- FES in cable spaces – high-pressure water mist,
- FES for external transformers – flooding system,
- FES for TG oil tanks – foam extinguishing,
- FES for solid combustible RAW storage – gas extinguishing with CO_2,
- FES in MCP pumps room – gas extinguishing with FM200,
- FES with foam for DG station – foam based extinguishing,
- water curtain in longitudinal intermediate electrical building – cooling facility.

For the mobile DG, local gas extinguishing is used.

The FES systems were properly tested before commissioning in accordance with the requirements of national legislation [10]. The tests were carried out with real extinguishing agent (except for gas FES) in the presence of representatives of supervisory authorities (Regional FaRC Headquarters Nitra and NRA SR). Subsequently, since the commissioning of the FES, regular inspections are carried out within the scope provided for in the MoI SR Decree No. 169/2006 [10].

According to national legislation [7] it is obligatory to equip every fire compartment with portable or mobile fire extinguishers. The quantity of extinguishing agent is determined on the basis of a national standard and is independent of the existence of fixed extinguishing systems, the need for which is proposed independently based on different criteria laid down in the Decree [7].

Mist fixed fire extinguishing system

A water mist FES is installed at the MO3&4 NPP to protect the cable spaces in the transverse electrical building, longitudinal intermediate electrical building, turbine hall and the reactor building. The FES consists of two pumping stations, manifold valves and two manifolds with open (drencher) type discharge nozzles. There are two independent FESs:

- water mist FES seismically resistant,
- water mist FES seismically non-resistant.

Both FES systems (seismic-resistant and non-seismic-resistant) are fed by demi-water supplied from the NPP distribution network for the demi-water to ensure high purity of the medium and to prevent clogging of the nozzles. In an emergency, water supplied by the essential service water system can be used, but only for the seismic-resistant water mist FESs.

For both water mist FESs it is also possible to refill the tanks from the intervention mobile equipment of the PFB, which can be connected to the demi-water distribution system.

Each FES is rated for 30 minutes of operation without the need to replenish water in relation to the fire compartment with the highest water demand.

Each FES water mist pumping station contains four high-pressure piston-type servo-driven fire pumps, three main fire pumps and one back-up fire pump.

The seismic-resistant water mist FES is located in the longitudinal electrical building and consists of:

- 2×50 % demi water storage tanks at atmospheric pressure with a 30-minute extinguishing supply for the fire compartment with the highest water demand, without the need for water replenishment,
- 4×33 % high-pressure fire pump, electrical piston pumps (one pump is a backup pump), designed to supply the required flow of demi-water to extinguish the fire in the fire compartment with the highest water demand.
- one 1.5 MPa rotary-type make-up pump; protected from the high-pressure side by a relief valve, the make-up pump keeps the main manifold between the high-pressure fire pumps and the control discharge valves "pressurised". This pump does not perform a safety function and does not affect the reliability of the water mist FES. The pressurizer installed at the discharge of this pump is intended to control its start-up and shutdown and to regulate the pressure in the distribution line,
- interconnecting piping between storage tanks with demi-water and high-pressure fire pumps,
- the main manifold at the discharge of the high-pressure fire pumps is supplemented by safety pressure relief valves and a pressure compensation device designed to prevent pressure pulsation,
- return water distributor - after the safety pressure relief valves where the demi-water will be released in case of overpressure in the main distributor,
- control panel,
- electrical switchboard,

- control drain valves in the reactor building,
- quick-acting valves (QAV) – electric and pneumatic ones, are installed at the interface of the FES piping transition to the hermetic zone. The electric QAV is installed before the entrance to the hermetic zone, the pneumatic QAV after the entrance. The above QAVs are classified in safety class SC II.

Seismically non-resistant water mist FES protects selected areas (cable ducts) in the TG turbine hall and in the longitudinal intermediate electrical building.

The FES engine room is located in an extension to the TG turbine hall and has a similar composition to the seismic-resistant water mist system.

Both FES systems based on water mist are designed in compliance with international and national standards and regulations binding for design [40] and [41]. Demonstration of the water consumption and technological parameters of the FES, i.e. the required pressure and flow rate at the nozzles for each protected space and the nozzle placement in the space in accordance with the standard [40], with the results of the fire tests for water mist [87] and in accordance with the hydraulic calculation. The individual components of the FES are shown to comply with the Act [18].

Demi-water is used as the main source of water for the FES. As an emergency water source it can be used:
- essential service water (seismic category 1a),
- water from the fire engine.

The FES wiring is pulled in accordance with the principles of cabling separation.

The FES engine rooms are located in separate fire compartments. These fire compartments serve only as FES engine room.

The FES based on high-pressure water mist does not consume large quantities of water and is therefore not a source of consequential damage. Nevertheless, the protected areas are equipped with a drainage system and any water collected is thus drained.

In the case of the mist FES, a full-scale validation test was performed simulating real installation conditions with various non-standard layout constraints compared to certification testing. The test tested different scenarios in a conservative approach and validated the design assumptions with a significant margin. This demonstrated the strengths of the design by applying appropriate cabling, but also the effectiveness of the fire extinguishing system.

At NPP EBO3&4 and NPP MO1&2, the cable compartments in the transverse intermediate electrical building, the longitudinal intermediate electrical building, the turbine hall and the reactor building are protected by a fixed sprinkler system that uses water as a fire extinguishing agent.

Fire Extinguishing Equipment of External Transformers

The transformer flood FES provides fire protection for the external oil transformers of NPP EBO3&4, MO1&2 and MO3&4 against possible transformer oil fire in case of oil leakage. It protects equipment that is not classified and partly together with the spacing distance prevents the transfer of fire from the external transformers to the TG turbine hall building. Flooding FES consists of:
- flood valve station for each protected transformer,
- discharge nozzles,

- detection sprinklers,
- the FES control room is common to all flood FESs for transformers.

The source of water for the FES is fire water, which is provided by pipelines from the NESW system.

The fire water pumps are located in the NESW PS building (described above). There are two electrically driven pumps (1+1) and one fire pump with DG.

Fire water is taken from the circulating cooling water system. The system is replenished via a pumping station, directly from the Veľké Kozmálovce water reservoir on the Hron River.

The water piping of each transformer is in the form of a separate loop located at the bottom around the transformer, to which rising distribution pipes are connected in which filters are installed at the head of the pipes to protect the drain nozzles from being clogged by possible water impurities. The rising pipes are horizontally connected by zinc-coated steel pipes at three elevation levels around the transformer to form a separate frame structure. These circuits are fitted with a specified number of discharge nozzles located around the transformer and catch basin. Some drain nozzles are also designed to extinguish the oil tank above the transformer.

The fire detection system is pneumatic and consists of a series of detection sprinklers connected to a pressurised air pipe. The pressurised air is supplied by a low-pressure NPP pressurised air distribution system via a supply pipe to each transformer. The air piping branch is divided into two separate piping sections, each equipped with sprinkler-type thermal detectors, two pressure switches, pressure gauges and check valves.

The flooding FES is in standby mode during the nominal operation of the NPP (nominal operation of the FES). The FES activation is possible:
- automatically based on the signal from FDPS,
- local manual start of FES from the panel,
- remote manual start via FDPS in HMI modules located at Unit Control Room, Emergency Control Room, Common Control Room and PFB,
- emergency manual start of the FES at the flooding station,
- automatic activation of the flooding FES for outdoor transformers by activating two pressure switches on the air detection circuit on the transformer.

Flooding FESs for transformers [88] are designed in accordance with the Regulation for drencher systems [42] and the MoI SR Decree [10].

The equipment protected by this FES is located outdoors and any false alarms or actual extinguishing does not cause consequential damage.

The demonstration of water consumption and technological parameters of the FES, i.e. the required pressure and flow rate at the nozzles for the individual protected spaces and the nozzle placement in the space in accordance with [42] are in the hydraulic calculation. The individual components of the FES are demonstrated to be in conformity in accordance with [18].

TG oil tank extinguishing equipment

Foam FES of TG oil tanks [89] are installed to provide fire protection for the lubricating oil tanks of the turbo-generators, which are located in the TG turbine hall building. Each TG oil tank is protected by a separate foam FES.

The foam FES of TG oil tanks consists of:

- foaming agent container,
- foam-booster,
- drain valve,
- shut-off valve,
- solenoid valve,
- filters,
- drain nozzles,
- control panel,
- local panels,
- audible and light warning signals,
- STOP buttons.

The foam FES of the TG oil tanks is in automatic standby mode during nominal operation of the unit (nominal operation of the FES).
Activation of the FES is possible by:

- automatic start (initialization from FDPS – logic selection two of two independent fire loops),
- local manual start of the FES from the panel,
- remote manual start via FDPS in HMI modules located at Unit Control Room, Emergency Control Room, Common Control Room and PFB,
- emergency start of the FES at the control discharge valve.

During normal operation of the unit, all piping downstream of the discharge valves is empty, while the main fire water distribution system in the engine hall is under constant pressure. The discharge valves for each TG are located at two different locations and are connected to the foaming agent dispenser. The foam from the storage tank is supplied to the foam dispenser via a pipe which comes out of the AFFF foaming agent tank.

The TG lubricating oil tank fire detection system is part of the FDPS system.

When the drain valve is opened by the solenoid, the pressure in the drain valve chamber drops and the water passes into the pipe with the foam drain nozzles. The flow of water after the discharge valve leads to the activation of the foaming agent mixer and to the suction of foaming agent from the tank, thus ensuring a constant 3 % foaming agent mixing, while this foaming agent dosage is not affected by different back pressure, pipe length, viscosity or changes in the volumetric water flow rate.

The water for extinguishing is passed through a "water motor" using the pressure difference to create a linear flow for activating the foaming agent admixture pump. The admixture pump takes the foaming agent from the tank and feeds it - injecting it into the driven water intended for extinguishing.

The admixture pump is driven by water flow; if there is no water flow (standby mode), the foaming agent will not be delivered to the discharge nozzles (no suction from the atmospheric foaming agent tank).

The piping of the FES system for TG lubricating oil tanks is arranged in two circles, one above the other. At the beginning of each circuit, diameter filters are installed to protect the drain nozzles from impurities in the water. The extinguishing circuits are equipped with the number of discharge nozzles specified by the design, arranged around the oil tank. The drain nozzles, like the foam generator, are designed with air suction for foam generation.

The need for fire water is provided by pipelines from the non-essential service water system (NESW).

Protected areas are equipped with a drainage system and its false actuation or extinguishing alone will not cause consequential damage.

The FES was designed in compliance with international and national standards and regulations [43] and [10] binding for the design. Demonstration of water consumption and technological parameters of the FES, i.e. the required pressure and flow rate at the nozzles for the individual protected spaces and nozzle placement in the space in accordance with [43], are in the hydraulic calculation. The individual components of the FES are demonstrated to be in conformity in accordance with [18].

Fixed CO_2 extinguishing system for RAW storage

Fixed gas fire extinguishing system FES-CO_2 [90] is installed in the Auxiliary Services Building and is used to extinguish the following rooms:

- stock of filters for the ventilation system (activated carbon filters),
- storage of solid RAW after treatment and before transport to the Bohunice RAW Treatment Centre for final conditioning,
- storage of sorted non-radioactive waste,
- storage of active oils prior to their removal for final conditioning.

The FES-CO_2 is a gas-operated fixed volume extinguishing system [81] consisting of:

- extinguishing agent source - cylinders,
- a distribution pipe,
- a discharge valve,
- a trigger mechanism,
- a signalling device.

CO_2 is used as a source of extinguishing agent, which complies with the requirements of STN EN ISO 5923 and is located in the FES-CO_2 engine room. The FES-CO_2 engine room is located in a room in the Auxiliary Plant Building and is housed in:

- standby cylinder set,
- a spare set of cylinders,
- pilot cylinders with N2 filling,
- an optical device to measure the weight loss of the set,
- electric trigger valves,
- pressure sensors,
- manifold,
- mechanical deactivation valves with position sensors,
- electrical switchboard,
- control panel 1,
- odorizer.

The four branches of the discharge pipe are routed above the protected area and then the individual pipes enter the corresponding protected area where they split into many more branches leading to the CO_2 discharge nozzles. The FES-CO_2 system is operated:

- in an automatic mode – standby status (starting from FDPS signal by selecting 2/2 fire detectors),
- manual mode.

The FES-CO_2 system may be operated in manual mode only for the time necessary for repairs, maintenance or when people are present in the protected areas and adjacent areas.

Starting the FES can be done automatically or manually via the drain valve. Subsequently, there is a release of N2 from the pilot cylinder and a gradual release of CO_2 via pneumatic connections and valves from all standby cylinders. Due to the possible presence of a person in or near the protected area (maintenance or any other reason), two mechanical shut-off (deactivation) units will be available.

The gas released into the protected areas from this FES will be vented through a standard ventilation system and no consequential damage will occur.

The FES-CO_2 was designed in compliance with international and national standards and regulations [10] and standard [44] binding for design. The demonstration of the extinguishing agent (CO_2) consumption and technological parameters of the FES, i.e. the required pressure and flow rate at the nozzles for the individual protected spaces and the nozzle placement in the space in accordance with [44] are in the hydraulic calculation. The individual components of the FES are demonstrated by conformity in accordance with [18].

FES in the room of the main circulating water pump

The fixed gas extinguishing system with extinguishing agent FM200 (hereinafter referred to as FES-FM200) is installed in the reactor building of both NPP MO3&4 and NPP EBO3&4 and is used for volume extinguishing of the main circulation pump room. The FES-FM200 is a gas-based fixed volume extinguishing system consisting of:

- source of the extinguishing agent – cylinders placed in 5 sets,
- distribution piping,
- draining valve,
- triggering mechanism,
- signalling device.

The FES-FM200 is designed in accordance with standards [45] and [46]. The extinguishing is triggered simultaneously from all 5 sets. HFC 227ea gas (trade name FM200), chemical name heptafluoro-propane (C3HF7), is used as the source of extinguishing agent. The extinguishing agent is contained in ten cylinders which are divided into five identical sets. The FES-FM200 [80] system is operated in:

- automatic mode – standby status (starting from FDPS signal by selecting 2/2 fire detectors),
- manual mode.

The FES-FM200 system can only be operated in manual mode for the time necessary for repairs, maintenance, during hermetic zone testing or when people are present in the protected area. The FES-FM200 starts automatically from the FDPS alarm "FIRE" (selecting two detectors from the detector group). After initialization, the extinguishing agent of all sets is released simultaneously.

Electrical switching relays are installed in the control panel of the FES system and in case of a "FIRE" alarm, they operate the respective quick release valves. The FM200 extinguishing agent is then released through the manifold to the open discharge nozzles. Pressure sensors signal the flow of extinguishing agent through the manifold (this is only pressurised during extinguishing agent discharge).

A small amount of extinguishing agent is discharged through the interconnecting pipe between the individual cylinders and this is used to operate the pneumatic valve (relay) which opens the second quick release valves and so the FM200 extinguishing agent is discharged from the cylinders into the pipework and finally into the open discharge nozzles. Pressure sensors signal the flow of extinguishing agent through the manifold (this is only pressurised during extinguishing agent discharge).

Cylinder pressure sensors are used to generate an ALARM signal if the cylinder pressure drops below a pre-set level (fault condition). Interruption of extinguishing is possible from deactivation pushbuttons located before entering the protected room.

The gas released into the protected areas from this FES will be vented through a standard ventilation system and no consequential damage will occur.

The FES-FM200 is designed in compliance with international and national design standards and decrees [10], [45] and [46]. The demonstration of the extinguishing agent consumption (FM200) and the technological parameters of the FES, i.e. the required pressure and flow rate at the nozzles for the individual protected compartments and the nozzle placement in the compartment in accordance with [45] and [46] are in the hydraulic calculation. The individual components of the FES are demonstrated to be in conformity, in accordance with [18].

At MO1&2 NPP, the main circulation pump room is protected against fire by a fixed sprinkler system that uses water as an extinguishing agent.

Foam FES for the DG station

The foam FES for the DG station is used for protection of individual rooms of the DG station at NPP MO3&4 and EBO3&4, where there is a higher fire hazard mainly due to the presence of flammable liquids. The foam FES for the DG station consists of the following main components:

- the foaming agent container,
- mixer,
- light foam generator,
- drain nozzle - type FI-MEn 45,
- alarm siren,
- FES control panel,
- electrical switchboard for FES power supply for electrical valves.

Foaming agent container
- vertical tank, filled with AFFF foam concentrate. The tank is at atmospheric pressure during refilling which is designed using a mobile tank and a hand pump.

Mixer
the ad-mixer works proportionally. This means that 2 % of the foaming agent is mixed into the pressurized water stream passing through the calibrated inlet.

Source of water for the FES
The water source is located in the Essential Service Water and System Fire Water Pump Station of II. RB. The foam FES for the DGS is the only one that uses fire water from the ESW system, except that

this water can also be used to replenish the tanks for the high-pressure mist FESs (seismic-resistant) for Units 3&4 of the MO3&4 NPP. In addition, for this fire water supply, non-essential service water can also be used. It can be used to supply the foam FES for the emergency DG; a valve in the piping channel makes this possible. The water supply covers the maximum water volume as required by the FES for the DG station.

Foam generated in the fire truck can be used as a source of extinguishing agent. The fire truck can be connected to the connection point by means of a coupling and manual manipulation - by opening the valve (appropriate for the fire-fighting section).

The machine part of the FES includes a machine room and distribution pipes ending with foam generators for light foam and discharge nozzles for medium foam. The foam solution is prepared in the FES engine room and starts to form only when the FES is started to extinguish. The manifold delivers the foam solution to the foam generators and discharge nozzles. The electrical part of the FES and the automation provide control and start-up of the FES, also transmitting signals on the FES status to the FDPS. This system activates and monitors the position of the electric valves via the control panel.

Discharge nozzles forming light foam and medium foam.
The manifold is connected to sectional valves (actuated by a servo drive) for space protection. When foam FES fire extinguishing is activated, only one sectional valve is open and the others are electrically blocked. The standby air pressure in the manifold is atmospheric. In the event of a fire, i.e. after activation of the FES, the pressurized water passes through the foam solution mixer and the foam solution tank. The operating time of the foam FES is 30 minutes for light foam and 60 minutes for medium foam.

During nominal operation of the unit, the foam FES for the DG station is in standby status in automatic mode (nominal FES operation). Activation of the FES is possible:

- automatic start,
- local manual start of FES from the engine room,
- remote manual start from the Unit Control Room,
- emergency manual start of FES on the control discharge valve,
- emergency fire-fighting from fire truck [92] Foam FES for DG station [93] is designed in accordance with [10]. METEOR P+ foam solution is used for extinguishing flammable liquids.

After activation of the extinguishing system, the water is led under pressure to the dosing unit and into the foam solution tank. The water generates an overpressure which forces the foam solution out of the tank through the mixing chamber of the mixer, where the extinguishing water and the foam solution are actually mixed to produce a concentrate with the required 2 % of foam solution.

The water with the foam solution from the mixer goes through the pipeline to the foam generators, where it mixes with the air to form foam.

The foam FES for the DG station was designed in compliance with international and national design standards and regulations [10] and [43]. The demonstration of the extinguishing agent consumption and technological parameters of the FES, i.e. the required pressure and flow rate at the nozzles for the individual protected compartments and the nozzle arrangement in the compartment in accordance with [43], are in the hydraulic calculation. The individual components of the FES are demonstrated by compliance in accordance with Act No. 133/2013 Coll. [18] and documented in the ATD.

At NPP MO1&2, the DG station is protected against fire by a fixed gas automatic fire extinguishing system.

Water curtain between the longitudinal intermediate electrical building and a common TG turbine hall

The water curtain at the boundary of the civil structures between the TG turbine hall and the longitudinal intermediate electrical building protects the openings in the fire separation structure (wall) by cooling them down. The system is installed at NPP MO3&4 and EBO3&4.

The supply water piping is led through a pipe branch from the main fire water distribution system with pressure gauge, filter and shut-off valves.

In the event of a fire, the heat generated by the fire will open one or more automatic discharge valves equipped with a thermal fuse, allowing the subsequent flow of fire water to the discharge nozzles at the respective openings.

The need for fire water is provided by pipelines from the non-essential service water system (NESW).

The water curtain is in automatic standby mode during nominal operation of the unit. Activation of the FES is possible:
- automatic start – reaching temperature of +141 °C,
- local manual start (all nozzles are started at the same time).

NPP EBO3&4 and NPP MO1&2 are equipped with fixed fire extinguishing systems in similar areas as at NPP MO3&4. It is therefore a fire extinguishing of:
- cable spaces,
- outdoor transformers,
- diesel generators and diesel generator for severe accidents,
- oil systems (turbo-generator, oil systems of primary circuit),
- solid RAW storage facility,
- other equipment (e.g. Server room).

Facilities for the removal of heat and combustion products

The facility for removal of heat and combustion products for the TG turbine hall is used for:
- maintaining a layer of warm combustion products and smoke at a predetermined height above the floor or maintaining a smokeless layer above the floor at a height necessary for the evacuation of persons and for intervention,
- correcting the temperature of the hot gas layer under the roof or ceiling of the building in such a way as to prevent, or at least additionally prevent, damage and collapse of the structure of the building as a result of exceeding the critical temperatures of the materials,
- enabling the identification of a fire source and safe access to it in a smoke-filled area,
- reducing the extent of damage caused by the direct effect of heat and smoke and the indirect effect of inaccurate extinguishing in a smoke-filled area,
- reducing the risk of fire transfer to adjacent fire compartments,
- reducing the risk of fire transfer due to hot gases to the roof shell of the building, in which it is installed,
- reducing the temperature below 300 °C at higher heights, thus reducing the risk of the roof structure collapsing.
  Note: In accordance with [95], [96] and [97], the maximal design temperature of the smoke layer under the roof structure shall be lower than 100 °C.

The main principle of the heat and combustion products extraction system (HCPE) and day ventilation is the stack effect principle, where smoke/warm air rises and exits through the ventilation dampers in the skylight and fresh air is brought in through the inlet openings of the aeration duct. Electrically operated shutter flaps are used as intake and exhaust flaps. The main elements of the HCPE system of the turbine hall of NPP MO3&4 are:

- smoke barriers,
- shutter flaps to remove the products of combustion and heat – FLW SmoTec
- blind flaps for fresh air supply – FLW SmoTec,
- control units and control panels that operate the HCPE system and communicate with other fire safety systems (FDPS and DCS).

Smoke barriers

Smoke barriers are used to separate the individual smoke sections of Units 3&4 of the Mochovce NPP. They are made of a special fire-resistant fabric (KlevoGlass 330). Smoke barriers meet the D30 classification according to EN12101-1.

Openings for the removal of products of combustion and heat

These openings are formed by electromotive (LDF 100/060) controlled FLW SmoTec blind dampers. These blind dampers are equipped with 5 horizontal blades that rotate along their horizontal axis.

Openings for fresh air intake

These openings consist of electrically operated FLW SmoTec blind dampers. These blind dampers are equipped with 5 horizontal blades that rotate along their horizontal axis.

During normal operation of the MO3&4 NPP turbine hall, the HCPE system serves as a ventilation device to create the required temperature conditions in the TG turbine hall building. In the event of a fire where HCPE system needs to be used, HCPE system is ready for programmed opening or closing of windows in the vented smoke sections. Control of the opening of the supply air vents in one smoke section is provided by a central control panel connected to the FDPS system, allowing also manual control of the device.

The HCPE system for the natural outlet is designed in a similar manner to the system designed for the part of the turbine hall belonging to the MO1&2 NPP. Fresh air flows through openings located along the arresting channel along the entire turbine hall building. The openings are fitted with certified dampers designed for smoke and heat extraction, opened by electric linear motors. The windows provide air supply during a fire, these are open at the same time during HCPE system operation. The same windows are also used for heat and combustion exhaust. They are located at roof level in the skylight and are in a closed state. These windows are connected by a lever mechanism in fours and all the windows are opened at the same time, lined up in one lever mechanism. An electric linear drive is used for opening.

The installation of the HCPE system ensures that the boundary area of the fire section of the engine room is reduced, the temperature at higher heights is reduced, thereby reducing the risk of collapse of the roof structure and, in conjunction with the water curtain, ensures that a large fire is prevented from spreading between the turbine hall and the longitudinal electrical building where equipment relevant to nuclear safety is located.

The HCPE system was designed in compliance with international and national standards and regulations binding for design. The components of the HCPE system are proven to comply with the requirements of Decree No. 558/2009 [20] and the relevant technical standards [52].

The HCPE system for NPP EBO3&4 is designed and installed similarly to the one for the part of the turbine hall belonging to NPP MO1&2.

3.2.1.2.3 Management of adverse effects and consequent risks

The design of the FES also took into account the potential consequences of false FES alarm and the risk of consequential damage. All FESs are designed in such protected areas that substantial consequential damage will not be caused by the operation of the FES. This is mainly due to:

- secured drainage of used media through the existing drainage of protected areas,
- FES generates a small amount of extinguishing agent for effective fire suppression,
- the premises are equipped with standard ventilation.

At the design stage, a potential negative impact of the foam FES in the DG station building on nuclear safety was identified in relation to possible false alarm and consequent impact on the correct operation of the DG. The risk resulted from the possibility of interruption of the DG function after the foam generated by the foam FES was sucked in, based on a false automatic activation of the FES by the FDPS system and the subsequent need to start the DG. This would potentially compromise the safety function of the DG in accordance with the NRA SR Decree No. 430/2011 [2].

After a detailed analysis, the method of activation of the FES was changed so that the firefighting section of the engine room of the DG, i.e. where the DG is located, will be activated only manually and also the possibility of manual activation from the unit control room will be abolished. In this case the role of the PFB is important, which is located near the DG station, the range of the PFB is up to 5 minutes and after verification of the situation the FES will be activated manually. The fire suppression delay is negligible in this case. This solution eliminates the potential negative impact of the FES on nuclear safety and at the same time the fire safety of the building is maintained.

Accidental activation of the FES system does not have a significant negative impact on the structure, technology nor does it significantly endanger the personnel.

Another factor in the selection of a suitable extinguishing system and the medium used are ecological aspects. They were particularly applied to the choice of extinguishing agent in the case of gas FES, which is intended to extinguish the room with the main circulation pumps. The choice of extinguishing agent had to comply with EU Regulation 517/2014/EU on greenhouse gases.

Ecological aspects were also taken into account in the case of the use of foaming agent for foam FESs to ensure its biodegradability.

The products of combustion mixed with the extinguishing agent are discharged into the sewage system and subsequently treated in the wastewater treatment plant. Gas-based extinguishing systems mixed with combustion products will be vented through standard air ventilation systems.

3.2.1.2.4 Alternative/temporary measures

The fire-technical equipment (FTE) shutdown is required for a variety of reasons, whether it is hot work, PTZ maintenance, or it may also be a malfunction of the system itself.

If it is necessary to switch off the FES from the automatic mode, the procedure according to the methodological instruction [100] shall be followed by issuing the corresponding PO-order.

If there is a request in the PO-Order for switching the FES from automatic mode, the works supervisor is obliged to report the start of the work and ask the reactor unit supervisor (RUS) to switch the fire sections of the FES to manual mode, and the RUS informs the fire reporting room of the PFB about this fact.

During works based on PO-order, the works supervisor is responsible for continuous monitoring of the area protected by switched-off FDPS and FES systems from the moment of reporting the commencement of the works until the interruption or completion of the works is reported to the PFB fire reporting room.

In order to determine the appropriate conditions and measures in terms of fire safety, the FP technician may request additional documentation from the issuer (e.g. technological procedure, etc.). The PO technician shall include in the PO-order a requirement for the establishment of a fire assistance patrol. The request for the establishment of a fire assistance patrol from the staff of the PFB must be stated in the measures. The FP technician shall also determine the provision of fire-technical equipment for the fire assistance patrol. Once the mandatory data have been filled in, the FP technician sends the PO-order to the next status - to the fire reporting room of the PFB.

As part of the design of the mist FES, a full-scale test simulating realistic conditions with and without extinguishing was performed. The test showed that due to the cables used and their properties, the risk of fire spread in the cable compartments is very limited and self-extinguishment occurs in a relatively short time even without FES operation. This validated behaviour of the cabling under fire conditions creates a prerequisite for a possible reduction of alternative measures, which are nevertheless set as standard.

Failure of the FES or FDPS is also addressed in the Limits & Conditions for Safe Operation [124], where their operability is assumed in terms of legislation [6], [10], [16] and [11]. In the event that these FTEs are not operable, the Limits & Conditions instruct that corrective action be taken immediately, in particular by physically inspecting the premises at specified intervals and taking effective measures to prevent the start and spread of fire.

All NPP premises are equipped with portable or mobile fire extinguishers in accordance with the FSB solution, which can be used immediately upon spotting a fire by the personnel and until the arrival of the PFB.

3.2.1.3 Administrative and organisational issues of fire protection

3.2.1.3.1 Overview of the fire-fighting strategy, administrative and security measures

The fire protection strategy is based on a staged NPP quality assurance programme for trial run and for operation [115]. This document describes the NPP management system, covers all items/equipment, NPP systems from a safety perspective, all activities/processes that affect the quality of these items and the security of the NPP and are therefore subject to the integrated management system.

The programme also includes Fire Protection Management, where it sets out the principles, management procedures and control activities in the field of fire protection so that the conditions are created on the basis of fire prevention and the activities of the PFB for:

- effective protection of the life and health of employees, property and the environment from fires,
- providing assistance in the event of adverse events, operational incidents and other emergencies at the NPP site.

The NPP Quality Assurance Staged Programme [115] also discusses the safety culture that:

- requires a proactive approach to safety from all employees of the NPPs and also from all employees of the contractors, and an understanding and ownership of the commitments, policies and objectives announced by the NPPs management of the SE, a.s.,
- requires both NPP employees and their contractors to apply the principles of safety culture in their work,
- supports individuals and teams to perform their tasks in a safely and successfully at all times, taking into account the interactions between individuals, technology and the organisation.

The whole process of applying the principles of safety culture is described in a separate procedure [126].

Document [115] sets out the key objectives, which are:

- to minimise the risk of fire through preventive action,
- to detect and extinguish fires as quickly as possible to minimise damage,
- to prevent the spread of fires that could not be extinguished in time and to minimise their impact on the safety functions of the nuclear installation, property, health and lives of personnel.

The phased programme is followed by a procedural directive [98], which is the basic document in the field of fire protection (FP). The directive contains a strategy for the approach to FP and discusses the procedures, responsibilities and authorities in the FP process. This document is elaborated in more detail for the conditions of NPP MO1&2 and NPP MO3&4 in the guide [114].

Document [114] describes the following:

- organizational arrangement of fire protection in SE, a.s.,
- the duties of the statutory body, other managers and other employees to ensure fire protection in SE, a.s,
- the basic requirements and the fire protection concept, which includes:
  - prevention,
  - passive means,
  - active means,
  - Plant Fire Brigade,
- Fire alarm drill,
- fire protection:
  - during non-working hours,
  - during activities with a higher risk of fire,
  - in places of increased fire hazard,
  - at events attended by a larger number of people,
  - protecting the forest from fires,
- control activity:
  - preventive fire patrols,
  - operation and inspection of technical equipment,
- operation of fire equipment,
- principles of fire safety,
- fire protection training,
- training of fire patrols,
- fire reporting,
- evaluation of the state of the FP,
- FP documentation,

- fire reporting room,
- a list of buildings and an overview of locations with an increased fire risk,
- a list of buildings with simple conditions in terms of evacuation of persons and other requirements for fire safety,
- fire precautions.

The FP documentation covers the following types of documents:
- fire identification card,
- fire regulations for the workplace,
- fire alarm guidelines,
- fire log book,
- fire evacuation plans,
- fire hazard analysis,
- evidence of inspection of fire-fighting equipment in accordance with specific decrees,
- data on fires, causes of fires, reports on the results of analyses and on the measures taken in the FP section,
- documentation of staff training on FP,
- documentation on training of fire patrols,
- documentation on the activities of the firefighting unit,
- the fire safety solution of the building from the design documentation,
- other documents, if provided for in a special regulation for FP,
  - inspections and testing of FDPS,
  - inspections and testing of FES,
  - inspections and testing, inspection of the electrical wiring,
  - stacks and smoke-flues,
  - FE-36 gas extinguishing,
  - inspections and testing of classified technical equipment,
  - operating logs and operating books of PZ – at PZ managers,
  - documents on the inspection of PZ and firewater distribution systems.

Managers and supervisors are obliged to apply the principles of fire protection in the management of SE-EMO units, which are defined in the procedural documentation of fire protection management and in the operational documentation.

The FP management acts of the company´s management, such as setting objectives, action plans, expectations and priorities, enable decisions to be made, actions to be taken and changes to be implemented that contribute to the safe and reliable operation of the plant. These acts are communicated across the plant structure.

Control activities at all levels of management ensure supervision of compliance with legislation in the field of fire protection and internal regulations of SE in connection with the performance of work by employees of SE or in the control of contractors in the process of performance of works and services according to contracts made with SE.

Managers and supervisors:
- monitor and observe employees to improve employee performance in fire protection. Observations are regularly evaluated by plant management and at the meetings with plant managers,
- communicate fire safety rules to employees, carry out walk-down inspections and supervise the performance of work in accordance with fire safety rules.

For example, in 2022, a total of 947 walk-down inspections were carried out at MO1&2 NPP and MO3&4 NPP Unit 3, during which 533 deficiencies were identified (the walk-down includes, in addition to fire prevention inspections, also other aspects e.g. cleanliness of the premises, leakages, etc.), which were subsequently rectified.

Employees and management staff lead their colleagues and subordinate staff to comply with fire safety rules in accordance with the principles of safety culture. Providing feedback to colleagues, co-workers and subordinates is encouraged by the management.

Education and training

- The rules for initial and periodic training at Mochovce NPP are defined in the management documentation [98] and also for EBO3&4. Training is organised by the NPP Personnel Training Unit. Periodic safety training to maintain the general competence of SE employees is conducted once every 24 months,
- staff receive periodic training to increase their knowledge, are kept informed of the status and are encouraged to report identified deficiencies and fire protection incidents, such as the status of:
    - fire barriers,
    - fire doors,
    - restrictions in certain areas in terms of fire load and volatile flammable materials.
- line managers, specialists and technicians are professionally trained and hold the appropriate certificates for the activity in question, demonstrating their expertise.
- the fire prevention programme and the coordination of the PFB activities is integrated in the safety unit.
- for each event and identified finding, near-miss and event, an NG notification is issued in SAP Nuclear. Analysis is performed based on the severity of the event.

Identified deficiencies are processed in the Correction and Prevention Program (CaPP), which follows the following scheme:
- identifying and reporting problems,
- examining and analysing the causes of problems,
- implementing corrective actions,
- evaluating corrective actions from event analysis, trending and coding.

Fire protection is evaluated by: the Independent Safety Assessment Unit, HSE and FP, a committee of employee representatives discusses the HSE status report, thus promoting and reinforcing the importance of fire safety for safe nuclear operations.

The FP training is carried out in accordance with the Fire Protection Act [6] and the Fire Prevention Decree [16]. The FP training is divided into:
- newly hired employees,
- employees – managers, supervisors and other employees,
- persons providing fire protection during non-working hours,
- persons who, with the knowledge of SE, stay in the buildings and premises of SE to: carry out activities for SE based on an agreement (contractor's personnel: construction/services/other activities) also employees-foreigners and students on internship,
- persons involved in activities with an increased fire hazard (e.g. welder, issuer of PO-order).

The FP training is conducted by the fire protection technician with the following periodicity for:

- SE employees and supervisors once every 24 months,
- persons providing FP during non-working hours, once every 12 months,
- contractor staff (construction/services/other activities) must be provided before the performance of activities – prior to commencement of work at SE,
- newly hired employees of SE receive initial training on FP on the day of starting the job,
- fire assistance patrols once every 12 months.

The scope of the training must be indicated in the training record. The aim of the training is to refresh the knowledge acquired in previous training and to add new information, regulations, procedures.

Organisational arrangements for increased fire hazard

For activities with an increased fire risk, the procedure is laid down in internal procedure [100]. A PO-order is issued for the job order, which lays down the measures for the safe performance of work with increased fire risk. Procedure [100] lays down the rules:

- the use of tools and protective equipment in work carried out in places where there is a risk of explosion or fire
- for the establishment of a permanent and temporary storage site for flammable materials. The authorisation of the establishment of the storage site shall be confirmed by the signature of the FP technician on the signpost temporary storage site for the material. This signpost shall serve as a marking of the temporary storage site and shall be placed in the vicinity of the site for the entire duration of the establishment of the temporary storage site.

Fire prevention

Fire protection checks are carried out daily by operational staff. Management staff carry out walk-down checks. FP technicians perform scheduled fire prevention inspections and random fire protection inspections. FP inspections at Mochovce NPP:

- preventive fire safety inspections by the FP technician,
- inspections during general outages (GO) of Units,
- checks by the managerial staff,
- inspections by other staff (a routine check before leaving the workplace,
- checks required by law, etc.),
- checks and inspections by the SE headquarters, OHS Unit,
- audits by the staff of SE,
- NOS,
- audits by external auditor,
- inspections provided for by law (e.g. fire protection equipment, fire-extinguishing equipment, electrical equipment, etc., are carried out by persons with professional competence, authorized, designated persons),
- inspections in the framework of state fire safety oversight,
- controls and inspections by external organizations.

Fire Prevention Service personnel perform preventive fire inspections in all civil structures. The findings of the inspections are recorded via the SAP Nuclear in a 'fire log book' which is submitted quarterly to the Plant Manager for approval. The content of the preventive fire inspections is mainly to check compliance with fire protection regulations in the area of:

- comparison of the actual situation with the fire protection documentation,
- construction design of buildings,

- production, storage and handling of flammable materials,
- ensuring the functionality of fire protection and fire-fighting equipment, fire water supply systems and water sources for fire extinguishing,
- operation and condition of technical and process equipment,
- the marking of workplaces and premises with safety markings.

Management staff carry out walk-down inspections, which include checks on fire protection. Control activities at all levels of management ensure compliance with the applicable legislation in the area of fire protection and the internal procedures of SE in relation to:

- performance of works by SE staff,
- inspection of contractor work and services pursuant to contracts concluded with the SE.

The aim of the control is prevention, i.e. to verify compliance with fire protection requirements and thus prevent an undesirable event. During the control activity, attention is focused on potential hazards that could be a source of threat and could cause the occurrence of an adverse event.

For example, in 2022, a total of 465 preventive fire inspections were conducted at NPP MO1&2 and NPP MO3&4 Unit 3, identifying 196 deficiencies, which were subsequently rectified.

Places with an increased fire hazard

For places with an increased fire hazard, workplace fire regulations are developed, which contain a description and characteristics of workplaces and set out the measures required to prevent fire and spread of fire.

For areas where flammable liquids and flammable gases are stored, Workplace Fire Regulations (places with increased fire risk) are elaborated, which contain basic and specific requirements for eliminating the possibility of fire ignition and spread. These areas are regularly monitored.

Regulation is in place for:

- introduction of flammable liquids and flammable gases into the monitored NPP process areas. The entry shall be approved by the FP technician. Information on the approved introduction of flammable materials is also sent to the PFB.
- temporary storage sites for flammable materials. The permission to establish a storage site shall be confirmed by the FP technician's signature on the temporary storage site sign. This sign serves as a designation of the temporary storage site and must be placed close to the site for the entire duration of the temporary storage site.

In the Mochovce NPP premises there are storage facilities for flammable materials (liquids and gases). The storage facilities are built in accordance with the legal requirements of the Slovak Republic. The change of the design of the construction and the change of the use of the construction is commented by the FP technician or the design of the fire safety solution of the building is updated.

Flammable materials are generally inspected by staff, the Safety Unit, and during management staff walk-downs. Findings are reported to the responsible staff and through NG-notifications. Findings are remediated as a matter of priority.

In places of increased fire hazard, a workplace fire patrol is established. Members of the workplace fire patrol shall undergo workplace fire patrol training once every 12 months.

Activities with an increased fire hazard

The plant manager issues the instruction and the FP technician issues the fire prevention actions to ensure protection in activities with increased fire hazards [114]. The activities associated with increased fire hazards at MO1&2 and MO3&4 NPPs are mainly:

- operation, shutdown and start-up of production in technological equipment containing flammable materials,
- maintenance and repairs of technical and process equipment containing flammable materials and the removal of their failure conditions.

For activities with increased fire hazard (e.g. welding, cutting, grinding, gluing of flammable floor coverings), a system of PO-orders is in place, in which conditions and measures in terms of fire safety are set for the given activity - by the asset manager, the fire section manager and the FP technician. The PO-order is issued for the job order in SAP Nuclear. The PO-order sets out the requirements for the provision of fire precautions. For high-risk work, the assistance of the PFB is requested.

For activities with an increased risk of fire:

- which are not regulated in terms of fire protection by special regulations of the Slovak Republic, an "Instruction of the Plant Manager" is issued to ensure fire protection in the performance of these activities,
- training is provided on fire safety conditions for persons involved in activities with a higher fire hazard. The training shall be provided every 24 months, as part of the periodic safety training,
- training of members of fire prevention assistance patrols is carried out. This training is provided every 12 months,
- regime of use of electrical, thermal and fuel appliances in administrative and process areas (fire safety measures are specified in the form "Fire safety principles for operation of thermal electrical appliances at Mochovce NPP “).

All the rules above also apply to contractors' sites and workplaces. NPP Mochovce fire safety requirements are specified in the contractual standards, or in the documentation commenting process, are incorporated into the contractors' design documentation.

Fire protection is integrated into the work management process. Safety orders are issued, PO-order, ZP-order, which are part of the job order file. It is prohibited to carry out work with open flames without a permit issued and measures taken.

Personnel handling chemicals and mixtures are trained and a risk assessment is included in the operating procedures.

Risk assessments and operating procedures for working with chemicals are issued. Staff are made familiar with the operating procedures.

Safety data sheets for hazardous materials handled and stored and the fire-technical characteristics of other flammable substances handled and stored and the principles for their safe use and storage shall apply to the performance of work [101].

Monitoring is ensured by operational staff and patrols provided by the PFB in accordance with a written instruction or also a PO-order.

Physical parameters of combustible materials are monitored on the technology equipment - online or during walk-down inspections by operating personnel (functional duties). Leakage monitoring is in place on important equipment located in process areas.

The Operations Unit submits to the meeting of the Plant Manager of Mochovce NPP information on the status of leakages on equipment containing flammable substances:
- gas leaks on equipment once a month,
- equipment leaks once a quarter.

Corrective Action and Prevention Program

SE has an established correction and prevention program [109] and [110], which is elaborated for the Mochovce NPP into a methodological guide [111].

The Methodological Guide [110] sets out uniform (general) procedures for managing non-conformities/issues, taking corrective, remedial and preventive actions, identifying near-misses and other initiatives for continuous improvement of the company's management system and its processes in accordance with the relevant legislation, the requirements of international standards ISO 9001, ISO 14001 and ISO 45001, the requirements of the IAEA No. GSR Part 2, and related safety guides, and in accordance with the principles of safety culture.

SE has a closed feedback loop of " Issue (non-conformity) management". This closed cycle continuously ensures that issues (non-conformities) are corrected, analysed and, in specified cases, the cause is identified and eliminated. In the form of proposed and implemented corrective actions and/or preventive measures, the results of the analyses are fed back into practice (operations, maintenance, etc.), thus ensuring that issues/non-conformities do not recur for the same or similar causes.

Methodological guide [111], as part of the CAP program [109], sets out procedures for identifying, documenting and screening issues and specifies:
- writing NG notifications,
- reviewing NG notifications by shift personnel,
- daily screening of NG notifications,
- management of NG notifications.

NG Notification is a document in the SAP Nuclear that is used by employees to report issues, suggestions for improvement, requests for external operational experience assessment, for assessment activities with self-assessment and peer review tools, and requests for document release/revision/cancellation.

Based on the NG notification, a request for repair or a design modification proposal can be created.

3.2.1.3.2 On-site and off-site fire-fighting capabilities, responsibilities, organisation and documentation

The requirements for the establishment of the PFB arise from the legislation [6] and [9], based on which a fire hazard analysis was prepared [71], which determined the minimum numbers of forces and resources at the Mochovce NPP site (similarly, for the Bohunice site). In relation to the above legislation, the phased programme [115] states that PFBs are established on the sites and the principles of their operation, material and technical equipment and other requirements are set out, which are elaborated in more detail in the relevant fire protection manual [114].

Based on the fire hazard analysis [71], the following minimum numbers of PFB personnel at the

Mochovce NPP site are established:
- Minimum number of staff with irregular working hours 76,
- A minimum of 15 staff members per shift, of which 1 fire control room operator and fire reporting room and 14 fire-fighters dedicated to effectively fight the most complex scenarios of anticipated fire.

The Mochovce NPP has a PFB, which is operated by an external company under a works contract. The PFB is composed of employees who perform activities at the PFB as their job. The building of the fire brigade, which is the seat of the PFB, is located on the site of the Mochovce NPP.

The PFB is able to quickly manage and execute the extinguishing of fires of technological equipment necessary for the safe shutdown of the NPP. The ability to carry out effective intervention is ensured by reliable fire detection, immediate dispatch of the firefighting unit to the site of the fire alarm and immediate execution of initial intervention by the PFB staff even in difficult and specific conditions of the NPP.

Ensuring operability is the primary task of the PFB. PFB ensures operability by observing the minimum number of personnel serving the shifts and the minimum material and technical resources determined in the decision of the Regional FaRC Headquarters.

The material and technical equipment of the PFB consists of:
- fire-fighting equipment,
- material means,
- personal protective equipment for self-rescue, respiratory protective equipment, body surface protective equipment, first aid equipment, means of determining the harmfulness of the environment, means of eliminating a fire or a spill of a dangerous substance,
- radio and other telecommunication equipment, signalling equipment and computer technology enabling information support to the intervention commander;
- means of fire rescue and flood rescue services,
- extinguishing agents, decontamination agents and sorption agents,
- other means.

The PFB provides:
- continuous reception and evaluation of messages, reports and signalling of fire, accidents and other emergencies in the intervention perimeter of the NPP site, as well as off-site buildings that are the property of the SE,
- evaluation of the reported incident announced via the electric fire alarm system and the fire alarm notification to the fire brigade within 1 minute from the start of the alarm,
- evaluating a reported incident that is reported verbally and giving a fire alarm to the fire brigade within 2 minutes of the start of the reported incident,
- departure of designated (predefined) forces and means of the firefighting unit within 1 minute from the fire alarm announcement,
- commencement of activities at the scene of intervention (boarding area for the firefighting unit) within 5 minutes of reporting the incident to the fire reporting room, but no later than halfway through the first phase of the fire's development.

All PFB employees have a thorough knowledge of fire protection, which they acquire by completing fire brigade staff training. Types of training that the staff of the Fire Brigade must undergo in accordance with Decree No. 611/2006 [19] of the MoI SR on firefighting units:

- basic training of fire brigade personnel is in the scope of 400 hours. The basic training shall be carried out by a legal entity authorised to do so by the Ministry of Interior.
- specialized training consisting of:
  - training and verification of professional competence for designated functions in a firefighting unit,
  - training to acquire competence to perform special fire-fighting activities and rescue works in the event of fires, natural disasters and other emergencies,
  - training to be able to operate fire-fighting equipment.

Specialised training of professional services technicians and commanders shall be carried out by the Ministry.

- periodic training of firefighting unit personnel assigned to the functions for the performance of which professional competence is required shall be carried out before the expiry of the issued certificate of professional competence.
- refresher training of PFB staff, which is conducted at the PFB, attended by all PFB staff, is part of the service, and is carried out in the scope of 50 hours per month. The contents of the refresher training shall be determined by the commander of the fire brigade, differentiated according to the functions in the fire brigade and according to the fire hazard in the fire-fighting perimeter. Tactical exercises are also part of the refresher training.

The commander of the PFB, his deputy, shift commanders, team and squad leaders, and specialist technicians of the PFB professional services are subjected to a proficiency test. The verification of professional competence is carried out by the Ministry.

Employees of the PFB operator in the positions of PFB commander, PFB deputy commander, PFB shift commander and PFB shift commander deputy must complete basic training and obtain professional competence for the II. d category of the NPP Mochovce licensee, fire protection group, complete an internship at the nuclear installation and on-the-job training. Upon completion of the training programme, competent personnel are issued with a work authorisation to perform work activities.

Employees of the PFB operator in other functions of the PFB must undergo basic training and obtain a certificate of completion of category VI.d of the Mochovce NPP licensee, other employees group, and undergo on-the-job training.

The PFB has developed fire-fighting procedures for all high-risk power plant systems with increased fire risk, which are elaborated in the documentation of fire fighting in the form of operational plans. Operational plans are maintained as controlled documentation which is updated at least once a year. The procedure and activities of the PFB as elaborated in the operational plan shall be regularly practised by drills and exercises of the PFB as part of the refresher training of the PFB personnel for the respective training year.

Fire response activities at Mochovce NPP are provided in accordance with the Fire Protection Act [6], which regulates the conditions for the protection of life and health of natural persons, property and the environment against fires. In order to prevent fires or for the purpose of fire response, the organisation shall draw up, maintain and keep in accordance with the actual state of the documentation on fire protection.

Fire alarm regulations define the duties of employees in the event of a fire. Fire alarm regulations shall be posted in appropriate locations on the premises of the plant in such a way that they are legible, visible and permanently accessible to all persons.

The fire evacuation plan regulates the organisation of the evacuation of persons from buildings affected or threatened by fire. Its contents include, in particular, the designation of the personnel who will manage the evacuation and the place from which they will manage it, the designation of the personnel and means by which the evacuation will be carried out, the designation of the method of evacuation and the evacuation routes, the designation of the place where the evacuees will be gathered and the designation of the responsible employee who will check the number of evacuees, the method of providing first medical aid to the affected persons, and the graphic indication of the evacuation routes in the floor plans of the individual floors of the building.

The effectiveness of the measures provided for in the fire evacuation plan shall be verified by a mock fire alarm in all buildings for which a fire evacuation plan has been drawn up. If there are fire hazardous materials in the building which could affect the evacuation of persons, safe access or the intervention of fire brigades, a fire evacuation plan shall also be drawn up for the evacuation of these materials.

Material and technical equipment of the power plant in terms of fire protection is determined by the design. The civil structures are divided into fire compartments. All important areas are secured by the FDPS system. The FDPS fire detector signalling is recorded, registered and analysed at the PFB control room. The response to the FDPS FIRE alarm is the departure of the PFB within 1 minute of the alarm being issued.

In the event of a fault being detected in any of the components of the FDPS system, it is immediately reported via an NG notification in the SAP Nuclear.

Critical facilities in terms of nuclear safety and fire safety are protected by the system of fixed fire-extinguishing equipment. Portable or mobile fire extinguishers are deployed at positions in all areas of the plant.

Fire equipment (fixed fire extinguishing systems, electrical fire detectors, fire extinguishers, fire dampers) shall be maintained in a serviceable and reliable condition to the maximum extent possible. In the event of failure or shutdown of fire-fighting equipment, alternative measures shall be implemented to maintain the safety of the plant. Failure of the fixed fire extinguishing system, fire water distribution system, electrical fire alarm system shall be reported to the PFB and recorded in the operational documentation.

Portable and mobile fire extinguishers of all types used in the Mochovce NPP are located in the PFB. In the event of detection of an inoperable extinguisher at its station, the PFB shall ensure immediate replacement of the inoperable portable extinguisher at the position with an operable one.

Inspection of fire equipment is carried out in accordance with the requirements of the legislation in force. Records are kept in the relevant responsible departments. Equipment malfunctions are reported via the FES and the fire water distribution system logbook, which is kept at the PFB control room.

Inspections and repairs of fixed fire extinguishing systems, electrical fire alarms, fire extinguishers are provided by qualified personnel or by a contractor. The contractor's personnel shall have the required qualifications, authorisations, and long experience for the performance of the above-mentioned activities.

The location of manual and mobile fire extinguishers is determined by the design documentation. The design documentation also addresses the types and number of fire extinguishers.

Fire hydrants are installed in the civil structures in the escape or intervention route on each floor of the building. Hose devices with a form-stable hose and a tank for extinguishing agent, which is automatically added to the hose by simply opening the valve, are also installed in technological buildings.

The Mochovce NPP has also other fire equipment installed – voice fire alarm and equipment for heat and combustion products removal. Regular inspections and maintenance are carried out in accordance with the documentation.

The PFB has firefighting equipment, technical and material means, which are well maintained, immediately at hand, stored in the fire truck, or in the emergency stock, all well maintained.

The PFB shall conduct scheduled exercises in accordance with the schedule of emergency drills and exercises developed for the calendar year. The schedule shall be approved by the Plant Manager. The scheduled drills are of the following nature:
- tactical exercises of the PFB,
- verification exercises of the PFB,
- interoperability exercises of the PFB with other services.

According to the recorded data, the PFB performs an average of 140 callouts per year at the Mochovce site. This includes 1 to 2 fire calls, false alarms, technical intervention, medical intervention, ecological intervention and exercises. In the case of the registered fires at the Mochovce site, these were fires in the first phase of their development (i.e. in the phase of ignition t = 0 to 10 minutes), which were, in accordance with the standards of the adopted "SE-EMO Fire Suppression Strategy", eliminated by the local competent firefighting unit – the PFB in such a short time that did not allow their development into the next phases (i.e. they were fires with low or negligible threat potential with no direct or consequential damage).

SE has signed an agreement on cooperation in the provision of the civil protection information system and the provision of assistance and aid by external units of the FaRC.

The subject of the Agreement is the cooperation of the Parties in providing a civil protection information system in the population protection area in the vicinity of NPP EBO3&4 and NPP MO1&2 in the event of an incident or accident at nuclear installations of severity degrees 1 to 3 or in the event of a non-nuclear emergency, in the event of erroneous activation of the VYRVAR system and false triggering of sirens in the population protection zones around the NPP, and providing assistance by the FaRC to SE, a.s. plants in carrying out the activities necessary for fighting and eliminating the consequences of fires and a nuclear accident, in the restoration of the affected area, including assistance on the premises of these plants.

A detailed description is given in the PFB Manual [116], which describes:
- the structure of the PFB, the different functions and their responsibilities and competences,
- procedures and methods, which are:
  - ensuring the operability of the PFB,
  - PFB activities,
  - professional services of the PFB,
  - PFB organization and management,
  - control activity,
  - shift operation service,
  - intervention by the PFB,
  - interaction between the PFB and the operations staff,
  - training of the PFB,
  - competence of the PFB,
  - PFB exercises,

- PFB documentation.

Binding documentation related to the activities of the PFB also includes documentation related to emergency planning [118], [119] and [120].

The key document is the on-site emergency plan [118], which establishes the personnel, technical and documentary support for the preparedness of Mochovce NPP staff and external organisations involved in the work for Mochovce NPP to successfully cope with classified events, with an emphasis on:
- reducing the risk of incident or accident or mitigating of their consequences,
- prevention of serious health damage (death, serious injury),
- reducing the risk of the likelihood of stochastic health effects (e.g. cancer, heritable manifestations) to the extent reasonably achievable.

The on-site emergency plan is followed by:
- a building emergency plan [119], which sets out the organisation, responsibilities and procedures for managing the response to an emergency in a building, unless the event is classified by severity level (1-state of readiness, 2-emergency at the site of NI, 3-emergency in the vicinity of NI),
- health Action Plan [120] , which defines:
  - the principles for the care of employees in the event of an accident or sudden deterioration of health,
  - the basic actions to be taken by plant personnel and plant medical centre staff in the event of incidents associated with possible contamination.

Documentation on fire-fighting

The fire-fighting documentation is prepared as part of the process. Rules and procedures are established for the development, maintenance, updating and use of fire-fighting documentation for a specific civil structure in accordance with [19] and is binding for the staff of the PFB, external services and other emergency services. This includes:
- operational plans,
- operational cards.

In particular, the operational plans describe:
- operational – tactical characteristics of the building,
- the most complex fire scenario,
- calculation of forces and resources,
- recommendations for the intervention commander,
- building and technological equipment schemes,
- situational diagram of surrounding buildings and fire water distribution.

Operational cards describe in particular:
- operational - tactical characteristics of the building,
- recommendations for the commander of the intervention,
- description of floors, list of rooms and FTE,
- evacuation plans of the buildings,
- situational diagram of the surrounding buildings.

The PFB has developed a regulation [117], which establishes the organisation of activities, responsibilities and procedures for response activities of PFB-EMO, the Fire and Rescue Corps, other firefighting units, rescue services of the Integrated Rescue System (IRS) and response groups/units of the Mochovce NPP during fire-fighting, rescue of persons and property endangered by fire, rescue work during accidents, natural disasters and other emergencies, environmental protection, provision of pre-medical and medical assistance on the territory of the operator of Mochovce NPP, i.e. in the intervention perimeter of the EMO PFB. The cooperation between the PFB and the shift operations personnel is described in the methodological guide [123].

Plant Fire Brigade (PFB) exercises

An indispensable function of the PFB is in emergency planning activities [119], where specific responsibilities and duties for the PFB are set out in the object-based emergency arrangements. The document [119], among other things, describes:
- basic response control algorithm,
- intervention management according to the type of event,
- procedures for evacuation of persons.

Plant management approves an annual plan for refresher training of PFB staff for a specific training year, which usually includes subject areas and time allocation for:
- theoretical training (legislation, internal regulations, fire-fighting documentation, emergency training, etc.),
- practical training,
- physical training,
- tactical exercises,
- walk-downs,
- and other areas.

The annual plan is broken down in more detail into monthly plans.

In the case of tactical exercises, a tactical exercise plan is developed, which usually includes:
- the purpose and scope of the exercise,
- rules and assessment criteria,
- the participants in the exercise,
- a description of the exercise and its individual parts (e.g. characteristics of the building, communications, tactical intent, etc.),
- calculation of forces and resources,
- basic scenario.

An example is the emergency response exercise "Hydrazine hydrate fire“ [121].

Each exercise is evaluated to verify that the exercise has met its objectives. The evaluation verifies that the predetermined criteria (activities, arrival times, adherence to time limits, etc.) have been met and provides an overall assessment. If necessary, external forces are deployed in accordance with the alarm plan of the State Fire and Rescue Corps.

3.2.1.3.3 Specific measures

In the NPP conditions and also in the current legislative environment, certain problems arise in their application in places where there is a conflict of different requirements applied simultaneously. Examples are fire barriers on intervention routes, where on the one hand access is restricted, often with technical means, to prevent unauthorised access (e.g. for physical protection reasons).

In some places, this creates restrictions for the access of the intervention services of the PFB, or prolongs the time to intervention. Examples include electrical substations or even areas around the Unit Control Room and the Emergency Control Room, where strict access regime rules apply.

The above deficiencies are continuously identified, interaction with operational personnel is practiced and they are gradually eliminated by replacing them with more appropriate technical solutions.

In the case of the provision of roads for external forces (e.g. additional FaRC forces), the issue was analysed mainly from the perspective of extreme external events, such as earthquakes. This analysis identifies locations and proposed actions in the event of loss of roads. The results of this analysis are also partially applicable to the case of loss of roads during more extensive fires. Incidents involving loss of internal and external roads are dealt with in the context of emergency plans [118] and [119].

3.2.2 Research reactors

Not applicable

There are no nuclear installations in the category of research reactors that have been or are being constructed, commissioned, operated or decommissioned in the Slovak Republic.

3.2.3 Fuel cycle installations

Not applicable

There are no nuclear installations in the category of fuel cycle installations that have been or are being constructed, commissioned, operated or decommissioned in the Slovak Republic.

3.2.4 Dedicated spent fuel storage facilities

3.2.4.1 Fire detection and alarm

In particular, the following ensures fire detection and fire alarm:
- electrical fire alarm systems,
- voice fire alarm,
- visual fire detection systems.

Voice fire alarm is not used in the ISFS. In accordance with Article 90(1) of Decree No. 94/2004 [7], the ISFS building does not have to be equipped with a voice fire alarm.

Visual fire detection devices are not used in the ISFS. In accordance with Article 90(3) of Decree No. 94/2004 of the MoI SR, the ISFS building does not have to be equipped with a voice fire alarm.

For a description of the ESSER FDPS operation procedure, refer to Instruction 15-INS-403 Issue 2 [130]. The description and scope of controls for the ESSER FDPS is in Instruction 15-INŠ-403 Issue 2 [130] and is in accordance with the legislative requirements of the Decree of the MoI SR No. 726/2002 [11].

3.2.4.1.1 Design approach

The ESSER FDPS was designed in accordance with the following standards (versions valid at the time of design in 2006):

- STN 73 0875 Designing a FDPS,
- STN EN 54-1 (92 0404) Electric fire alarm. Part 1: Introduction,
- STN EN 54-2+AC (92 0404) Electric fire alarm. Part 2: FDPS control room,
- STN EN 54-4 +AC(92 0404) Electric fire alarm. Part 4: Power supply equipment,
- STN EN 54-11 (92 0404) Electric fire alarm. Part 11: Push-button fire detectors.

The calculation of the need to protect the fire compartments of the ISFS is documented [70].

3.2.4.1.2 Types, main characteristics and expected performance

The detectors are located on the ceiling or on the suspended ceiling. If the detector is located in an intermediate space (ceiling - suspended ceiling), the fire detector does not have a visual signal to the suspended ceiling. In the case of a location near luminaires at a distance of at least 50 cm from the luminaires.

The FDPS distribution is carried by the cable JE-H(St)H 1×2×0.8 in armoured tubes laid firmly on the surface and cable grids. In areas with suspended ceilings, the FDPS distribution is routed in PVC tubes above the suspended ceiling. The distribution of the ESSER control panel FDPS network connection is routed via TECKFY 6×2×0.8 cable.

3.2.4.1.3 Alternative/temporary measures

During work in which the relevant detectors may be activated, the relevant FDPS detector shall be deactivated on the basis of the relevant approved fire order. The relevant measures (e.g. control, presence) are specified in the PO-order.

3.2.4.2 Fire suppression

In general, the main means of fire suppression are:
- portable and mobile fire extinguishers,
- internal fire water distribution systems together with hose reels,
- external fire water distribution systems together with underground or aboveground hydrants,
- the plant fire brigade.

The civil structure of the ISFS has no fire-technical equipment - fixed fire extinguishing equipment. In accordance with the design of fire safety of buildings according to STN 92 0201-1 [35], due to the small plan area of the fire compartment, it is not necessary to equip the fire compartment with a fixed fire extinguishing system. This approach is in accordance with Article 87(4) of Decree No. 94/2004 [7] that the building does not have to be equipped with a fixed fire-extinguishing system.
(*Note: The FES is a fixed extinguishing system with automatic extinguishing action in the event of a fire e.g. sprinkler systems in coordination with fire detection and protection systems (FDPS) and evacuation management systems.*)

There are no fire-technical facilities installed in the intermediate storage building - equipment for heat and combustion products removal. In accordance with the fire safety design according to STN 92 0201-1 [35], due to the small plan area of the fire compartment, it is not necessary to equip the fire compartment with heat and combustion products extraction equipment.

3.2.4.2.1 Design approach

Portable and mobile extinguishers

The number of portable and mobile fire extinguishers shall be determined in accordance with STN 92 0202-1 [35]. The location of portable and mobile fire extinguishers is in accordance with Decree No 347/2022 [17] and STN 92 0202-1 [35]. The positioning of fire extinguishers shall also take into account the distance between individual extinguishers, which shall not be greater than 30 m. The location of the different types of portable and mobile fire extinguishers is shown in the evacuation plans of the ISFS building for each floor.

Fire water supply

Determination of the water needs for fire extinguishing for the fire compartments of the ISFS building was determined in accordance with Decree No. 699/2004 [9] and STN 92 0400 [37], The water needs for fire extinguishing was determined in total for both off-site and on-site fire water distribution for each fire compartment. The maximum aggregate water demand at a water flow velocity of v=1.5 m.s-1 is Q=25.0 l.s-1. The necessity of fitting hose equipment has been determined for selected fire compartments.

The hose assemblies have been installed in the structure so that the hoses permit effective action by at least one jet at each point of the fire compartment (for a hose reel length of not more than 30 m of hose with a shape stable hose; the method of positioning and type of hose assembly shall permit operation by one person).

3.2.4.2.2 Types, main characteristics and expected performance

The raw water and fire water pumping station is used to pump raw water to the filtration station and then filtered raw water to the filtered cooling water pool, distribute fire water to the fire water distribution system, and supply raw water for chemical water treatment. The raw and fire water pumping station pool has a bottom below the surrounding ground level.

The Fire Water Pumping Station (FWPS) is designed to supply the fire water distribution system. The water supply for the FWPS is created in the intake pits of the fire pumps and their associated manholes. This water reserve is replenished from the raw water pool, which is replenished from the Pečeňady pumping station. The quantity of fire water is guaranteed by monitoring the level in the intake wells of the fire pumps. Low water levels in the fire pump intake wells are signalled to the Operations Centre (OC)/Warden Service (WS). The fire water distribution system shall be maintained at a pressure of > 0.25 MPa at all times. The fire water pumping station system consists of two sets of pumps due to the 100 % back-up of the system (2×100 %).

The power supply of the fire pumps is redundant from the switchboard and the diesel generator (DG). The switchboards are spatially separated. They are located in different rooms on different floors. An ESSER IQControl C/M monitoring unit is installed in one of the switchboards, the outputs of which are fed to the OC/WS. The functionality of the equipment is regularly verified and tested in accordance with the Decree of the MoI SR No. 726/2002 [11].

3.2.4.2.3 Management of harmful effects and consequent risks

Not applicable. No harmful effects anticipated.

3.2.4.2.4 Alternative/temporary measures

Currently, underground fire hydrants on the fire water distribution system are being replaced with aboveground fire hydrants according to STN EN 14384 [56] due to the modernisation of sampling points and at the same time to optimise the location of aboveground fire hydrants on the fire water distribution system in JAVYS due to the decommissioning of the buildings belonging to the nuclear facilities of NPP V1 and NPP A1 in accordance with the requirements of the Decree No. 699/2004 [9] – in particular, the distances and the number of consumption points.

3.2.4.3 Administrative and organisational fire protection issues

The basic administrative and organisational procedures in the field of fire protection for JAVYS are elaborated in Directive BZ/KB/SM-07 Fire Protection [127]. Within JAVYS, the coordination of activities related to fire safety, as well as the control activities resulting from the regulations on fire safety is ensured by the following specialised units:

- fire prevention:
    - safety Section,
    - nuclear safety, security technical service (STS) and guarding department,
- interventions:
    - PFB SE-EBO based on a service contract.

3.2.4.3.1 Overview of fire-fighting strategies, administrative measures and provision

The basic document in the field of fire protection in JAVYS is Directive No. BZ/KB/SM-07 Fire Protection [127]. The specific provision of fire prevention tasks is ensured by a fire protection technician with professional competence and by authorised employees.

Types of fire prevention patrols at JAVYS:

- workplace fire prevention patrol - established in workplaces with increased fire hazards,
- fire prevention assistance patrol - set up by the operator of activities with an increased fire risk or the organiser of an event involving a large number of people.

Fire prevention patrol is established:

- to ensure tasks related to fire prevention,
- to carry out necessary measures related to fire-fighting and evacuation of persons,
- in places with an increased fire hazard,
- in activities associated with an increased fire hazard,
- at events attended by large number of people.

The objective of the control activities in JAVYS in the area of FP is to objectively determine:

- compliance with legal regulations related to FP,
- the maintenance and up-to-dateness of FP documentation,
- the implementation of corrective measures imposed to remedy identified deficiencies in the area of FP.

The FP inspections in JAVYS are conducted:

Internally:

- fire prevention inspections:
  The inspection activities shall be carried out in accordance with the inspection plan of the Nuclear Safety, STS and Security Department approved for the relevant year by the Nuclear Safety, STS and

Security Department Manager. The fire protection technician shall carry out preventive fire inspections aimed in particular at:

- organisational support of FP at workplaces,
- comparison of the actual situation with the FP documentation,
- construction design of buildings, in particular from operational point of view,
- fire-fighting equipment,
- permanent clearance of escape routes,
- operation and condition of technical and technological equipment,
- marking and equipping workplaces and premises in accordance with the Government Regulation No. 387/2006 on requirements for ensuring health and safety marking at work as amended,
- production, storage and handling of flammable materials,
- the operability of fire-fighting equipment,
- checking compliance with FP regulations during works,
- implementation of corrective actions from previous fire prevention inspection,
- compliance with the measures imposed for activities with increased fire risk.

The periodicity of these inspections:

- every 12 months in buildings and premises where there are only occasional workplaces, where the staff member is not regularly assigned and where he is only present occasionally at intervals of a few days, normally only for the purpose of inspection, maintenance or repair,
- every 6 months in buildings and premises where only administrative activities are carried out,
- every 3 months in other buildings or premises.

A record of the fire inspections shall be made in the Fire Logbook.

Externally:

- inspections conducted by state fire supervision and by the NRA SR.
  The state administration bodies in the field of FP are:
  - Ministry of Interior of the SR,
  - Regional FaRC Headquarters,
  - District FaRC Headquarters.

The fire protection technician provides FP training in the following cycles:

- once in 24 months for managerial staff,
- once in 24 months for other staff,
- once in 12 months for persons providing FP outside working hours,
- once in 12 months for workplace fire prevention patrols,
- training of newly recruited staff on commencement of their employment at the invitation of the Employee Affairs Department (prior to commencement of work once they have been assigned to the workplace).

3.2.4.3.2 On-site and off-site fire-fighting capabilities, responsibilities, organisation and documentation

The PFB serves for fire-fighting in JAVYS, and is located on the premises of JAVYS. The cooperation, duties and conditions for the cooperation of PFB and shift personnel are described in Regulation BZ/KB/SM-08 [128]. The PFB equipment shall be in accordance with the fire hazard analysis (in particular Annex C and D) [73]. The PFB has a documented organisation, operating rules, minimum staffing levels, technical equipment, protective work equipment and requirements for the physical fitness and training of its staff in accordance with the legal requirements of the Slovak Republic. The PFB has developed fire-fighting methods elaborated in the fire-fighting documentation in the form of operational fire-fighting plans for all places with increased fire hazard. Operational fire-fighting plans are kept as controlled documentation, which is updated once a year. The procedure and activities of the PFB elaborated in the Operational Fire Fighting Plan are regularly rehearsed by drills and exercises of the PFB, which are part of the refresher training of the PFB staff. The intervention commander shall establish a managing staff, which shall be an advisory and executive body to ensure the management of large-scale or long-lasting fires, natural disasters or other emergencies and shall ensure a unified organisation of the management of firefighting units and other forces and means deployed to combat them. Within JAVYS, permanent management staffs are established for selected facilities. The permanent management staff for the ISFS consists of:

- Shift operations manager,
- the PFB intervention unit commander,
- energy equipment field operator – the ISFS operator – shift operator,
- radiation safety technician – shift,
- operating electrician – shift.

3.2.4.3.3 Specific measures

Specific fire protection measures for fire-fighting are described in the individual operational plans, in particular the protection of firefighters from radioactive exposure. When the Fire Brigade exits the controlled area, it does not enter the area through the hygiene loop, as the PFB's emergency truck is equipped for this purpose:

- equipment for work in the controlled zone,
- isolation breathing apparatus,
- work footwear.

When going to premises located in the controlled zone, the shift supervisor shall, at the request of the PPA, arrange for a dosimetry officer to be dispatched to these premises to assess the radiation situation. The PFB shall leave the controlled area after the intervention, if conditions permit, principally through the hygiene loop.

No incident (fire, near-fire, smoke) with an impact on nuclear safety or fire protection has been recorded at the ISFS so far. This confirms the implementation of sufficient fire prevention.

3.2.5 RAW storage facilities

Not applicable

The nuclear installations Integral RAO Storage and National RAO Storage facilities are excluded from the review. The justification for the exclusion is given in Annex 1 to this Report.

3.2.6 Installations under decommissioning

Not applicable

NPP V1 and NPP A1 nuclear installations are excluded from the review, the justification for exclusion is given in Annex 1 to this report. The results of the ISFS verification can be transferred to NPP V1 and NPP A1.

3.3 Passive Fire Protection

3.3.1 Nuclear Power Plants

3.3.1.1 Prevention of fire spreading (barriers)

3.3.1.1.1 Design approach

The civil structures of NPP MO3&4 are divided into fire compartments in accordance with legislative, normative documents and safety guides [2], [32], [7] and [26]. When dividing the civil structures into fire compartments, the following principles were followed:

- the creation of separate fire compartments for areas where safety systems and nuclear safety related systems are located, respecting their redundancy. In the case where it was not technically possible to implement the above division into fire compartments, dividing the fire compartment into fire cells was used in accordance with [32],
- the creation of separate fire compartments listed exhaustively in [7],
- ensuring the evacuation of persons from each fire compartment,
- ensuring the rapid and safe intervention of firefighting units,
- separation of operations with a higher fire load, or equivalent fire duration, or operations with a probability of fire and its spread from other operations,
- limiting the number of penetrations in fire-separation structures,
- limiting the extent of damage.

Prevention of the spread of fire between the fire compartments is ensured by the consistent delimitation of each fire compartment by fire-separation structures with the required fire resistance specified in the design.

3.3.1.1.2 Description of the design of fire compartments and/or cells and their key features

Building Structures

In accordance with legal requirements [7] and subsequently technical standards [35] and based on a deterministic analysis [59], the FSB [61] determined the fire safety levels of the building for the fire compartments in the civil structures and according to them, the minimum fire resistance of the individual building structures was determined for:

- the fire separation structures,
- fire closures in fire walls and fire ceilings,
- envelope walls,
- roof load-bearing structures,
- load-bearing structures providing for the stability of the building,
- load-bearing structures not providing stability of the building,
- structures supporting technological equipment, the collapse of which contributes to the spread of fire,
- non-load bearing structures,
- stairways structures inside the fire compartment, which are not part of protected escape routes,
- elevator and service shafts,
- roof covering

Structural systems and classes of products according to their reaction to fire

Structural systems in civil structures are non-combustible in accordance with the requirements of [7] and [35]. Building products with reaction to fire classes A1 and A2 [54] are used in building structures. The use of products of reaction to fire class B, C and lower is only justified where the level of fire protection (OPP) is not compromised in relation to nuclear safety and operational reliability (examples for the use of products of reaction to fire class D are doors in sanitary facilities in buildings of groups A, B).

For the products used, an additional classification in terms of smoke generation s1 according to [54] was required; in terms of flame burning of drops/particles d0 for class A2. A derogating classification was only possible in justified cases where the level of FP in relation to nuclear safety and operational reliability was not compromised.

Floor coverings are of reaction to fire class Bfl [54] at the highest; a higher class was only used where it was not possible to provide a product that also had the other required performance characteristics for the application and at the same time the FP in relation to nuclear safety and operational reliability was not compromised. The products used have the additional classification s1.

Roof covers on Group A buildings are made of D1 type elements, have thermal insulation made of materials having reaction to fire A1 or A2 and classification $C_{ROOF(t4)}$ according to STN EN 13501-5 in accordance with [7].

For the construction of double floors, the double floors are made of materials of reaction to fire class A1 or A2, except for the surface layer.

The reaction to fire classes for construction products are documented in the accompanying technical documentation for the construction products used. The flammability of existing building structures and products that were implemented before the building permit was issued (the NRA SR Decision No 246/2008) were determined and evaluated in the basic design document [59] according to the technical standards ČSN 73 0861 and ČSN 73 0862.

Fire resistance of building structures

Building structures built before the approval of the change of construction before completion have proven fire resistance in accordance with ČSN 73 0821 or on the basis of attestations or expert opinion. The documents are part of the accompanying technical documentation (ATD).

Building structures used after approval of a change to the construction prior to completion shall have the required fire resistance demonstrated by initial type tests carried out in accordance with product standards or by calculation in accordance with technical standards called 'Eurocodes'. This is documented in the Fire Construction Certificates included in the ATD.

Increasing the fire resistance of building structures - steel structures in RB is made by fire-resistant plaster or fire-resistant cladding - boards to the required fire resistance. Increasing the fire resistance of steel building structures - fire separation structures - is solved by double-sided cladding with fire protection boards.

All implemented improvements of fire resistance of building structures are documented in Fire Construction Certificates according to Decree [7] and registered in the common database of fire structures.

Fire closures

Fire doors and fire hatches shall comply with the fire resistance and construction type requirements in accordance with the FSB. A fire damper is a device used in heating, ventilation and air conditioning systems to separate fire compartments and to protect escape routes in the event of a fire. Fire dampers are characterised as follows [13]:

- fire-resistant damper - a damper assembly with a movable structure closing a permanent opening in a fire separation structure through which a duct of a ventilation system providing supply or exchange air passes, or closing a duct with the fire resistance of a ventilation system providing supply or exchange air, which, when closed, prevents the spread of heat, limits the spread of heat or prevents the transmission of flame,
- Smoke-tight damper - a damper assembly with a movable structure closing a permanent opening in a fire separation structure through which a duct of a ventilation system providing air supply or exchange passes, or closing a duct with the fire resistance of a ventilation system providing air supply or exchange which, when closed, prevents the passage of smoke,
- Combination damper - a damper assembly with a movable structure closing a permanent opening in a fire separation structure through which a duct of a ventilation system providing air supply or exchange passes, or closing a duct with the fire resistance of a ventilation system providing air supply or exchange, which, when closed, prevents the spread of heat and the passage of smoke, restricts the spread of heat and prevents the passage of smoke, or prevents the transmission of flame and the passage of smoke.

Fire dampers shall have the following fire resistances demonstrated by tests carried out in accordance with standard [55]:

- EI 90 ve, ho (i↔o) S,
- EI 120 ve, ho (i↔o) S.

This is documented in the Fire Construction Certificate in the STD.

Fire resistant grill

They are used to prevent the spread of fire from one fire compartment to another and are installed in the fire compartmentation structure. Products with fire resistance EI 90 D1 with mechanical actuation and an initiation closing temperature of 72 °C tested according to the technical standard STN EN 1364-1 have been used.

Fire seals and penetrations through fire structures

The penetrations of distributions, penetrations of installations, penetrations of technical equipment and penetrations of technological equipment through fire partition structures are sealed in such a way as to prevent the spread of fire to another fire compartment. The fire seals and gaskets shall be made in accordance with European technical certificates ETAG 026/1, ETAG 026/2, ETAG 026/3, ETAG 028/2 and technical standards [54]. This is documented in the Fire Construction Certificate in ATD.

In places where the level of flammable liquid can reach the level of the pipeline penetration (e.g. emergency tanks of process equipment), materials resistant to the chemical effects of the liquid, as well as to the hydrostatic pressure of the column of escaped liquid, are used to seal the penetrations.

Penetrations of distribution lines and installations through fire partitioning structures with an opening area of more than 0.04 m2 shall be marked with a visible, legible and difficult to remove "PENETRATION" sign placed directly on or in close proximity to the structural element sealing it.

Spacing distances

For all civil structures, the spacing distances were defined in the framework of the fire safety design of the building [59]. The individual civil structures of the MO3&4 NPP are situated in such a way that in the event of a fire in any civil structure, the civil structure located in its vicinity would not be endangered by the fire and secondary effects of the fire.

The spacing distances for fire open areas or partially open areas of civil structures have been determined in accordance with the standard [35].

In the case when it was not possible to observe the spacing distance and the civil structure or technical equipment could be threatened by fire from a neighbouring building, measures were taken to prevent the spread of fire and the impact of secondary effects of fire – e.g. by building fire separation structures or other technical solutions.

An example is the water curtain installed in the EBO3&4 NPP on the wall adjacent to the external transformers and the machine room, which eliminates the design requirement of insufficient spacing distance from the external transformers. This water curtain is fed from the fire water distribution system and is triggered along with the FES of the outdoor transformers.

Intervention roads

For the access of fire trucks, the intra-areal paved roads with the required load capacity of at least 80 kN per vehicle axle are used. In most safety-significant civil structures, the intervention routes shall be protected escape routes of type A or C with forced ventilation.

The FSB design for the MO3&4 NPP did not imply the need for fire lifts. Nevertheless, they are supplied and installed in the same design as for fire lifts.

3.3.1.1.3 Lifetime performance assurance

All fire equipment, including FTEs, are subject to the relevant legislation that defines the requirements for their regular inspection:

- fixed fire-extinguishing systems are inspected weekly, monthly and yearly in accordance with [10],
- electrical fire detectors are inspected daily, monthly, quarterly and yearly, in accordance with [11],
- the heat and flue gas extraction system is inspected once a year in accordance with [16],
- Fire closures, according to the legislation[13], are inspected at least once every 12 months,
- fire extinguishers, according to the legislation[17], are inspected at least once every 12 months or 24 months according to the type of the extinguisher,
- ventilation systems for the protected escape routes are inspected once a year in accordance with the legislation [16].

In the case of components whose fire protection function may be altered over time due to external factors, the degradation processes are monitored by a controlled ageing system.

An example is the fire retardant coating implemented at MO1&2 NPP on the cable systems. As part of the monitoring of the ageing of the fire retardant coatings on the cables, samples of the fire retardant coating were taken to the operating areas in 1998. Representative test samples were deposited in selected rooms so that different environments were represented depending on the humidity.

Monitoring of the ageing of fire retardant coating on cables was done in: 1998 (initial testing), 1999, 2000, 2001, 2003, 2010, 2011, 2012, 2014, 2016, 2018, 2020 and 2022. As an example, during the shutdown of Unit 1 of NPP MO1&2 in 2022, 4 samples of fire retardant coatings were taken and analysed in an external laboratory, where the properties of the fire retardant coating under fire conditions were monitored.

As part of the implementation of fire retardant coatings of steel structures at NPP MO3&4, samples of steel plates with applied fire retardant coating were placed on the steel supporting structure, which will serve in the future to verify the foaming properties of the applied coating on the supporting steel structures.

3.3.1.2 Ventilation systems

3.3.1.2.1 Design of the ventilation system: ensuring segregation and insulation

The HVAC systems are among the auxiliary process systems of the MO3&4 NPP. They form an integral part of the operation of nuclear installations. They play an important role in ensuring nuclear safety and health protection against ionising radiation both in normal operation and in the event of malfunctions and accidents.

In general, the functions of the HVAC systems can be formulated as follows:
- to create suitable conditions for the activities of the operating personnel,
- create suitable conditions for the safe and reliable operation of technological equipment,
- to prevent the release of radioactive substances into the working environment and the environment,
- contribute to the mitigation of the consequences of any malfunction or accident (including fire).

In terms of achieving the required parameters of the environment for a given building, space or room, a number of fundamental solutions are used.

The parameters of the environment are ensured by:
- heating,
- ventilation,
- air-conditioning,
- cooling.

The solution used is based on the specific purpose of the building or space. In most cases, it is a combination of the above air conditioning methods.

From a conceptual point of view, the parameters of the environment are achieved by technical means:
- supply,
- drainage and
- circulation HVAC systems.

In terms of the division of operating rooms into protection zones to ensure radiation protection of NPP personnel during NPP operation, the HVAC systems ensure the environmental parameters in the premises of:
- the controlled zone,
- outside of the controlled zone.

The essence of protecting a building from the spread of fire by an HVAC system is to design an HVAC system that has the ability to prevent the spread of fire:

- by protected ductwork or by protection of unprotected ductwork (without ductwork firestops) that meets specified fire resistance requirements,
- fire dampers fitted at the interfaces of fire compartments.

By controlling the fire dampers (FD) from the FDPS signal via the I&C, the following objectives are pursued:

- increase fire safety,
- immediate closure upon fire detection,
- remote control of the closure status (open - closed),
- remote opening of closed closures,
- simple checking of the functionality of closures.

Basic requirements

The design of fire protection in HVAC systems is based on the input requirements of the HVAC design (required parameters for ventilation of individual rooms) [104], [105], [106], [107] and on the design of fire safety of buildings for specific civil structures [59].

HVAC distribution

The protection of the HVAC equipment is designed using as much as possible the protection of piping with defined fire resistance.

A HVAC system serving a single fire compartment may have an engine room that is part of that fire compartment.

At the point of penetration through the fire separation structure, the HVAC equipment is made of non-combustible materials, the insulation of this equipment is at least made of not easily combustible materials.

If the HVAC piping follows the activated carbon filters of the filtration stations, these are monitored by FDPS automatic detectors, so that the relevant part of the system can be closed with shut-off valves or fire dampers.

Fire dampers

A fire damper is fitted at the point of penetration of the HVAC equipment (pipes, or other parts and elements) through the fire separation structure.

Fire dampers installed at the entrance to electrical substations (from rooms or fire compartments with a lower FSB level – corridors, staircases) have a required minimum fire resistance of 60 minutes and are made of construction type D1.

Fire dampers installed at the entrance to cable ducts and in cable rooms have a fire resistance rating of 90 minutes and construction type D1. Fire dampers are tested according to the technical standard [55] and meet the requirements of the applicable decree [13].

Control of fire dampers:

- fire dampers equipped with a servo drive are closed from the initiation of the FDPS. In case of "FIRE" alarm from the rooms protected by fire dampers or from the premises where fire detectors are located, which initiate the fire damper closure, the fire dampers are closed and the closure lasts for the entire duration of the "FIRE" alarm,
- fire dampers are also controlled by a thermoelectric fuse when the limit temperature of 72 °C is exceeded in the HVAC piping or in the damper location area - the damper closure lasts until the thermoelectric fuse is replaced,
- the fire dampers close when the supply voltage is lost, the indicated loss of supply voltage is signalled to the fire damper control system.

Each fire damper:
- has a status indication - closed, open, fault,
- the signal of fire damper closure is transmitted to the HVAC control system, which ensures the subsequent steps for the correct operation of the HVAC system (e.g. shutdown of fans),
- The fire damper is installed so that it can be accessed,
- The fire damper is fitted into the fire separation structure so that the damper blade, in the closed position, is positioned in the face of the fire separation structure,
- Fire dampers in seismically resistant structures are seismically resistant and functional during and after a seismic event.

Division of HVAC systems

HVAC systems in the hermetic zone

The hermetic zone (HZ) includes rooms that are differentiated according to the length of stay of the operating personnel in these rooms, namely unattended and semi-attended rooms [104]. The HZ includes all spaces into which the environment will extend after the occurrence of a maximum design-basis accident.

The heat load of the HZ is removed by circulation cooling systems. To reduce air activity during operation, a circulation filtration system is installed. All equipment used is designed to operate in normal, abnormal and emergency mode. No HVAC equipment is in operation at maximum design basis accident. However, the proposed equipment shall be designed to be operational after the maximum design basis accident.

The air supply system to the hermetic space supplies fresh air to the HZ space, which mixes with the rest of the atmosphere. The negative pressure in the HZ is maintained by a system that extracts and pressurises the HZ to 200 Pa less than the pressure in the surrounding spaces. It also provides filtration of the extracted air before it is discharged into the atmosphere. The difference in the amount of air is determined by the assumed leakage rate of the HZ. The actual exhaust air quantity was set during commissioning tests to a negative pressure of approximately 200 Pa.

Additional inlet and outlet systems are provided for the period of refuelling and atmosphere exchange following a design basis accident and subsequent requirement for operator input. They ensure the ventilation of the HZ so that the atmosphere corresponds to the hygienic conditions for the continuous operation of the operator.

The HZ is also equipped with two types of circulation systems. The first are cooling circulation systems and the second are filtration systems. The cooling systems ensure the removal of heat radiated into the space by the process equipment. The filtration system ensures the purification of the HZ air by being equipped with filters for the filtration of radioactive aerosols and filters for the capture of iodine and its compounds. Cooling systems are also basically twofold. They are systems that have machinery outside the cooled space and systems that have HVAC equipment (units) located directly in the cooled space.

Also included are recombiners, which also function as igniters from a certain concentration of hydrogen, suitably positioned in the HZ premises.

Air-tight zone HVAC systems

The airtight zone includes rooms that prevent the spread of activity from a potential accident further into the rooms of the controlled zone and to the ambient environment. The rooms in this zone are further subdivided according to the possible length of stay of the operating personnel. The indoor air parameters in the air-tight zone rooms are maintained according to the requirements of the individual process operations [105].

The pressure in the premises is maintained 50 Pa lower than in the surroundings (unattended premises). The heat load of the plant is removed by the incoming air and circulating cooling systems. To reduce activity, some exhaust systems are equipped with aerosol filters. The designed HVAC systems create suitable working conditions for process equipment and personnel. The systems are of low pressure. Waste air is discharged to the atmosphere through a ventilation stack.

HVAC circulation systems

Circulating cooling systems are systems for removing heat losses from process equipment. Circulation systems are located directly in the spaces they cool [106].

Supply systems ensure the supply of fresh conditioned air to corridors and areas with permanent or regular service. Fresh air flows by positive pressure to adjacent areas with process equipment. The air is transferred through openings fitted with grates or automatic pressure dampers (mechanical – KID type), which help to maintain a set pressure differential between rooms after the weights have been set.

Exhaust systems provide airflow from room to room in the direction of increasing activity. With the use of pressure relief dampers (KID), a pressure of 30 to 50 Pa less is created in the ventilated space than in the space from which the air is flowing. The exhaust systems, in conjunction with the supply systems, provide the required air exchange in each room. They also provide extraction of pollutants from technological processes, removal of air mass from the surface of pools, etc. The extraction systems are equipped with suitable filters for filtering aerosols and iodine as required. All ventilation air from the airtight zone is discharged to the atmosphere via a ventilation stack.

The role of other HVAC systems is:

- to supply the reactor building with fresh and conditioned air to achieve the required exchange and prescribed environmental parameters in the ventilated spaces,
- ensure cooling of the process penetrations,
- provide air supply and distribution for the use of the suits in the spaces of both units,
- to provide air supply to the ventilated zone necessary for secondary containment extraction needs in the event of a severe accident,
- to ensure the supply of treated air to the suits used in the reactor building.

Air treatment is carried out in assembled and block units for air intake. The units are independently operable when connected to the heating and cooling water distribution system, the electrical supply system and the higher-level control system.

The HVAC piping is thermally and fire insulated.

Ventilation of the auxiliary plant building

The role of the HVAC system [107] is to supply fresh and conditioned air to the active auxiliary plant building (APB) to achieve the required exchange of the prescribed environmental parameters and to provide supply and distribution air for the use of the suits in the active APB areas. The fresh air supply shall be from the free space/atmosphere. The air is purified by filtration, heated or cooled in ventilation units and ducted to the connecting corridors and, to a limited extent, directly to the active APB rooms. Exhaust air is sucked into the exhaust ducts and, after filtration or without filtration, is introduced into the ventilation stack via a common discharge duct and discharged to atmosphere. The HVAC system has a 100 % back-up. The suit air supply system delivers conditioned air to the suits used by the operator and therefore has a 200 % back-up.

The designed HVAC equipment ensures:
- the inlet air temperature (21 °C),
- exhaust air from the rooms,
- the required air exchange,
- the negative pressure (30-50 Pa) in rooms with possible activity,
- filtration of the air mass on aerosol filters,
- exhaust to the ventilation stack,
- supply of suit air to corridors,
- ventilation of the escape stairwell in the event of fire,
- installation of fire dampers and fire insulation to increase the fire safety of the building,
- extraction of exhaust gases from the transport vehicle.

3.3.1.2.2 Performance and management requirements under fire conditions

Protected escape routes and intervention routes are identified in the approved FSB design. An escape route is a permanently unobstructed route or space in or on a structure that permits the safe evacuation of persons from the structure or from a fire-threatened compartment to an open space or to an area that is not threatened by fire.

Escape routes are subdivided according to the degree of protection [7] and [35] they provide to persons escaping:
- unprotected,
- partly protected
- protected:
  - protected escape route type A,
  - protected escape route type B,
  - protected escape route type C.

For safe and early evacuation and to enable the fire brigade to intervene, unprotected or partially protected escape routes are established in all NPP MO3&4 buildings and protected escape routes type A, type B or type C are established in buildings where the FSB design requires it.

The FSB technical reports demonstrate that all escape routes (unprotected, partially protected and protected) comply with the requirements of Decree of the MoI SR No. 94/2004 [7] and the relevant technical standards in terms of the minimum evacuation time and the limit length of escape routes, as well as in terms of the number, capacity and width of escape routes.

Ventilation of protected escape routes ensures the supply of fresh air during a fire, mostly in stairwells or corridors with access to the open space. In all cases, the pressure ventilation used is controlled automatically, either from a common control room or by activation of an FDPS button from the point of the protected escape route.

The largest fire compartment, the turbine hall, is also equipped with a device for heat and combustion products extraction [96], which creates a safe space below the neutral plane, especially in terms of visibility, for the firefighters during intervention in these spaces. The behaviour of the heat and combustion products extraction (HCPE) system has been verified by a CFD model [97].

3.3.2 Research reactors

Not applicable

There are no nuclear installations in the category of research reactors that have been or are being constructed, commissioned, operated or decommissioned in the Slovak Republic.

3.3.3 Fuel cycle facilities

Not applicable

There are no nuclear installations in the category of fuel cycle facilities that have been or are being constructed, commissioned, operated or decommissioned in the Slovak Republic.

3.3.4 Dedicated spent fuel storage facilities

3.3.4.1 Prevention of fire spreading (barriers)

The fire safety design of the building (FSB) for the ISFS was developed as part of the basic design based on the then valid standard ČSN 73 0802.

In 2002, the FSB solution was reassessed in accordance with the requirements of Decree of the MoI SR No. 288/2000 [8], which establishes the technical requirements for fire safety during construction and use of buildings. The given FSB design was assessed by the Regional FaRC Headquarters and a favourable opinion was issued. In 2005, the ISFS building was reassessed in terms of the application of the Decree of the MoI SR No. 94/2004 [7] and the standards of the STN series 92 0201. In 2010, the implementation of the proposed fire protection measures specified in the revised (new) FSB design was completed. [70].

3.3.4.1.1 Design approach

Currently, the division of the structure into fire compartments based on the FSB design of 2005 [70], which is part of the fire hazard analyses [69], is valid for the ISFS. The ISFS civil structure is divided with respect to:

- requirements of the MoI SR Decree No. 94/2004 [7],

- the functional use of the individual spaces of the building under consideration in relation to the lengths of escape routes in order to allow the escape of persons from each point of the fire compartment,
- access of firefighting units to the endangered structure,
- minimising the potential extent of damage,
- minimising costs.

3.3.4.1.2 Description of the design of fire compartments and/or cells and their key features

The civil structure ISFS was assessed as a production building in terms of the FSB design in accordance with the Decree of the MoI SR No. 94/2004 and the STN 92 0201-1 standard [35]. Selected fire-technical parameters of the building are e.g.:
Structural element – D1 type

- construction products and materials used:
  - monolithic reinforced concrete up to level ±0,00 m – reaction to fire class A1,
  - monolithic reinforced concrete for storage pools with auxiliaries up to level ±0,00m – reaction to fire class A1,
  - steel structure (two halls, steel skeleton) – reaction to fire class A1,
- horizontal structures:
  - ceilings above the underground floor – reinforced concrete slab, thickness more than 200 mm,
    - required fire resistance according to FSB design [70] – 90/D1,
    - proven fire resistance of 240 minutes according to [57], [58],
  - ceilings above the ground floors – shaped VSŽ sheets filled with concrete with a slab thickness of 100mm lined with PROMATECT-H boards and shaped VSŽ sheets filled with concrete with a slab thickness of 100mm protected with PORFIX fire-resistant material,
    - required fire resistance according to FSB design [70] – 60/D1,
    - proven fire resistance REI 60 minutes according to [63].
- vertical structures
  - perimeter wall and internal walls of the 1st underground floor and part of the perimeter walls of the above-ground floors – reinforced concrete walls, thickness more than 200 mm,
    - required fire resistance according to FSB design [70] – 90/D1,
    - proven fire resistance of 180 minutes according to [57] and [58],
  - internal walls of the above-ground floors - concrete, made of solid bricks and from aerated concrete blocks, thickness 140 mm and more,
    - required fire resistance according to FSB design [70] – 60/D1,
    - proven fire resistance for masonry walls, 120 minutes according to [57] and [58],
    - proven fire resistance for concrete walls, 180 minutes according to [57] and [58],
  - steel structures ensuring the stability of the building – steel structures protected by SIBATERM and PLAMOSTOP P9 coating,
    - required fire resistance according to the FSB design [70] – 60 minutes,
    - proven fire resistance increased with PLAMOSTOP P9 coating to 60 minutes [63],
  - steel roof support structure – steel structures protected with SIBATERM and PLAMOSTOP P9 coating.

3.3.4.1.3 Lifetime performance assurance

Inspection of fire- separation walls and load-bearing structures is carried out as part of preventive fire inspections. The scope and method of execution are described in the Regulation BZ/KB/SM-07 [127].

3.3.4.2 Ventilation systems

3.3.4.2.1 Ventilation system design. Segregation and isolation

Basic principles for ventilation systems:
- maintaining negative pressure in areas where activity is likely to occur,
- ensuring parameters of the environment for operating personnel,
- ensuring external safety by filtering the air discharged from the ISFS into the environment.

3.3.4.2.2 Performance and management requirements under fire conditions

To ensure ventilation of protected escape routes of type B, the exhaust system is used for forced overpressure emergency ventilation - stairways by means of axial fans VAN 420 (4 pcs in total) and a system of automatic overpressure dampers located under the ceiling of the stairways. The fans are controlled manually from all exits from the ISFS premises to the staircase.

In the case of FDPS alarm, automatic shutdown of HVAC systems is not ensured. Any required shutdown or start-up of the HVAC system in the event of fire is carried out manually on the instruction of the intervention commander after consultation with the HVAC operator.

In the case of fire damper closure, the HVAC system is not automatically switched off. Alternatively, switching off or starting another HVAC system is done by manual manipulation by the HVAC operator. The functioning of the HVAC system (manual manipulation) is in accordance with the decree MoI SR No. 94/2004 [7].

3.3.5 RAW storage facilities

Not applicable

The nuclear installations Integral RAW Storage and National RAW Storage facilities are excluded from the review. The justification is given in Annex 1 to this report.

3.3.6 Facilities under decommissioning

Not applicable

NPP V1 and NPP A1 nuclear installations are excluded from the review, the justification is given in Annex 1 to this Report. The results of the review of the ISFS nuclear installation can be transferred also to NPP V1 and NPP A1.

3.4 Licensee´s experience of the implementation of fire protection concept

The Licensees´ (SE, a.s. and JAVYS a.s.) have several decades of experience in the implementation of fire protection concepts. Four VVER 440/V213 units are currently in operation in Slovakia - two at the Bohunice site and two at the Mochovce site. There are also two WWER 440/V213 units under construction at the Mochovce site, one of which is in the commissioning phase. The other three nuclear units at Bohunice are under decommissioning. In addition, both Bohunice and Mochovce have non-reactor nuclear spent fuel storage/radioactive waste storage facilities. Furthermore, the licensee uses the available experience with the implementation of the fire protection concept at other nuclear installations obtained through the WANO association/databases, but also from non-nuclear installations.

3.4.1 Nuclear Power Plants

The fire protection concept is based on national and international legislation and is applied on all NPP civil structures, in particular to:

- maintain the load-bearing capacity and stability of the supporting structures,
- prevent the spread of fire and smoke within the structure,
- prevent the spread of fire to neighbouring buildings,
- ensure the safety of personnel,
- ensure the safety of the intervening units.

The above-mentioned basic objective has already been largely fulfilled in the original design solution and improved together with the adopted experience or safety improvements from the reference NPP, implemented international recommendations and adapted requirements of the applicable national legislation in the field of fire safety of the construction, despite the fact that the design of Unit 3 of NPP MO3&4 does not represent a new design of the NPP.

The basic premise was to minimize the use of flammable substances and materials, whether in building structures or in technological systems. The use of materials with reaction to fire class A1 and A2 in the building structures is required, thereby significantly eliminating the possibility of fire spreading within the building between fire compartments or between civil structures.

In the case of technological systems containing flammable liquids, in buildings with safety-critical components in terms of nuclear safety, the seismic resistance has been increased in order to preserve their integrity after an earthquake and thus prevent the possible spillage of flammable liquids. Similarly, the choice of flammable liquids with a higher flash point, where possible, contributes to reducing the fire risk.

The application of the current legislation on flammable liquids [14] required the extension of the technology to include containment or emergency tanks for collecting oil, or to be equipped with flame arrester and permanently effective liquid seals, which significantly prevents the possible spillage of flammable liquids in the event of leaks.

In these areas, as well as in other areas, e.g. where flammable gases are present, explosive environment zones for electrical and mechanical equipment have been established and the areas are duly marked with safety signs according to the Government Regulation No. 393/2006 [22].

Despite the priority function of passive fire protection systems, active fire protection systems are installed, namely:

- for early fire detection, a fire detection system is installed in all buildings, the priority function of which is to detect and acoustically and visually signal a fire; in addition, the electrical fire alarm system also performs additional functions, such as control of fire dampers, control of FES, fire pumps, fans, etc.,
- the buildings are supplied with fire water from three independent looped systems; these systems are interconnected and have a sufficient supply of water for fire-fighting,
- fixed fire extinguishing equipment is designed in places and on technological systems with a high fire hazard, i.e. in particular where flammable substances are present in the technology.

During the ongoing construction of Unit 3 of NPP MO3&4 and the commissioning phase, experiences from the operating units (NPP EBO3&4 and NPP MO1&2) have been identified, evaluated and transferred to the design within the processes governed by the feedback guidelines [108] and the Correction and Prevention Program in the NPP [109]. In this way, issues were identified that were being transferred from operating units to units under construction through the OERs. Their application was then evaluated and, if approved, subsequently transferred to the design.

An example is the proposed change to the FDPS in the fire reporting room and the linking of the DesigoCC system to the Koja system, thus unifying the imaging from all operating units (1, 2, 3 and later 4). This system generates Dispatch Cards for the intervening fire brigade at a fire alarm. The change was subsequently addressed through the design change management process.

In the case of FESs, the systems were designed in accordance with international standards such as VDS or NFPA. Due to the extensiveness of some of the systems and their innovative nature, such as the water mist system and the ruggedness and diversity of the protected areas, there have also been some deviations from the designer's original intent. These deviations were then aggregated into a special program and test in order to verify the behaviour of the water mist FES in cable spaces under real conditions. A full-scale test of the water mist system simulated in real conditions was carried out, which demonstrated reliable extinguishing efficiency even under specific conditions and significant safety design margins of the adopted fire safety design concept for the building.

Similarly, in the case of the water curtain on the boundary between the turbine hall and the longitudinal intermediate electrical building, it has been shown that the cumulative fire protection measures in these protected areas have already achieved the safety objectives by other means and the water curtain has only a supporting supplementary function. In particular, the extraction of heat and combustion products from the turbine hall is an important contribution, which has been shown to significantly reduce the temperature during a fire in these spaces.

An important contributor to the fire safety of the building is mainly passive fire protection, where the essential requirements of the designer have been applied, in particular:

- the use of construction materials of reaction to fire class A1 and A2,
- civil structures are consistently divided into fire compartments or fire cells,
- the required fire resistance of building structures exceeds the minimum fire resistance required by the national legislation [7].

In specific cases, e.g. in cable ducts, the maximum fire compartment areas allowed by the standard have been significantly reduced.

The division into fire compartments was also respected by the HVAC design, based on which fire dampers were installed at the boundaries of the fire compartments, which are in seismic design in safety-significant civil structures. Most fire dampers are controlled by the FDPS system, mechanical dampers are closed only by a thermal fuse. In addition to the fire dampers, fire insulation of the HVAC ductwork was also used.

In spite of the specificities of the building of the main production unit, where the airtightness of the civil structure is required, protected escape routes with forced air ventilation were also implemented. This ventilation is automatically triggered by an FDPS signal. The overall design of the protected escape routes with forced ventilation contributes significantly to the safe evacuation of persons and firefighters.

Fire protection within the NPP units in operation is governed by internal regulations [98], [100] and [114], based on which the basic framework for the organisation of fire protection is established. Managers and supervisors communicate fire protection rules to employees, carry out walk-down inspections and supervise the performance of work in accordance with fire protection rules.

Within the organisation of works there are rules for activities with an increased risk of fire, storage of combustible materials and appropriate documentation is kept on this.

The Mochovce NPP site has a permanently present PFB, which is equipped with forces and means based on the conducted analysis [71] and is regularly trained.

3.4.1.1 Overview of Strengths and Weaknesses

In general, it can be stated that the design solution of NPP fire protection is conservative in terms of the use of construction materials, the division of buildings into fire compartments, the characteristics of cabling, the assumptions of safety analyses, the results of functional tests of fire-extinguishing equipment, the predefinition of the composition of the forces and means of the PFB for the most complex fire scenario in the respective civil structure, etc.

The Strengths include:

Design

- the characteristics of the cabling used, which consists of fire-retardant or fire-resistant cables that significantly reduce the fire hazard and, in addition, it was determined with consideration of the fire load of PVC cables,
- the fire resistance performance of the structures achieved is in many cases beyond the requirements of the design or national legislation,
- fire partitions in external cable ducts divide the space into smaller sections than required by the applicable standard for cable ducts. In addition, given the characteristics of the cables used, fire partitioning is not required by the applicable technical standard,
- the roof sheathing on the civil structures were made of materials meeting the CROOF (t4) criterion, despite the fact that roof coverings are not located in the fire hazard area of the adjacent building.
- in areas with oil systems, holding tanks have been installed to collect any leaking oil. In the case of the turbine hall, emergency tanks have also been constructed into which leaking oil from the holding tanks is drained,
- the existing staircase areas have been rebuilt based on the current legislation and made into protected escape routes with forced air ventilation,
- smoke-tight doors have been used beyond the requirements of the legislation and are located on protected escape routes between the fire hallway and other areas, and also in areas with increased smoke generation and around the unit control room and the emergency control room,
- preservation of the partition wall in the common fire compartment of the turbine hall between unit 2 and unit 3, which significantly eliminates the distribution of combustion products between the units and thus eliminates the negative consequences of a possible fire,
- all fire-resistant structures are maintained in a clear form with information on the fire resistance achieved and related documentation demonstrating the fire resistance,
- in the case of the use of innovative technologies (such as the water mist extinguishing system), deviations from the designer's original intent have occurred due to the granularity and diversity of the protected spaces. These deviations were then accumulated into a special program and test to verify the behaviour of the water mist FES in cable rooms under real conditions.

Functional tests and periodic inspection of the fire-fighting equipment

National legislation [6] a [16] distinguishes between different types of equipment used for protection against fire, which are collectively referred to as fire equipment. These include fire-technical equipment

(FTE), which are:

- fixed and semi-fixed extinguishing equipment,
- equipment for removal of heat and combustion products,
- electrical fire detection and protection system (FDPS).

The requirements for these installations are specified in the following Decrees [10], [11] and [16], which are binding on the licensee and are subject to inspections by the state supervisory authorities. During the placing into operation of the FES, the applied procedure was in accordance with the Decree of the MoI SR No. 169/2006 [10], where the functional test was carried out with a real medium (except for gas FES) in the presence of the representatives of the MoI SR, the Presidium of the FaRC. Once they were put into operation, they switched to periodic inspections. The legislation specifies the different types of periodic inspections and their content, or they are specified by the FTE manufacturer. These are usually the following types of inspections, depending on the type of FTE [10], [11] and [16]: daily, weekly, monthly, quarterly, semi-annually and annually. Written records are kept of the inspections carried out, e.g. an Operational Log, which indicates the deficiencies found and the proposed actions to remedy them. All FESs have been tested in the presence of the supervisory authorities before being put into operation.

Testing beyond the legal requirements was also carried out as part of the design validation. The functionality of the mist FES, as well as the overall conceptual design of the fire safety in the cable ducts was verified by a full-scale fire test in an accredited laboratory (see 3.2.1.2.1).

Plant Fire Brigade (PFB)

Among the strengths is clearly the existence of a PFB on-site, which is staffed and technically equipped in terms of fire hazard analysis according to the requirements of the MoI SR Decree No. 611/2006 [19].

In addition, PFB personnel receive detailed training on site-specific hazards, conduct site walk-downs and periodic drills in accordance with a refresher training plan approved by plant management.

Specific to the training is the familiarisation with the NPP technology and specific risks, during which the leading positions of the PFB undergo, among other things, standardised training for the NPP staff.

As a result, PFB personnel have theoretical knowledge and practical experience with the technology and civil structures at the site, locating areas with increased fire hazards, and have practiced cooperation with NPP operational personnel.

Staff of external cooperating units are also included in the training process, who also attend the theoretical part, tour of the premises, premises and surroundings of the NPP.

The PFB also performs other tasks in addition to those related to the FP. One of the tasks is the operation of mobile means for coping with beyond-design basis accidents.

One of the successful interoperability exercises with the FaRC was the verification of external transport of cooling water for the Mochovce NPP from the Hron River 7.6 km away, which is required by the emergency regulation [122]. The achieved times for the deployment of the required length of hose line and the start of water delivery with the required parameters were significantly better than expected when the exercise plan was developed.

Weaknesses include the issue of intervention routes, which, due to other legal and technical constraints, may cause delays for the intervening units. This issue is gradually being identified and addressed by appropriate technical solutions at the problem areas of the intervention routes.

3.4.1.2 Lessons learned from events, assessments and missions on fire safety

In general, the results of any mission are analysed, then specific tasks and deadlines are defined in the form of a Plant Manager's Order with an Action Plan on the results of the peer review mission.

A WANO mission at MO3&4 NPP Unit 3 was in 2021, still in the construction phase, and resulted in a number of findings and proposals for action, namely:

- ensuring the availability of FTE,
- introduction of adequate compensatory measures in the event of FTE malfunctioning,
- the lack of fire extinguishers at the posts,
- inconsistently sealed penetrations through fire separation structures,
- training of personnel in the operation of the FES,
- training of personnel in DG station oil spill incidents,
- monitoring of the premises with a focus on uncontrolled storage of combustible materials,
- marking of fire structures,
- updating evacuation plans.

From the above findings, an Action Plan has been developed, monitored by management, with responsible departments and deadlines for resolution defined. The identified deficiencies were eliminated, the tasks from the action plan were closed by the management in 2022.

Fire safety missions were carried out to a greater extent mainly at the operating units of NPP Mochovce and NPP Bohunice.

A number of technical and organisational deficiencies have been identified in the units in operation over the extended period of operation, particularly in the early days of these missions. These deficiencies were analysed by the licensee, the method of their solution was defined, the necessary steps that are standard for an investment project were planned and subsequently implemented.

Another example is the 2018 WANO mission, where deficiencies were identified:

- on staff attitudes towards fire hazards, as spills, leaks of flammable substances and unmanaged dumps of combustible materials were identified.

The Action Plan consisted of revising the operational loggers, changing the dumping of combustible materials, and adjusting the way contractors are managed.

Examples of other suggestions from Missions are given in 3.4.1.3.

Some of the practices at Mochovce NPP were also identified as good practice in the context of such missions. An example is the WANO mission, which identified the PFB as a good practice with the following justification: "The fire reporting room and the PFB control room are equipped with modern hardware and software with an update (dispatching system) that allows a fast and accurate presentation of the location of a reported fire. This upgrade unifies the outputs from two different electrical fire alarm centres and greatly assists in the operator's decision-making process. The dispatching system is linked to the fire station's dispatching equipment and performs a number of automated actions to enable the timely and safe dispatch of the fire brigade. One of these activities is the printing of an Exit Card with the specification of the fire location, with the visualization of textual and graphical information for the area. The use of state-of-the-art technology at the control centre greatly improves the reception and evaluation of emergency calls (electrical fire alarm systems, telephone calls, RDSt, Stenofone), Dispatching of pre-defined forces and equipment of the fire brigade (composition of dispatching based on the importance of the structure/premises and the presence of hazardous substances in the premises, firefighting tactics + recommendations for the commander of the intervention) and shortens the period from the reporting of a fire to the effective use of the forces and equipment of the Plant Fire Brigade."

It follows from the above that peer missions identify gaps, bring suggestions for improvement or experience from other operators. Findings are always treated with high priority and emphasis is placed on their elimination or implementation. The high priority of these tasks is evidenced by the fact that they are monitored by the management of the licensee.

3.4.1.3 Overview of measures and status of implementation

During the construction stage of Unit 3 of NPP MO3&4, the activities were carried out in accordance with the Integrated Safety Plan [125], which established the procedure and responsibilities in ensuring and applying the requirements of the Slovak legislation in the field of FP. Its aim is to ensure safety, fire protection and protection of property at the MO3&4 NPP construction site and is binding for all employees of SE contractors and their subcontractors involved in the execution of the work.

Based on these requirements, the following measures shall be applied continuously during the construction phase:

- carry out fire protection inspections on the construction site,
- coordination of risk activities in terms of FP,
- a system is in place for issuing PO permits for activities with increased fire hazards and fire precautions are determined,
- fire extinguishers are deployed and controlled on site,
- special measures are prepared for hazardous activities (tests, start-ups),
- securing the site during non-working hours.

The operating units (NPP MO1&2 and NPP EBO3&4) have undergone a number of safety or peer reviews in the field of FP during the lifetime of their operation. In addition to clarification of individual system functionalities or ambiguities, these missions also resulted in suggestions or recommendations for the implementation of organisational or technical measures to improve the level of FP. An Action Plan with a specific proposal for a solution is always developed for the deficiencies identified during the missions. In the case of organisational measures, the solution is usually implemented in a short time. Investment projects require a longer timeframe for implementation.

Table 3-1 Example of measures implemented at NPP based on recommendations from the insurers

Plant	Year	Citation of finding/ recommendation	Method and status of implementation
EBO 3&4	2008	It is necessary to eliminate flammable scaffolding (e.g. in an RAW treatment plant);	Replacement of wooden scaffolding floors with metal ones.
EBO 3&4	2008	Fire separation between units: It is necessary to install automatic fire doors, min EI60/D1, at the transitions between the units, also in the vertical direction.	Implementation of the separation between fire compartments based on the fire project.
EBO 3&4	2008	It is common practice to locate each fire pump, its drive and controls in a room separated from	The fire analysis showed that the space is with minimal fire load. Supporting steel structures of SO

Plant	Year	Citation of finding/ recommendation	Method and status of implementation
		other fire pumps by a fire barrier with a minimum fire resistance rating of 180 minutes.	584 with fireproofing coating in 2009 to 2013.
EBO 3&4	2008	External separation of outdoor transformers from adjacent structures: oil-insulated transformers with a capacity of 2250l of oil or more should be separated from adjacent buildings by a fire-resistant wall with a two-hour fire-resistance rating. Separation is acceptable if the wall on the side of the transformers has a 1-hour fire resistance rating and if, at the same time, the transformers are protected by an approved automatic water sprinkler system.	Realized water curtain between transformers and Turbine hall wall.
EBO 3&4	2008	Areas adjacent to security facilities should have fire separation. This is also an example of a "kitchenette" located next to a unit control room. A minimum fire compartmentation of EI60 is required.	Fire doors and glass with the required fire resistance installed.
EBO 3&4	2008	The turbine lubricating oil tanks and reservoirs pose a high fire hazard as they are not fire separated and in the event of a fire, water from the sprinklers (without generating a foam product) would spray burning oil (even through open grates in the floor) over the turbine hall. These tanks should be located in the RI80 enclosure, protected by the sprinklers. Sufficient fire protection of the tank supports, an effective automatic SHZ system (+ foam!) and a drainage system would need to be provided as soon as possible in case it is impractical to implement the whole enclosed space.	Installed foam semi-fixed extinguishers.
EBO 3&4	2008	We found that the division of the laundry into fire compartments did not comply with our regulations. As the laundry represents a large fire load, there is a high level of risk to the controlled zone, which is in close proximity. For this reason, we recommend investigating the possibility of a fire compartmentation of the laundry (min. EI60) and, if feasible, making the necessary improvements.	The special laundry room was separated from the other areas by installing fire doors.
EBO 3&4	2008	The room in which the lubricating oil drain tank is also located is visibly well separated against fire. However, it would be desirable to install fire dampers on the vent pipe.	Fire dampers installed.
EBO 3&4	2008	There is also a lack of suitable dampers on the oil vent line of the main circulation pumps.	In the MCP room, a FES was installed and fire dampers were added.

Plant	Year	Citation of finding/ recommendation	Method and status of implementation
MO 1&2	2006	During a visit to an active workshop we found a large stock of wooden planks (used for scaffolding). This is causing an undesirable fire load in the controlled area. The fire load in these areas should be minimal and the use of non-combustible materials for scaffolding is highly recommended.	Wooden scaffolding floors replaced with metal ones.
MO 1&2	2009	In the turbine hall there is a spacious fire separated oil room, where there is also an oil drain tank for the drained lubricating oil from the turbine. Given that it would not be easy to extinguish the fire and the heat could affect the concrete structure, there is a real risk that electricity generation would be paralysed for a considerable period of time. Therefore, this room should be equipped with an automatic fire extinguishing system.	In 2013, a foam FES was installed and tested in the central oil management (COM) area.

Other measures are implemented based on other suggestions, such as changes in legislation or periodic safety assessments. Examples are the following:

- based on the requirements of the Decree of the MoI SR No. 96/2004 [14], the capacity of the emergency tanks of the outdoor transformers for transformer oil leakage was increased in NPP EBO3&4,
- as part of the implementation of the measures resulting from the NRA SR inspection for NPP EBO3&4 on the periodic nuclear safety review performed in 2017, tasks were adopted to implement the FP measure related to the NPP safety systems; these have already been implemented,
- the deterministic analysis of 2017 for NPP EBO3&4 showed the need to install a fire detection system for the oil management of the electrical feed pump in the turbine hall; the implementation of the task is in the process of preparation with a planned implementation date in 2025; furthermore, this analysis resulted in a task for the implementation of the automatic start of the fire extinguishing of the transformers; the implementation is in the process of preparation.
- corrective actions for NPP MO1&2 are formulated in an internal management regulation and concern the updating of fire protection documentation, in particular in relation to nuclear safety requirements, categorisation of installations and control of the fire engineering properties of structures; the tasks resulting from this regulation are in the process of preparation.

3.4.2 Research reactors

Not applicable

There are no nuclear installations in the category of research reactors that have been or are being constructed, commissioned, operated or decommissioned in the Slovak Republic.

3.4.3 Fuel cycle facilities

Not applicable

There are no nuclear fuel cycle facilities in the Slovak Republic that have been or are being constructed, commissioned, operated or decommissioned.

3.4.4 Dedicated spent fuel storage facilities

In general, it can be stated that the design solution for the protection of the Interim Spent Fuel Storage facility against fires is conservative.

3.4.4.1 Overview of Strengths and Weaknesses

Strengths:

- verified fire resistance of building structures,
- power cables for selected safety equipment in non-fire propagating design (IEC 332) and with functional fire resistance (IEC 331) according to the above standards in force in 2010,
- Plant fire brigade.

Weaknesses have been identified in other controls and assessments carried out. They have led to the following recommendations for improving the level of fire protection:

- to complete the replacement of fire hydrants on the fire water distribution system in the JAVYS premises,
- to review the components of the FDPS system in terms of their durability and market availability,
- to replace the cable connections of the FDPS control panels by creating redundancy (one cable contains cores that are redundant, so that redundancy becomes meaningless when the cable breaks),
- re-evaluate the use of voice alarm in the ISFS civil structure,
- re-evaluate the possibility of controlling important fire equipment (HVAC equipment, ventilation of protected escape routes, fire doors, power shutdown) via the FDPS,
- elaborate procedures for the repair of damage to fire protection measures (coating, spraying, lining) applied to fire structures,
- develop operational cards for intervention in the ISFS construction,
- to develop a clear system of marking of fire closures.

The above recommendations only serve to improve the level beyond the required legal and regulatory requirements.

3.4.4.2 Lessons learned from fire safety incidents, assessments and missions

There are no recommendations.

3.4.4.3 Overview of measures and status of implementation

Currently none

3.4.5 RAW storage facilities

Not applicable

The nuclear installations Integral RAW Storage facility (IRAWS) and National RAW Repository (NRAWR) are excluded from the review. The justification is given in Annex 1 to this report.

3.4.6 Installations under decommissioning

Not applicable

NPP V1 and NPP A1 nuclear installations are excluded from the review, the justification for exclusion is given in Annex 1 to this report. The results of the ISFS nuclear facility review can be transferred to NPP V1 and NPP A1.

3.5 Regulator´s Assessment and Conclusions on Fire Protection Concept

The NRA SR approves the basic design of the nuclear installation and related amendments, which includes the fire protection concept and fire safety solution of the construction. The Authority also approves the probabilistic fire risk assessment. During the construction of the nuclear installation, the NRA SR, as well as the Presidium of the FaRC carried out regular inspections of the erection works, participated in conformity checks and functional tests of the fire protection equipment. During operation, the Authority's inspectors conduct regular inspections and monitor the state of fire protection. The licensee shall inform the Authority of any changes to the fire protection equipment and structures. Major changes or cumulative changes with an impact on the fire protection concept lead to an update of the fire hazard analyses. The NRA SR, in cooperation with the FaRC Presidium, checks the modifications in the framework of inspections. Identified deficiencies are continuously eliminated. Fire protection is subject to periodic safety review.

3.5.1 Overview of Strengths and Weaknesses of the fire protection concept

The NRA SR performs state supervision in the form of inspections in nuclear installations based on the Act [1] and Act No. 10/1996 Coll. on Control in State Administration, as amended. The NRA SR is guided by the internal regulation "Guideline on the inspection activities of the NRA SR" with the code S 310 007:22. The regulation describes the procedure for performing inspections, the processing of the documentation of inspections, as well as the categorisation and analysis of the results of the inspections. The NRA SR inspections are carried out based on an approved inspection plan. The inspection plan is issued annually in the form of an Order by the Chairperson. The inspection plan defines the inspection areas. For fire protection, the inspection area is defined as 'FP'.

The NRA SR carries out inspections according to the inspection procedures. In case it is necessary to inspect an area not covered by the inspection procedures, a specific inspection procedure shall be developed. In case of repeated use of a specific inspection procedure, the procedure shall be converted to a standard inspection procedure. During the construction or refurbishment of a fire protection installation, inspectors shall follow the Inspection Procedure – Inspection of Installation Work (P 320 022:18). After the systems or parts thereof have been installed, inspectors shall inspect the fire protection equipment in accordance with the inspection procedure – Post-installation inspection – Compliance check (P 320 021:18) in accordance with the requirement of Section 10(1)(w) of the Atomic Act [1], which states that during the construction, reconstruction or repair of nuclear installations, the licensee must ensure, in the presence of the Authority or persons authorised by the Authority, that the assembled systems, structures, components or parts thereof are checked for compliance with the design documentation, quality assurance requirements, quality requirements and verify the compliance of their accompanying technical documentation with the generally applicable legislation, and that records of the inspections are made and kept. Based on inspection procedure P 320 021:18, the Authority's inspectors participated in 22 compliance checks for fire-fighting equipment. Fire dampers were inspected as part of the compliance checks for HVAC systems, in which the Authority also participated. Based on the approved inspection plans, the results of the compliance inspections are reported in the quarterly inspections conducted by the inspectors at the MO3&4 NPP and result in an inspection record or report. During the construction of MO3&4 NPP, inspectors also participated in selected functional tests of fixed fire extinguishing systems and electrical fire alarm systems.

The NRA SR on-site inspectors carry out walk-down inspections according to the inspection procedure (P 310 004:18), by the individual modules. Fire protection is included in module M4 "Fire safety". Pre-prepared checklists are used for the inspection.

The NRA SR carries out special inspections for fire protection according to the Inspection Procedure - Inspection of Fire Protection Assurance (P 350 005:22). According to this inspection procedure, the designated inspector of the NRA SR carries out a comprehensive inspection at a frequency of once every seven years at a given nuclear installation, i.e. one nuclear installation is comprehensively inspected each year. The designated Authority inspector evaluates the inspection and inspection intervals may be adjusted according to the severity of the findings. In accordance with inspection procedure P 350 005:22, the designated inspector shall also keep a record of information received from site inspectors if they identify deficiencies in fire protection. He/she analyses this information and, on the basis of his/her evaluation, determines which area of fire protection (drills, technical condition and functionality of the FDPS and FES) needs to be inspected more frequently and, if necessary, carries out unscheduled inspections. The designated specialist inspector continuously records the status of fire protection at the nuclear installations, participates in compliance checks in the case of installation of a new FES/FDPS, or repair and modification of FES/FDPS, checks the provision of fire protection in a civil structure, for which a decision was issued in the previous period for a building permit, for modification of a completed construction, for use of the construction (approval decision), for a change in the use of the construction, or for another permit in accordance with the Building Act. This inspection shall be carried out in cooperation with the Fire and Rescue Corps Presidium. The designated specialist inspector shall participate once every seven years, i.e. daily, monthly and annual inspection of the FDPS, daily, weekly and annual inspection of the FES, so that at each nuclear installation the inspector checks a different FDPS and FES system. Furthermore, the designated specialist inspector shall participate in the first functional test of newly installed FESs, which shall be carried out in accordance with Article 14(1) of MoI SR Decree No 169/2006, in cooperation with the Fire and Rescue Corps Presidium. The site inspector shall, in accordance with the inspection procedure P 350 005:22, participate once a month in the inspection of the functionality and condition of the FDPS and FES.

The NRA SR has experience in the inspection of fire protection measures from design, through their implementation and functional testing to operation. Based on the knowledge gained, the NRA SR is continuously improving the performance of its inspection activities. For example, the need to have a constant overview of the state of fire protection systems has become apparent, which has led to the definition of new duties for site inspectors, who check the state of fire protection installations on a monthly basis. The participation of inspectors in regular inspections (daily, monthly and annual inspection of FDPS, FES) of fire protection equipment and systems was also introduced, which proved to be a very effective tool for verifying the functionality of fire protection systems from the point of view of the NRA SR. During the construction of NPP MO3&4 it became necessary to participate in the first functional test of newly installed FES. These requirements for inspections were defined by the NRA SR in the inspection procedure (P 350 005:22). As the NRA SR inspects fire protection installations primarily in relation to nuclear safety requirements, cooperation with the Fire and Rescue Service has been developed on the basis of a signed cooperation agreement. Within the scope of its competences, the NRA SR inspects fire protection and has developed a documentation framework that reflects the gradual development of the experience gained and its implementation in the inspection practice.

The NRA SR considers the strong legislative framework, which the licensee complies with, to be a strength of fire protection. Other strengths are the application of feedback by the licensee for the purpose of continuous improvement, the implementation of thorough inspections of the facilities and the work carried out, which led to the detection and subsequent elimination of deficiencies before the functional testing of the facilities and the existence of a competent and adequately equipped Plant Fire Brigade on the NI site.

The fire protection concept is elaborated and developed in great depth, in many cases beyond the legal requirements. The concept is applied in all aspects of fire protection. The fire protection concept complies with the legislative framework and is implemented in accordance with the design.

3.5.2 Lessons learned from the inspection and assessment of the implemented fire protection concept under regulatory oversight

The supervisory authorities did not identify weaknesses in the fire protection concept itself. However, during the inspections, the supervisory authorities identified weaknesses in the implementation of the fire protection systems. During the construction of Unit 3 of NPP MO3&4, fire protection coatings were damaged, fire barriers were broken during cable installation or it was necessary to modify the location of FDPS detectors when the detection range was not in accordance with the design due to their overlay by other technology. Poorly executed detailed design led to engineering modifications at the site. For example, it was necessary to modify the design of the fire pumps, whose vibrations were transmitted to other system components. All of these deficiencies were corrected by the licensee, and the lessons learned from these deficiencies have been reflected in improved installation processes at the adjacent MO3&4 NPP Unit 4, where similar deficiencies occur to a much lesser extent or not at all.

3.5.3 Conclusions on the adequacy of the fire protection concept and its implementation

The fire protection concept in nuclear installations has been developed in many cases beyond the legal requirements and has also been implemented beyond the legal requirements. In case of necessity, in the preparation of the project documentation, priority was given to the implementation of nuclear safety, in accordance with the provision of fire safety of the building by an engineering approach.

Requirements for fire safety during construction and use of buildings are met in accordance with generally binding legal regulations in the field of fire protection.

The fire protection concept in the NI is in accordance with international standards and corresponds to good practice, as evidenced by the low number of fires.

4 Overall Assessment and General Conclusions

The fire safety design of the building was originally designed in accordance with the then applicable legal framework and standards of the former Soviet Union, adapted to the conditions of the former Czechoslovakia. The most significant changes to the fire protection design occurred in the 1990s, when the recommendations of the IAEA Safety Guide No. 50-SG-D2 on fire protection were applied [25]. This improvement was applied on all NPPs in Slovakia.

As the NPP MO3&4 project in the completion phase was started at a later time, the legal conditions, national [1], [2], [32], [6], [7] to [19] and international [25], [26], [27] standards were logically changed and these were applied during the construction. A series of standards for the design of fixed fire extinguishing systems [40], [41], [42] and [43], equipment for smoke and heat extraction [52] and electrical fire alarm systems can be mentioned [53].

A similar approach was taken for the ISFS, where there were also significant changes in the fire safety design of the building due to changes in the legislative framework and the application of new norms/standards and operational experience.

The fire protection design includes solutions in accordance with the principles of defence-in-depth, where it is proven that a fire at any location of the NI (despite the preventive measures taken) will not become a cause of non-compliance with the general safety conditions, the essential safety functions of the NI will not be compromised, and at the same time the fire protection requirements set out in the legislation and technical standards will be met.

The defence-in-depth is formed by three basic barriers:
- prevention,
- detection and repression - the rapid identification of a fire and the provision of means to rapidly extinguish or suppress the fire,
- preventing the spread of fire - by fire-separation structures.

The following analyses have been prepared in the framework of fire protection:
- deterministic analysis, which is a part of the fire safety design and was prepared for all civil structures and determined the requirements for fire structures, the need for installation of fire technical equipment (FTE) and other requirements in accordance with the Decree of the MoI SR No. 94/2004 [7] (for both NPP MO1&2 and NPP EBO3&4, a supplementary deterministic fire hazard analysis was also prepared, which includes an evaluation of the possible impact of fire on nuclear safety),
- probabilistic assessment, which includes an assessment of internal fires to identify fire sources of systems and components that may be rendered unavailable by fire, to determine the frequency of fire and the contribution of fire to core/fuel melting frequencies,
- fire hazard analysis in accordance with Decree of the MoI SR No. 611/2006 [19], the aim of which was to determine the forces and means necessary for intervention on the largest area by calculating the expected fire, or the most complex fire scenario.

The above analyses have been subject to review by the supervisory authorities in the case of:
- deterministic analysis or fire safety design by the MoI SR, the FaRC Presidium, on the stage of issuing the building permit and subsequently on all design changes with an impact on the fire safety design,
- probabilistic assessment by the Nuclear Regulatory Authority,
- fire hazard analysis by the Regional FaRC Headquarters.

In all cases, compliance with the legislative requirements has been confirmed by a decision of the competent authority. The analyses are kept up to date. They demonstrate the maintenance of an acceptable level of nuclear safety even in the event of a fire at a nuclear installation.

The concept of fire protection for buildings is aimed at:

- preserving the load-bearing capacity and stability of supporting structures, preventing the spread of fire and smoke,
- the evacuation of persons and the safety of intervention units in the event of fire.

Other essential preventive measures were:

- minimization of flammable materials,
- measures on process equipment to prevent the spread of fire, and ensuring nuclear and radiation safety,
- provision of means and conditions for effective fire-fighting.

In terms of minimising combustible substances, special mention should be made of cable distribution systems where fire-retardant or fire-resistant cables have been used. In the case of the older units and the ISFS, fire retardant cabling coatings were used.

Where the use of flammable liquids is unavoidable, the use of flammable liquids of higher flammability classes is preferred. Storage facilities and areas containing process equipment with flammable liquids shall be designed and constructed in accordance with Decree [14] in order to prevent the spread of flammable liquids, for example, in the event of an unintentional spillage.

As part of active fire protection, the premises are equipped with:

- fire detection - an electric fire alarm system, which is used to identify a fire in a protected area (the area in which the electric fire alarm detectors are located), acoustic or optical alarm and controls via input/output interfaces the devices that are connected to it (control of fire dampers, activation of FES, HVAC, etc.),
- fire water – the looped fire water distribution system in the Mochovce NPP and Bohunice NPP area is connected to an "inexhaustible" source of water for extinguishing, which provides the necessary amount of fire water to the external hydrant network, internal hydrants within the civil structures and to the systems of the fixed fire extinguishing system (FES),
- fixed fire extinguishing systems are installed at the NPP in the following areas: FES in cable rooms, FES of external transformers, FES of TG oil tanks, FES of solid combustible RAW storage, FES in the pump room of the MCP, foam FES in the DG station and water curtain in the longitudinal intermediate electrical building,
- the NPP heat and combustion products extraction equipment is installed in the largest fire compartment in the turbine hall, and is used for:
    - removal of combustion products and heat,
    - fresh air supply,
    - maintaining conditions for the intervening fire-fighters unit.

Passive fire protection is mainly represented by:

- structural systems in civil structures are non-combustible in accordance with the requirements of [7] and [35],
- building products with reaction to fire class A1, A2 [54] are used in building structures,

- the building structures have demonstrated the required fire resistance on the basis of the initial type tests carried out in accordance with the product standards or by calculation in accordance with the technical standards, 'Eurocodes'; this is documented in the Certificates of Fire Structures, which are part of the accompanying technical documentation (ATD),
- fire dampers proven by tests carried out according to standard [55] or fire-insulated HVAC piping are used in the HVAC systems,
- penetrations of pipelines, penetrations of installations, penetrations of technical equipment and penetrations of technological equipment through fire partition structures are sealed in such a way as to prevent the spread of fire to another fire compartment. Fire seals and gaskets shall be made in accordance with ETAG 026/1, ETAG 026/2, ETAG 026/3, ETAG 028/2 and [54].

Fire-protection equipment is qualified in accordance with the requirements of the NRA SR Decree No. 430/2011 [2]. As part of the validation of the fire protection project, tests beyond the legal requirements were also carried out. For example, the functionality of the mist FES, as well as the overall conceptual design of fire safety in cable ducts was verified by a full-scale fire test in an accredited laboratory.

The basic documents in the field of fire protection are [98] for SE, a.s. and [127] for ISFS, which deal with procedures, responsibilities and powers in the process of fire protection. Document [98] is further elaborated for the conditions of NPP MO1&2 and MO3&4 in the guide [114].

The fire protection procedural documentation clearly defines:
- organisational arrangements for fire protection for licensees,
- the duties of the statutory body, other managers and other employees to ensure fire protection in SE,
- a list of buildings and an overview of places with increased fire hazard,
- the method and time limits for carrying out inspections and preventive fire inspections of buildings and workplaces,
- a list of buildings with simple conditions in terms of evacuation of persons and other requirements in the field of FP,
- the method of ensuring fire protection during non-working hours.

In addition, the management documentation discusses the periodical training and education of staff, which are carried out at prescribed intervals.

Within the concept of fire protection, all civil structures are implemented with regard to:
- preserving the load-bearing capacity and stability of supporting structures, preventing the spread of fire and smoke,
- the evacuation of persons and the safety of intervention units in the event of a fire.

Other essential preventive measures are:
- minimization of flammable materials,
- measures on process equipment to prevent the spread of fire, and ensuring nuclear and radiation safety,
- the provision of means and conditions for effective fire-fighting.

Both the Mochovce and Bohunice NPP sites have a permanent PFB, equipped with forces and means based on the analyses [71] and [72]. The PFB is regularly trained in the conditions of the NI.

During the construction phase of Unit 3 of NPP MO3&4, i.e. from 2009 until 2018, a total of 11 fires were registered in various civil structures. All incidents were documented and evaluated in an "Incident Report" and did not have a major impact on the construction progress. As part of the assessment, preventive measures were proposed and taken to avoid similar events, typically:

- training of staff,
- intensifying control activities,
- technical measures.

During the construction, inspections were carried out by the MoI SR, the FaRC Presidium, aimed at the implementation of building structures and functional tests of FTE, during which several shortcomings or unfinished construction work were identified, which were subsequently removed. Records were kept of the inspections and individual findings were demonstrably removed, re-verified, and subsequently a decision of the MoI SR, the FaRC Presidium, was issued for the premises in question. During the inspections for the issuance of opinions for the purposes of the procedure for the premature use of the building, the MoI SR, the FaRC Presidium, checked the implementation of the building according to the approved project documentation from the point of view of fire safety of the building. It checked the equipment of the building with fire equipment and checked the documentation in accordance with the requirements of generally binding legal regulations. At the same time, it checked the elimination of identified deficiencies.

In the case of the fire technical equipment (FTE) at MO3&4 NPP, the legislation for the respective type of FTE was followed, where the supervisory authority (FaRC) participated in functional tests and after successful tests and putting the FTE into operation, periodical inspections according to the legislation in force [10] to [13] started. The NRA SR has a comprehensive system of fire protection controls in place and carries out controls and inspections during all stages of the NI life. The results are recorded by the supervisory authorities and are continuously evaluated. This comprehensive control system is continuously improved.

The adequacy of the NI protection against fires is the subject of the periodic nuclear safety review provided for in the Decree of the NRA SR No. 33/2012 [4] and specified in the safety guide [34].

During the last 38 years of operation of EBO3&4 and MO1&2 NPPs (1984-2022, 121 reactor-years), out of the total number of recorded fires, there have been two small fires (a fire in the turbine hall in 2005 on the electrical feed pump and in 2011 when the TG insulation was on fire), which, if not extinguished, could potentially cause more significant damage. The incidents were documented and evaluated in an "Incident Report" and had no impact on the safety of operations. As part of the evaluation, preventive measures were proposed and taken to avoid similar events. The risk of fire is minimised by the fire protection measures taken and compliance with obligations arising from generally binding legal regulations. The results of the PSA also confirm the negligible impact of fires on the risk of the NPP operation.

No incident (fire, near-fire, smoke) with an impact on nuclear safety or fire protection has been recorded at the ISFS so far. This confirms the implementation of sufficient fire prevention.

In conclusion, it can be stated that the design solution for the protection of the NI against fires is conservative. The achieved level of fire protection at the NPP and ISFS contributes significantly to the overall safety of the NPP. The permanent presence of an effective fire brigade on site, equipped with adequate fire-fighting forces and means, including regular training of personnel, can be considered as best practice.

5 References

[1] Act No. 541/2004 Coll. on the peaceful uses of nuclear energy (Atomic Act) and on amendments, as amended

[2] Decree of the Nuclear Regulatory Authority of the SR No. 430/2011 on the requirements for nuclear safety as amended by Decree No. 103/2016

[3] Decree of the Nuclear Regulatory Authority of the SR No. 431/2011 on the Quality Management System, as amended

[4] NRA SR Decree No. 33/2012 on the periodical, comprehensive and systematic nuclear safety review of nuclear installations as amended

[5] NRA SR Decree No. 58/2006, laying down details of the scope, content and method of preparation of documentation of nuclear installations necessary for decisions as amended

[6] Act No. 314/2001 Coll. on fire protection, as amended

[7] Decree of the Ministry of Interior of the Slovak Republic No. 94/2004, laying down technical requirements for fire safety during construction and use of buildings, as amended

[8] Decree of the Ministry of Interior of the SR No. 288/2000, laying down technical requirements for fire safety during construction and use of buildings

[9] Decree of the Ministry of Interior of the SR No. 699/2004 on the provision of water in buildings for extinguishing fires, as amended by Decree No. 562/2005

[10] Decree of the Ministry of Interior of the SR No. 169/2006 on the specific characteristics of a fixed and semi-fixed extinguishing equipment and on the conditions for their operation and ensuring their periodical inspection

[11] Decree of the MoI SR No. 726/2002, laying down the characteristics of electric fire alarms, the condition for their operation and ensuring their periodical inspection

[12] Decree of the MoI SR No. 719/2002, laying down the characteristics, conditions of operation and ensuring periodical inspection of portable fire extinguishers and mobile fire extinguishers

[13] Decree of the MoI SR No. 478/2008 on the characteristics, specific conditions of operation and periodical inspections of the firestop

[14] Decree of the MoI SR No. 96/2004, laying down fire safety principles for the handling and storage of flammable liquids, heavy fuel oils and vegetable and animal fats and oils

[15] Decree of the MoI SR No. 124/2000, laying down fire safety principles for activities with flammable gases and combustible gases

[16] Decree of the MoI SR No. 121/2002 on fire prevention, as amended

[17] Decree of the MoI SR No. 347/2022 on the characteristics and conditions of operation, labelling and periodical inspection of fire extinguishers

[18] Act No. 133/2013 Coll. on construction products and on amendments to certain laws, as amended

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Annex 1: Selection of NIs for TPR II and its justification

1) List of Nuclear Installations in the SR

The list of nuclear installations in the Slovak Republic subject to European Union Directive 2014/87/Euratom amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations includes the following nuclear installations:

- Nuclear Power Plant EBO3&4, Bohunice site
- NPP MO1&2, Mochovce site,
- NPP MO3&4, Mochovce site,
- Interim Spent Fuel Storage Facility (ISFS), Bohunice site,
- NPP V1 (under decommissioning), Bohunice site,
- NPP A1 (under decommissioning), Bohunice site,
- Integral RAW Storage facility (IRAWS), Bohunice site; and
- National RAW Repository (NRAWR), Mochovce site.

2) Candidate nuclear installations and justification for their selection

- NPP MO3&4 (Unit 3), Mochovce site,
- Interim Spent Fuel Storage facility (ISFS), Bohunice site,

NPP MO3&4 (Unit 3) (WWER-440/V213 in commissioning process) – candidate NI

All NPPs in operation in Slovakia (NPP EBO3&4 and NPP MO1&2) and all NPPs in delayed construction (NPP MO3&4) are NPPs of the same type (WWER-440/V213) and belong to one licensee - SE, a. s. NPP EBO3&4 (2 units) was commissioned in 1984 and 1985; NPP MO1&2 (2 units) was commissioned in 1998 and 2000. NPP MO3&4 (Unit 3) is expected to be commissioned in 2023, i.e. it is now in the commissioning process. All operating NPPs are subject to periodic and comprehensive periodic safety reviews. All NPPs (both operating and under delayed construction) have been subjected to stress tests and nuclear safety enhancement measures have been implemented at all NPPs. The NPPs in question have a comparable level of safety. For the purpose of Topical Peer Review (TPR-II) we are forming a group of WWER 440/V213 NPPs in Slovakia, which will be represented by MO3&4 NPP (Unit 3). The differences between the NPPs in fire protection will be described in the National Assessment Report (NAR). The fire protection assessment at NPP MO3&4 (Unit 3) is justified and is on the list of installations to be assessed due to the fact that the latest fire protection standards are in place at NPP MO3&4 and the lessons learnt from the review at NPP MO3&4 can be transferred to both NPP EBO3&4 and NPP MO1&2.

ISFS – Candidate NI

The ISFS is a nuclear spent fuel storage facility that has been in operation since 1987. Spent fuel is stored in a pool of demineralised water. The current capacity is 93 % full and therefore the storage capacity is currently being expanded to include a dry (passive) form where the fuel will be stored in special canisters cooled by natural air circulation. Due to the rich inventory of radionuclides, the release of radionuclides into the environment could be large in the event of a severe accident at the ISFS. Therefore, a fire protection review at this nuclear installation is justified and it is on the list of installations to be reviewed.

The fire protection of the ISFS is maintained at the level of the operating NPP through contract with the professional firefighting services of the SE (NPP EBO3&4) based at the same location as the ISFS.

A fire-resistant dry ISFS facility is under construction (SNF from the wet part of the storage facility will be moved to the dry part). This method of fuel cooling is independent of power supply.

3) Represented and excluded nuclear installations and justification for their selection

- NPP EBO3&4, Bohunice site
- NPP MO1&2, Mochovce site,
- NPP V1 (under decommissioning), Bohunice site;
- NPP A1 (under decommissioning), Bohunice site;
- Integral RAW Storage facility (IRAWS), Bohunice site; and
- National RAW Repository (NRWAR), Mochovce site.

NPP EBO3&4 (2 Units WWER-440/V213 in operation) and NPP MO1&2 (2 Units WWER-440/V213 in operation) – represented NIs

These operating nuclear power plants are not assessed separately, but are included in the fire hazard assessment envelope for NPP MO3&4 (Unit 3) for the following reasons:

- All NPPs in operation in Slovakia (NPP V2 and NPP MO1&2) and all NPPs under delayed construction (NPP MO3&4) are NPPs of the same type (WWER-440/V213) and belong to one licensee – SE, a. s. All NPPs have been subjected to stress tests and nuclear safety improvement measures have been implemented at all NPPs. The NPPs in question have a comparable level of safety and any differences between the NPPs in fire protection will be described in the National Assessment Report.
- NPP MO3&4 (Unit 3) is expected to be commissioned in 2023, i.e. it is now in the process of commissioning.
- In NPP MO3&4 (Unit 3) the latest fire protection standards have been introduced.
- Lessons learned from the inspection of NPP MO3&4 can be transferred to both NPP EBO3&4 and MO1&2.

NPP V1 (2 Units of WWER-440/V230 in decommissioning) – excluded from review

This nuclear installation is excluded from the scope of installations for which a fire risk assessment will be carried out based on the following arguments:

- Nuclear power plant V1 in Bohunice, 2 units WWER 440/V230, commissioned in 1978/1980, decommissioned in 2006/2008 after standard operation. Fuel removal from the NPP was completed in 2011. The first phase of decommissioning took place in 2011-2014. Currently, V1 is in the final - 2nd phase of decommissioning. The decommissioning activities are planned to be completed in 2027, when the site will be released from administrative control after the final survey. Much of the NPP equipment has already been dismantled and is being treated, with fragmentation and decontamination being the dominant material treatment activities. In this phase of decommissioning, the production of metallic materials and materials from demolition is predominant.
- Fire protection of NPP V1 is maintained at the level of the operating NPP through contracts with the SE´s professional plant firefighting unit (NPP EBO3&4), which is located on the same site as NPP V1.
- There are no significant quantities of flammable liquids and gases available or in use in NPP V1 that

could cause fires and consequent releases of radioactive materials to the environment. There is a significantly lower fire hazard compared to operating NPPs and a negligible radiation risk due to fire
- The radioactive materials are in solid, non-flammable form.

NPP A1 (1 Unit HWGCR under decommissioning) – excluded from review

This nuclear installation is excluded from the scope of installations for which a fire risk assessment will be carried out based on the following arguments:
- The 150 MWe heavy water and gas cooled reactor (HWGCR) of NPP A1, located at the Bohunice site, commissioned in 1972, shut down in 1977 after an operational accident and decommissioned in 1999. The decommissioning of NPP A1 has been underway since 1999 and is divided into five separately authorised phases with completion scheduled for 2033. Decommissioning, consisting mainly of decontamination and dismantling activities, shall be carried out in a stepwise manner, starting with low contaminated facilities and areas and ending with facilities and areas with the highest contamination. The decommissioning process is influenced by the need to address the management of atypical radioactive waste containing sludge and organic compounds.
- JAVYS, as a licensee is currently carrying out activities related to the decommissioning of original, non-functional and unused technological systems of external equipment and technological equipment of the main production units of the reactor hall. The decommissioning of highly contaminated components such as the primary circuit, reactor, for which the use of remotely controlled technologies is envisaged, is under preparation.
- In terms of fire protection, the overall condition of the NPP A1 buildings is good and they are constructed of non-combustible and fire-resistant materials. Fire protection procedures are in place and automatic fire detection systems are operational.
- The fire protection of NPP A1 is maintained at the level of the operating NPP through contracts with the SE's professional plant firefighting unit (NPP EBO3&4) located on the same site as NPP A1.
- NPP A1 is characterised by a significantly lower fire hazard compared to operating NPPs.
- The radiation risk due to fire is negligible. The calculated values of the annual effective dose at the boundary of the protection zone for the reference accident are ~3 orders of magnitude lower than the established acceptance criteria (1 mSv/year)).

Integral RAW Storage facility – excluded from review

This nuclear installation is excluded from the scope of installations for which a fire risk assessment will be carried out based on the following arguments:
- IRAWS is designed for the storage of solid or solidified RAW. Under the L&Cs, RAW containing explosive substances, Class 1 combustibles and residual heat producing materials are excluded from storage. This significantly reduces the impact of fire on the radiological risk to personnel, the public and the environment.
- The IRAWS is designed for long-term storage, which is also reflected in the choice of packaging and the physical-chemical form of the stored RAW, which emphasises the resistance to initiation events (including fire hazard related events), throughout the storage period. The design, the furnishing of the buildings, the barriers used as well as the technologies installed are preferably based on elements of passive safety, also in relation to fire hazard. Packaging sets are made of materials that are not expected to ignite or burn (fibre-concrete, galvanised sheet metal, steel structures and carbon steel).
- The IRAWS does not provide any other RAW management activities apart from storage. It does not contain RAW treatment technologies and lines that would increase the risk of fire.
- Handling of RAW packages is handled only by cranes, which reduces the risk of fire, e.g. because of

the breakdown of a forklift truck with a conventional (petrol or diesel) engine, leakage of combustible fuels, etc.

- In the development of the emergency scenarios, initiating events from internal and external causes were assumed in view of the nature of the nuclear installation. The scenarios of package drop, leakage of contaminated waste water, flooding of the storage facility and others were analysed.
- Another active element that contributes to reducing the risk of nuclear safety due to fire is compliance with technological operating procedures, instructions and schedules for in-service inspections of equipment.

National RAW Repository – excluded from review

This nuclear installation is excluded from the scope of installations for which a fire risk assessment will be carried out on the basis of the following arguments:

- The National RAW Repository Mochovce is a multi-barrier surface-type repository designed for the final disposal of solid and solidified low- and very low-level radioactive waste generated during the operation and decommissioning of nuclear facilities, research institutes, laboratories and hospitals in the Slovak Republic. The National RAW Repository was put into operation in 2000 and is operated by JAVYS.
- The facility is resistant to fire hazards.
- Low-level waste is solidified in highly resistant disposal containers.
- Disposal of explosive materials is prohibited according to waste acceptance criteria.

Annex 2: Photos of fire-engineering equipment and their testing

Fig. P2-1 Fixed extinguishing system test on horizontal cable trays in Pavus, Czechia

Fig. P2-2 Fixed extinguishing system test on vertical cable trays in Pavus, Czechia

Fig. P2-3 View of sprinkler on transformer stations (left)
Fig. P2-4 Sprinkler test of outdoor transformers (right)

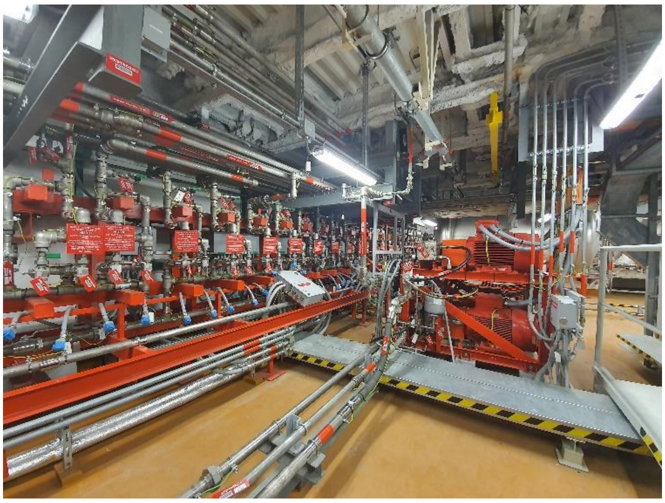

Fig. P2-5 View into the engine room of the foam fixed extinguishing system at the DG station (left)
Fig. P2-6 View into the engine room of water mist fixed extinguishing system (right)