European Nuclear Safety Regulators Group

Topical Peer Review II Country Review Workshop
‘Fire Protection’
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National Presentation of Ukraine

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National Presentation Outline

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List of nuclear installations

1. **Existing NPP:**

- ❑ 13 Units – VVER-1000 (V-320/302/338)
- ❑ 2 Unit – VVER-440/302 (V-213)

2. **Research Reactors:**

- ❑ RR (VVR-M) of the NRI NASU
- ❑ RR (IR-100) and Subcritical Uranium–Water Assembly SNUNEI
- ❑ Neutron Source of KIPT

3. **Spent Fuel Storage Facilities:**

- ❑ Wet Spent Fuel Storage Facility of Chornobyl NPP (ISF-1)
- ❑ Dry Spent Fuel Storage Facility of Chornobyl (ISF-1)
- ❑ Dry Spent Fuel Storage Facility of Zaporizhzhia NPP (DSFSF)
- ❑ Centralized Spent Fuel Storage Facility

3. **Decommissioning:**

- ❑ 3 Units of Chornobyl NPP (RBMK-1000)

National Presentation Outline

Regulations (nuclear):

1. Law of Ukraine “On Nuclear Energy Use and Radiation Safety”
2. General Safety Provisions for NPP, RR, SFSF, Decommissioning NI:
   - NP 306.2.245-2024
   - NP 306.2.105-2004 (under revision)
   - NP 306.2.230-2020
3. OPB IR (under revision)
4. Requirements on safety assessment of NPP:
   - NP 306.2.162-2010
   - NP 306.2.214-2017
5. Requirements on Management for safety:
   - NP 306.1.190-2012
   - NP 306.1.182-2012
6. Specific requirements on SSCs of NPP:
   - NP 306.2.204-2016
   - NP 306.2.205-2016
   - NP 306.2.218-2018
   - NP 306.2.202-2015

Regulations (non-nuclear):

1. Code of Civil Protection
2. Fire Safety Rules:
   - NAPB A.01.001-2014
   - NAPB B.01.014-2007
3. State Building Codes (DBN)
4. State Standards of Ukraine (DSTU)

International standards and guidelines (EURATOM Directives, IAEA documents, WENRA reference levels)

- are not directly applicable as regulations (requirements)
- are used as references in the development/improvement of national legislation
- are used when developing methodological guidelines and conducting a regulatory review and assessment process as additional references

List of candidate installations considered in NAR

Installation	Licensee	Type of facility	Thermal/ electrical net power, MW	Date of the operating license	Design life time operation / long-term operation
RNPP-2	JSC «NNEGC «Energoatom»	VVER-440/213	1375/415	22.12.1981	22.12.2011/22.12.2031
RNPP-3	JSC «NNEGC «Energoatom»	VVER-1000/320	3000/1000	21.12.1986	13.12.2018/11.12.2037
PNPP-1	JSC «NNEGC «Energoatom»	VVER-1000/302	3000/1000	31.12.1982	02.12.2013/02.12.2033
RR of NRI	Nuclear Research Institute	VVR-M	10	12.02.1960	Not defined / 31.12.2026
SFSF (ISF-2)	SSE ChNPP	Dry SFSF (cask type)	-	23.04.2021	Not defined

Fire safety analysis

Fire safety analysis (FSA) (cf TS 02.1)

NPP

Fire safety is an integral part of nuclear and radiation safety

- **Objectives of deterministic fire safety analysis :**
  - determine compliance with the nuclear safety goals ensuring that the fundamental safety functions are achieved
  - determine compliance with the conventional non-nuclear fire protection goals
  - support the development of the PSA for identifying fire safety findings, providing recommendations and proposing corrective measures for their elimination.

- **Scope:**
  - full scope of operation states (power operation, low power, shut down modes)
  - reactor, SFP
  - internal and external fires

- **Main assumptions:**
  - Only one fire can occur at time.
  - Fires due to seismic hazards, airplane crashes and military actions are not considered
  - Combination of fires with other events/ hazards are not considered. But secondary effects from fires were analyzed
  - The negative consequences associated with the faulty operation of the automatic fire extinguishing system (potential flooding) are not considered in the fare safety analysis (are considered in flooding safety analysis). Secondary effects caused by the operation of the automatic fire extinguishing system during a fire are taken into account
  - Both compartment approach (for screening) and influent approach (for detail analysis) are used
  - Single failure criteria are considered

NPP

- **Fire PSA is an integral part of Full scope PSA (Level 1 and Level 2):**
  Living PSA (updates every 3 years, every 10 years)

- **Contribution of Fire PSA:**
  VVER-1000/320: CDF – 1.01% (power operation), 0.08% (low power and shutdown modes);
  VVER-1000/302: CDF – 4.7% (power operation), 0.2% (low power and shutdown modes);
  VVER-440/213: CDF – 3.55% (power operation), 26.07% (low power and shutdown modes).

- **Most penalising scenarios (deterministic/PSA):**
  VVER-1000/320: Ignition of the control cabinets in the premises of the reactor compartment during power operating
  VVER-1000/302: Ignition of the turbine generator equipment
  VVER-440/213: Ignition of the 6 kV backup transformer at different states during shutdown for maintenance and repair

Fire detection
(cf TS 03.2.1)

NPP

The function of fire detection is performed by the Fire Alarm System

- **FAS is designed to ensure the fire safety of personnel, buildings, structures, and technological equipment of the NPP by early detection of the fire, signaling of its occurrence to operational personnel to take the necessary measures, to manage of automatic fire extinguishing, ventilation, air conditioning installations, notification of a fire**
- **FAS is an I&C microprocessor system that implements its functions using information received from fire detectors installed in protected premises and buildings**
- **Fire detectors are placed in accordance with the Fire Safety Rules and State Building Codes (DBN) in all premises:**

- thermal fire detectors are installed in the premises of oil companies;
- smoke fire detectors in premises with cable products;
- in other premises, fire detectors are installed in accordance with the technological process and mode of operation of the protected equipment.

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❑ FAS characteristics:

- Classification: system important to safety
- Addressable detectors
- Three-channel principle. Two independent FAS channels are installed in the premises of each safety system channel.
- Seismic resistance:
  - I category for safety system premises (maximum calculated earthquake)
  - II category for systems important to safety premises (design earthquake)
- Self-diagnosis system
- Protection against loss of power: I category of electricity consumers (emergency power supply and batteries)

Active fire protection

Fire suppression (cf TS 03.2.2)

NPP

- **Fire extinguishing systems are selected and placed taking into account the requirements of the Fire Safety Rules, State Building Codes and Nuclear Safety Requirements:**
  - automatics & non-automatics fire extinguishing
  - water and gas are used
- **Cable floors, basements, tunnels, passage shafts, cable penetrations are equipped with automatic fire extinguishing devices**
- **Premises for electronic and electrical devices are equipped with automatics gas fire extinguishers provided that these premises are without permanent service personnel.**
- **Premises for electronic and electrical devices with permanent staying of service personnel are equipped with non-automatics gas fire extinguishing devices.**
- **Actuation of non-automatics fire extinguishing equipment is performed manually remotely or at the place of equipment location using the starting device.**

-Classification:

system important to safety (for safety systems and system important to safety)

system not important to safety (for systems for normal operation)

-Seismic resistance:

I category for safety system premises (maximum calculated earthquake)

II category for systems important to safety premises (design earthquake)

-Protection against loss of power: I category categories of electricity consumers (emergency power supply and batteries)

Passive fire protection

Compartmentation (cf TS 03.3.1)

NPP

❑ Methods for determining suitable fire barriers

- Compartmentation considers nuclear safety goals fand conventional safety goals
- Main compartmentation goal – prevention of the fire propagation to neighbored compartment.

❑ Fire resistance of barriers

- Main fire resistance barriers are walls, floors, ceilings, doors, dampers, penetration seals
- Prescribed fire resistance requirements, depending on equipment safety class
- Minimal fire resistance of the fire compartment – 1.5 hours;

❑ Compensatory measures:

- Replacement of doors.
- Replacement/installation of ventilation.
- Replacement/installation of fire dampers.
- Replacement of cables to fire resistant.
- Replacement/installation of other equipment.
- Application of a fire protection layer on structures and components.

NPP

Maintenance of fire dampers

- ❑ **Maintenance of ventilation systems is carried out by operational personnel**
- ❑ **Maintenance lifecycle of fire dampers is established by vendor in Technical specification:**
  - "TO-1" => visual inspection – every month
  - "TO-2" => "TO-1" + cleaning + mounting, threaded and electrical connections checks + actuation checks – every 6 months
  - "TO-3" => regular preventive repair ("TO-2"+ replacement of spare parts if needed) – every 4 years
  - "TO-4" => overhaul (replacement of gaskets, actuation components, etc.) – every 12 years

In addition, the limited visual inspection is performed during the regular walkdowns

- ❑ **During "TO-1,2,3", the repairment on technical conditions is performed, in case of the identification any issues in regard to conditions of components:**
  - Latch blade cracks, stratifications
  - Motor, fuse malfunctions, deviations
  - Cables damages, ageing impact
  - Gaskets cracks
  - Mountings corrosion, damage

Functionality testing is controlled by the indication means from MCR, local control points, and additionally by visual confirmation from the place. The relevant fire damper positions "open"/"closed" can be checked by the pointer on the damper.

Conclusion

TS 01.3 and
TS 04

NPP

- **Base for improvements:**
  - New and revised legislations
  - Results of safety assessment (PSA, PSR)
  - Results of oversight and international peer review missions (IAEA, WANO, EU stress-tests)
  - National and international OPEX

- **Significant improvements:**
  - Modernization of the automatic fire alarm system, incl. additional door opening alarm with indication on MCR (safety systems compartments with electrical and electronical equipment)
  - Implementation of smoke protection system for premises and evacuation corridors
  - Implementation of automatics and non-automatics gas fire extinguishing of NPP premises containing electrical and electronic equipment
  - Equipping with automatic control units of power oil-filled equipment
  - Replacement/installation of fire dampers
  - Replacement of cables to fire resistant.
  - Application of a fire protection layer on structures and components
  - Replacement of fire doors

Conclusion

TS 01.3 and
TS 04

NPP

- **Strengths:**
  - Amount fire safety improvements were implemented (automatic fire alarm system, fire dampers, fire resistant cables, door opening alarm, etc.)
  - Fire PSA Levels 1 and 2
  - Local (specific) fire brigades on each NPP site are foresing. It is possible to involve additional fire brigades from satellite city (if necessary). Both fire brigades are very well equipped, trained (including drills at NPP)

- **Weaknesses:**
  - National regulatory framework needs to be revised, in particular, in terms of fire safety analysis (this process is being conducted)
  - Analysis of fires in combination with other dependent and independent hazards (seismic, aircraft crash…)
  - Deepening and expanding the analysis of OPEX, in particular, taking into account experience at non-nuclear facilities

RR

Fire safety is an integral part of nuclear and radiation safety

- **Objectives of fire safety analyses:**
  - determine the possibility of the occurrence and development of a fire and the implementation of active and passive means of fire protection to ensure the fulfilment of the safety functions under the conditions of fire.

The possibility of transferring the reactor to a subcritical state and maintaining it in this state for a sufficient time is analyzed

- **Main assumptions:**
  - actions on timely detection of ignition are considered
  - actions of fire protection means are considered
  - actions of the staff in accordance with the instructions/procedures are considered

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- **Analyzed scenarios:**
  - fire in the premise of the reactor control panel;
  - fire in the premise of the power supply switchboard for reactor loads;
  - fire in the cable channel of the reactor hall;
  - fire in the reactor hall;
  - fire in the fresh and spent nuclear fuel storge facilities.

- **Results:**
  - possibility of mitigation of the consequences of fires with the provided means and actions is demonstrated
  - possibility of transferring the reactor to a subcritical state is demonstrated

- **The PSA for VVR-M was not performed and is not required by the national legislations**

RR

The function of fire detection is performed by the Fire Alarm System

- **FAS is designed to ensure the fire safety of personnel, buildings, structures, and technological equipment of the RR by early detection of the fire, signaling of its occurrence to operational personnel to take the necessary measures and notification of a fire**
- **Fire detectors are located in all reactor premises**
- **FAS characteristics:**

- Classification: system important to safety
- Each surface point to be protected monitors by at least two automatic address detectors of the same type in order to increase fire detection reliability
- Seismic resistance: qualified to magnitude of 6 according to MSK-64
- Protection against loss of power: I category categories of electricity consumers (emergency power supply and batteries)

Active fire protection

Fire suppression (cf TS 03.2.2)

RR

- Fire extinguishing systems are selected and placed taking into account the requirements of the Fire Safety Rules, State Building Codes and Nuclear Safety Requirements:
- Manual fire extinguishing system and manual means of extinguishing fire (fire extinguishers)
- Automatic fire extinguishing system are not provided
- Seismic resistance fire extinguishing system: qualified to magnitude of 6 according to MSK-64
- The design fire extinguishing system does not require emergency power supply

Passive fire protection

Compartmentation (cf TS 03.3.1)

RR

❑ Methods for determining suitable fire barriers

- Compartmentation considers nuclear safety goals and conventional safety goals
- Main compartmentation goal – prevention of the fire propagation to neighbored compartment.

❑ Fire resistance of barriers

- Main fire resistance barriers are walls, floors, ceilings, doors, dampers, penetration seals
- Prescribed fire resistance requirements, depending on equipment safety class
- Minimal fire resistance of the fire compartment – 1.5 hours;

❑ Compensatory measures:

- Replacement of doors.
- Replacement of ventilation.
- Replacement of cables to fire resistant.
- Replacement floor in the reactor hall

Passive fire protection

Ventilation management (cf TS 03.3.2)

RR

- **Four independent ventilation systems:**
  - V-1, V-2, V-3, V-4
  - active ventilation
  - are located in separate compartment with barriers, ventilation pipes do not penetrate fire barriers
- **System is switching off to provide the isolation function of fire compartments in case fire**
- **Fire dampers are not provided**

RR

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- **Base for improvements:**
  - New and revised legislations
  - Results of safety assessment (PSR)
  - Results of oversight
  - National OPEX

- **Main improvements:**
  - reserved control room has been implemented, which is located in a different room than the main control room
  - power and control cables and cable structures have been replaced with a fire-resistant cables and cable structures
  - plastic floor in the reactor hall has been replaced with a fire-resistant floor
  - automatic fire detection and notification system has been modified
  - emergency lighting system has been implemented

RR

- **Strengths:**
  - The effectiveness of the fire safety concept implemented at the research reactor is confirmed by the absence of recorded events related to smoldering or fire during the entire operational period

- **Weaknesses:**
  - National regulatory framework needs to be revised, in particular, in terms of fire safety analysis
  - Deepening and expanding the analysis of international OPEX

Fire safety analysis

Fire safety analysis (FSA) (cf TS 02.3)

Spent fuel storage

Fire safety is an integral part of nuclear and radiation safety

- **Objectives:**
  - determine the possibility of the occurrence and development and assessing the impact of fires on ensuring nuclear and radiation safety
- **Assessment of the impact of fires on the possibility to:**
  - exceeded temperature limit and violated integrity of fuel rod cladding
  - exceeded temperature limits of the HI-TRAC and DWSC containment materials
- Infernal and external fire have been analyzed
- No violations of the criteria have been demonstrated
- The PSA for SFS has not been performed and is not required by the national legislations

The function of fire detection is performed by the Fire Alarm System

- **Function:**

Early detection of fire, sending a signal about fire initiation to the fire alarm control panel in the premise with on-duty personnel and generating signals for activation firefighting equipment

- Addressable fire detectors are equipped. The type of fire detector (heat, smoke, etc.) is selected according to characteristics of combustible materials stored and/or handled in the technological process performed in this premise.
- Fire detectors are installed practically in all premises
- Each surface point to be protected monitors by at least two automatic address detectors of the same type in order to increase fire detection reliability
- Protection against loss of power: I category categories of electricity consumers (emergency power supply and batteries)

Spent fuel storage

- **Water and foam fire extinguishing on ISF-2 site was not envisaged**

- **Passive-modular gas fire extinguishing installations with decentralized storage of extinguishing agent => premises containing electronic and electrical equipment**

- **Additional Fire-fighting water supply system:**
  - inside fire-fighting water supply system (in the corridors and stairwells)
  - outside fire-fighting water supply system (hydrants at site)

- **Most of premises are equipped with manual extinguishing fire equipment**

Spent fuel storage

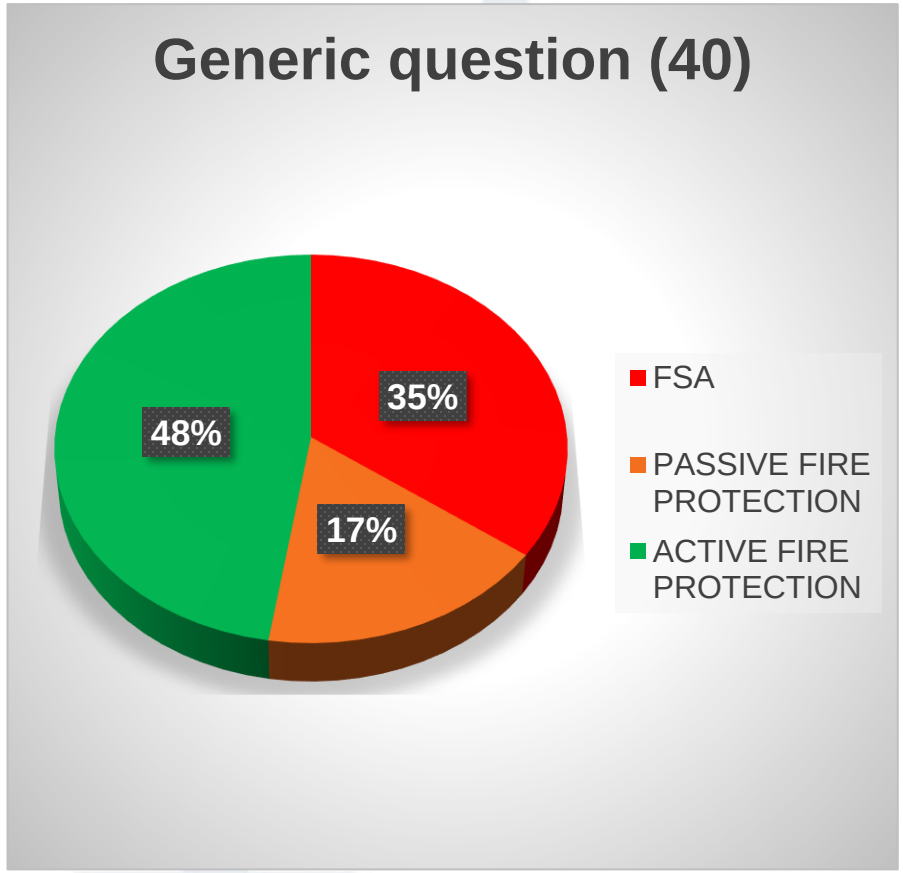
- ISF-2 operation was started on 07 June 2021
- In order to evaluate the adequacy, effectiveness and reliability of fire protection equipment, more operating time of a given facility is required.
- Areas for improvements have not been identified since the start of operation

- **Strengths:**
  - most of the state-of-art technologies and national requirements were considered under ISF-2 design and constriction.

- **Weaknesses:**
  - were not identified

Generic and specific question to NAR & answers

NPP


Generic question (40)
35%
17%
48%
FSA
PASSIVE FIRE PROTECTION
ACTIVE FIRE PROTECTION


Specific question (22)
9%
91%
FSA
Active Fire Protection

Fire safety analysis

NPP

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- **Approaches for analyses:**
  - screening criteria
  - assumptions
  - fire resistance/fire hazard rating
  - qualification of cables
  - transient combustibles and ignition sources
- **Analytical methods (methodology) and tools**
- **Implementation of identified improvements**

- **Scope of the analyses:**
  - direct fire effects
  - electrically induced fires
  - fire brigade actions
  - radiological consequences
  - operating experience
  - additional analyses (especially after Fukushima stress-tests)
- **Results of the analyses:**
  - fire contribution to CDF / LRF / LERF
  - more elaborated description of the results of the analysis since for some plants the description
  - strengths/weaknesses

Passive fire protection

NPP

- **Compartmentation:**
  - consideration of risk
  - prevention/delaying/mitigation propagation of fire
  - dividing of ventilation systems among trains/ compartments
  - improvements
  - compartmentation management
  - relationship between to fire compartmentation and fire rating of barriers
- **Management of fire loads:**
  - types of permanent and transient fire loads
  - inventory of fire loads
  - affects of change of fire loads on fire risk
  - using of existing knowledge of the inventory of fire loads
  - limits and practices on permanent and transient loads
  - inspection programs for fire loads

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- **OPEX on fire events**
  - classification and reporting of fire related events
  - sharing and discussing of information on fire related events at national and international level
  - improvements based on internal and external experiences
- **Management of ignition sources**
  - hot works management
  - approaches to systemically permit and control hot works
  - description of programs of inspections of hot works
- **Maintenance/Access/Inspection of fire dampers**
- **Management of the hydrogen risk**
- **Aging management of fire passive and active SSCs**

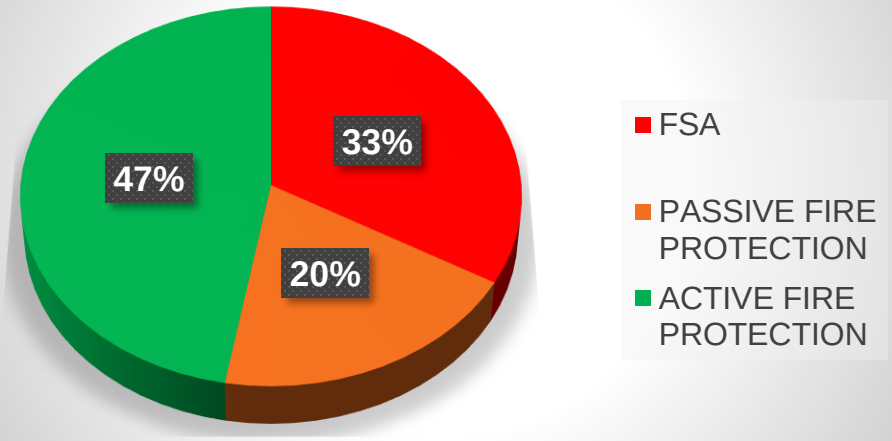
Active fire protection

NPP

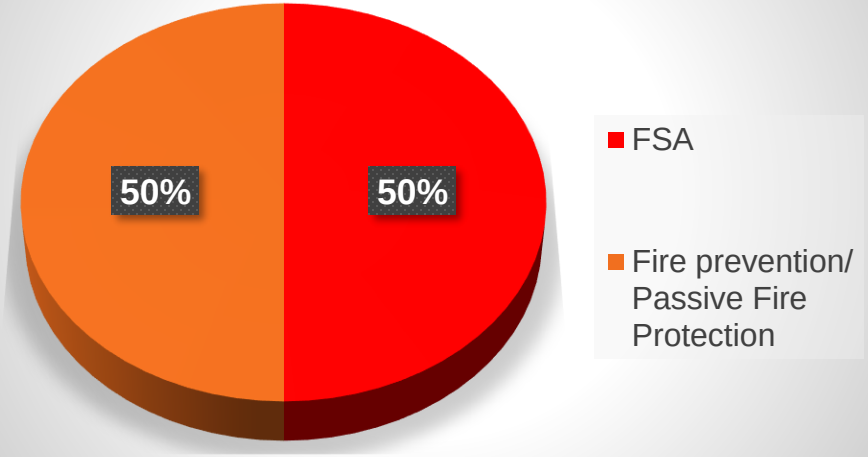
- **Clarification on fire detection description**
- **Clarification for fire suppression system**
- **Administrative and organizational fire protection issues:**
  - more detail clarifications for external fire brigade
  - staffing of fire brigades
  - criteria for off-site brigades involvement
  - equipping of the on-site and of-site brigades
- **Licensee and regulatory experience:**
  - OPEX from testing fire detection and suppression systems
  - lessons learn of fire events

RR

Generic questions (34)



Specific questions (10)



Fire safety analysis

RR

- **Fire safety objectives**
- **Approaches and results of fire analyses** (scope, results, CDF/LERF, radiological consequences of fires)
- **Fire resistance/fire hazard rating**
- **Transient combustibles and ignition sources**
- **Direct fire effects**
- **Description of Fire Brigade**
- **Analytical methods**
- **Management of temporary modifications and their impact on fire safety**
- **Operating Experience**
- **Additional analyses (especially after Fukushima accident)**
- **Strengths/weaknesses**

Passive fire protection

RR

- **Compartmentation** (risks consideration, fire propagation, description of the ventilation system, possible improvement, etc.);
- **Management of fire loads** (possible fire loads, fire load inventory documentation and management, approached for fire risks, using results, description of the inspection program for fire loads);
- **Fire barriers clarifications**
- **More detail information on fire dumpers, ventilations, filters**
- **OPEX on fire events** (classification and report on fire related events, information on events related to fire at facilities);
- **Management of ignition sources** (types of hot works, details of the approaches, detail the programs of inspections);
- **Maintenance/Access/Inspection of fire dampers** (types and frequencies of testing/inspection, insights have been gathered and improvements)
- **Management of the hydrogen risk** (all the elements of the management of hydrogen risk, events and lessons learned)
- **Ventilation management in case of fire**

Active fire protection

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❑ **Fire detection**

- robustness against earthquake
- location of fire detection system
- ability of the fire detection system to function in case of loss of power

❑ **Fire suppression**

- robustness against earthquake
- adverse effects of fire water
- emergency power arrangements for fire suppression
- balance between fixed fire extinguishing and manual firefighting

❑ **Administrative and organizational fire protection issues**

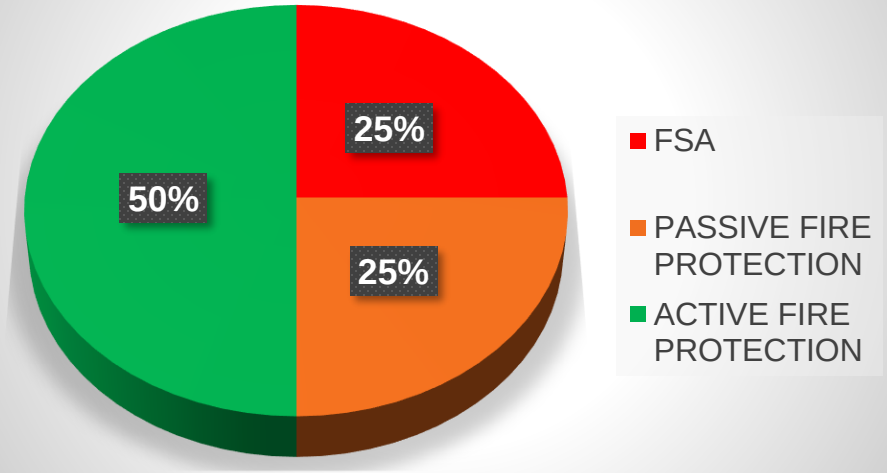
- Information about fire brigades (location, staffing, criteria for calling, etc.)

❑ **Licensee and regulatory experience**

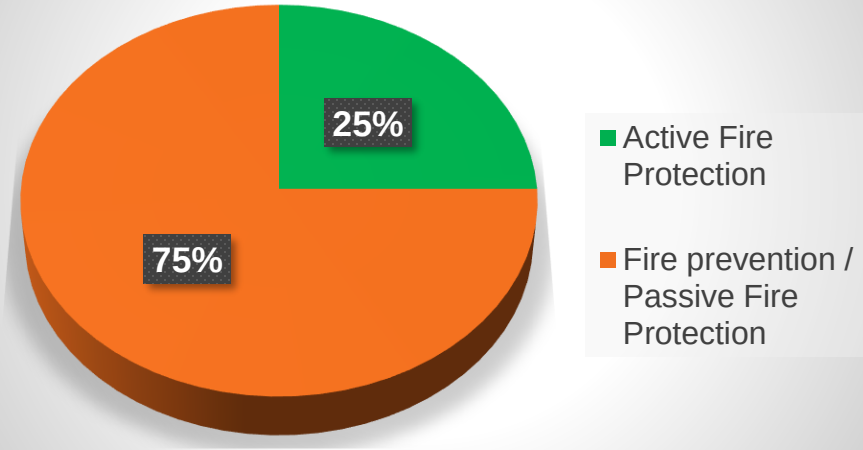
- OPEX from testing fire detection and suppression systems;
- lessons learn of fire events

Spent fuel storage

Generic questions (24)



Specific questions (8)



Spent fuel storage

- Accounting of fire combination
- Accounting of transient combustibles and ignition sources
- Operating Experience
- Additional analyses (especially after Fukushima accident)
- Strengths/weaknesses

Passive fire protection

Spent fuel storage

- **Compartmentation** (risks consideration, fire propagation, possible improvement, etc.);
- **Consideration of fire prevention under SF transportation**
- **More detail information about all types of fire extinguishing systems**
- **Management of fire loads** (possible fire loads, how used results of the fire load analyses);
- **OPEX on fire events;**
- **Management of ignition sources** (types of hot works, details of the approaches, detail the programs of inspections);
- **Maintenance/Access/Inspection of fire dampers** (types and frequencies of testing/inspection, insights have been gathered and improvements)
- **Management of the hydrogen risk** (all the elements of the management of hydrogen risk, events and lessons learned)
-

Active fire protection

Spent fuel storage

- **Fire detection**
  - How does the fire detection system allow to locate precisely the location of fires
  - strategy and criteria for selecting rooms where to install fire detectors in rooms
  - ability of the fire detection system to function in case of loss of power
- **Fire suppression**
  - adverse effects of fire water
  - balance between fixed fire extinguishing and manual firefighting
- **Administrative and organizational fire protection issues**
  - More detailed information about fire brigades (location, staffing, criteria for calling, etc.)
- **Licensee and regulatory experience (**any interesting operating experience feedback from testing fire detection and suppression systems**)**

Conclusions

- Received questions related to all candidate nuclear installations
- Received questions related to all area considered in NAR
- Received questions are aimed at providing additional information and/or clarifying the information specified in the NAR for the possibility of performing an peer review and preparing general conclusions, strengths and weaknesses
- Detailed answers to all questions were provided
- Received questions and preparation of answers did not open new significant weaknesses except provided in NAR

Nevertheless, taking into account the results of working with the questions and the results of the thematic workshop, the feasibility of some improvements were determined:

- Revising of national regulatory requirements for fire protection in particular, in terms of fire safety analysis (this process is being conducted, e.g. under INSC project)
- Analysis of fires in combination with other dependent and independent hazards (seismic, aircraft crash…)
- OPEX, in particular, taking into account experience at non-nuclear facilities and international OPEX (for RR)