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

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National Presentation Outline

List of candidate installations and their regulation

1. **NPP**
2. **RR – not applicable (no RR in Slovakia)**
3. **Fuel cycle facilities – not applicable (no FCF in Slovakia)**
4. **Dedicated spent fuel storage**
5. **Waste – not qualified, excluded from analysis**
6. **Decommissioning – not qualified, excluded from analysis**

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- **CANIDATE INSTALLATIONS**

  - Unit 3 of the Mochovce NPP (VVER-440)/V213 – safety upgraded design)
    - Results of its TPR are applicable to all NPPs operating in Slovakia (4+1)

  - Interim Spent Fuel Storage (wet storage)
    - The interim SFS contains spent nuclear fuel; a fire at the nuclear installation cannot be ruled out; a potential fire may cause a release of ionizing radiation or radioactive substances outside their protective barrier with a non-negligible adverse effect on the nuclear installation´s personnel and its surroundings

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- **REGULATION APPLIED FOR NPPs**

National regulatory framework

– **Nuclear regulator** – requirements related to fire safety vs. nuclear safety
  - Atomic act No. 541/2004 Coll. (NRA SR)
  - Decrees No. 430/2011 Coll., No. 431/2011 Coll., No. 33/2012 Coll., etc. (NRA SR)
  - Safety guide BN 2_2020 (NRA SR)

– **Fire Authority** – Fire prevention act and related national decrees
  - Fire Act No. 314/2001 Coll. (Fire authority)
  - Fire prevention Decree No. 121/2002 Coll. (Fire authority)
  - Fire requirement for construction Decree No. 94/2004 Coll. (Fire authority)
  - Other decrees – No. 169/2006 Coll. on fire brigades, No. 726/2006 Coll. on fire detection, No. 96/2004 Coll. on flammable liquids, etc.

International regulatory framework

– IAEA
– WENRA

Standards and guidelines

– Original design – Russian standards
– National standards
– European standards
– NFPA (National Fire Protection Association), IEC (International Electrotechnical Commission), KTA (Safety Standards Commission), etc.
– Guidelines of Insurance companies

Fire safety analysis

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

- **Types of analysis**
  - **Deterministic analyses**
    - Fire protection design (fire risk, compartments, detection & protection, escape routes, etc.)
    - Analyses (single postulated fire, all operational states & modes, combination fire and other events)
    - Verification of safe shut down, heat removal in case of fore in any place (full power and refueling)
  - **Probabilistic analyses**
    - Significant contribution of risk to in all operating modes reactor and spent fuel with potential to fuel damage
    - Set the most penalizing scenario – turbine hall
  - **Fire hazard analyses**
    - For selected buildings – condition for effective intervention and evacuation
    - Given quantity of required fire staff, amount of fire means
- **Objectives**
  - **Fire in any place in NPP:**
    - Not compromised essential safety function of NPP (safe shut down, heat removal, radioactive release limited)
    - Fire safety requirements are met
    - Fire will not cause non-compliance with general safety condition
  - **Defense in depth** (Prevention, Detection & Protection, preventing the spread fire)

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

- **Deterministic fire analyses**
  - Verifies ability to safety shut down and cool the unit
  - **Description** of fire protection of all buildings/systems from fire safety point of view
  - Verifies reaction of the unit to fire induced transients, coolant leakage, loss of power supply
  - Main part deterministic and probabilistic results:
  - ❑ **Deterministic analysis:**
    - Verifies reaction of unit to fire induced transition state, coolant leakage, loss of power supply
    - Analysis of separation of redundant cable routes and formation of false signals due to fire
  - ❑ **Probabilistic analysis:**
    - Calculation of the frequency of occurrence of a fire in a fire compartments
    - Sorting of fire compartment; sorting based on risk; PSA model
  - **The worst-case scenario:** fire in turbine hall
  - **Conclusion:** the occurrence of a fire in any place will not prevent the shutdown of the nuclear reactor, its maintenance in a safe condition and will not cause the leakage of radioactive substances or the irradiation of people above the established limits

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

- **Probabilistic fire analyses**
  - **The objective:**
    - Identification of fire sections of the nuclear unit, selection equipment for analysis, selection of cables and determination of cable routes, qualitative classification, analysis of the unit's response to fire, selection and analysis of emergency chains, calculation of the frequency of ignition of fires, quantitative classification, analysis of control circuit faults, analysis of the reliability of the human factor in fire conditions, quantification of fire risk, analysis of uncertainty and sensitivity of results, determination of the potential contribution of internal fires to the total frequency of core/fuel damage
  - Licensee has elaborated PSA level 1 and PSA level 2:
    - Fire protection description of all buildings and fire related systems
    - Identification of all systems and items related to fire safety
    - Sorting based on influence, frequency, quantitative and qualitative analyses
    - **Screening out** of fire compartments without impact also by application of detailed analyses to make it more realistic
    - Turbine hall: turbo-generator, fire of transient fuel, fire of cables, fire of pumps
    - **The worst case scenario**: fire in turbine hall $2{,}34.10^{-2}\ r^{-1}$
  - No specific requirement for improvements

Fire detection (cf TS 03.2.1)

NPP

- **Strategy for location of fire detectors:**
  - Civil structures (CS) with **safety classified systems** - all rooms
  - The rest of rooms – as per **national legislation** Decree No. 726/2002 Coll.

- **Characteristic of the fire detection system**
  - **Main functionality**: detection & control system (HVAC, dampers, etc.)
  - **Automatic** and continuously operational, incl. after seismic event
  - Fully **addressable** and 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
  - Backup **power supply** – 48 hours
  - Detector based on **different physical principles**, incl. pushbuttons:
    • 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)
  - Regular **inspection** as per national legislation requirements

Fire suppression (cf TS 03.2.2)

NPP

- **Fire suppression**
  - **Strategy for the selection:**
    - **Location of safety systems** with fire risk
      - Cable rooms – water mist system
      - Oil systems in reactor buildings – water mist system
      - Room with main circulation pumps – Gas FM200
      - Diesel generator station – Foam system
    - Area with **higher fire risk**
      - Oil systems in turbine hall – foam system
      - External transformers – deluge system
      - Solid radwaste – gas system CO_2
  - **Main characteristic of fix extinguishing systems (FES):**
    - **Water mist (cable rooms) –** seismic/safety classified, automatic actuation, demi water, low amount of water, high efficiency, 30 min extinguishing, non-seismic – dedicated for non-safety part of cable rooms
    - **Deluge system (trafo) –** non-seismic, automatic activation, fire water, 2 electrical driven pumps + DG pump, 20 min extinguishing
    - **Gas (MCP room)**– seismic/safety classified, automatic activation, gas FM200, 10 sec extinguishing
    - **Foam system (lube oil TG)** – non-seismic, automatic actuation, water/foam, 30 min extinguishing
    - **Gas (solid radwaste)** – non-seismic, automatic actuation, CO2, 1 min extinguishing
    - **Foam system (DG) –** seismic/safety classified, automatic/manual actuation, water/foam, 15+5 min extinguishing
    - **Water curtain** – non-seismic, automatic actuation, water, 90 min extinguishing

Compartmentation (cf TS 03.3.1)

NPP

- **Fire compartmentation**
  - **Safety concept – separation of safety systems, redundancies**
  - **Generally applied national legislation decree No. 94/2004:**
    - Limit dimension of fire compartment defined by calculation
    - Area strictly defined by decree (e.g. lift, protected emergency escape routes, main control room, etc.)
    - Number of above ground floors + limitation for underground floors
  - **Nuclear regulatory body – safety guide**
    - **Principle of fire cell** (separation by barrier, distance)
  - **Fire separation barriers –** walls, ceilings, doors, hatch, penetration, dampers etc. – made as certified construction product as per European directive 305/2011 (or Law 133/2013)
  - **Compensatory fire protection measures:**
    - Water curtain between turbine hall building and electrical building
    - Measures related to temporary fire sealed opening

Ventilation management (cf TS 03.3.2)

NPP

- **Safety concept:** radiological requirements, equipment condition, ventilation after accident, severe accident, hygienic requirements
- **National legislation requirements:**
  - Decree No. 478/2008 Coll. on fire closure (doors, windows, fire dampers, etc.)
  - Decree defines minimum range of inspection:
    - Visual control (completeness, damages, labelling, alignment with documentation)
    - Functionality test (easy running of movable parts, power supply, signalization, etc.)
    - Specific requirements defined by manufacturer
    - Periodicity: once per 12 months
- **Lessons learnt related to fire dampers (FD):**
  - Improvement of FD location during design and erection phase – to ensure accessibility
  - Location of revision openings – to ensure maintenance
  - The mostly repeated malfunction – I&C part or actuator

- **Significant improvements since NAR production**
  - Small modification of fire design (e.g. simulator building)
  - Adding a new extinguishing system NOVEC 1230 to data center in Simulator building – 12/2023
  - Planned improvements:
    - Replacement of obsolete fire detection system in EMO12 – under preparation
  - Strengths and weaknesses:
    - Fire brigade drill ensuring transport water from the nearest river (around 6 km in the distance) to safety systems of nuclear power plant

Conclusion

TS 01.3 and TS 04

NPP

- **The most significant good performance**
  - **Fire brigade** located on site NPPs Mochovce and NPP Bohunice
    - ✓ Standard firefighting activities
      - ✓ Extinguishing of fires, fire intervention, etc.- repression
      - ✓ All activities related to firefighting
      - ✓ Trainings, drills; large scale of fire - polygon of refinery
      - ✓ Permanent operation of fire detection switchboard
      - ✓ Fire assistance
    - ✓ Activities related to nuclear safety
      - ✓ Delivery water to steam generators by mobile means
      - ✓ Delivery of water to essential service water
      - ✓ Operation of all mobile means relate to severe accident
      - ✓ Support delivery of water with external
    - ✓ Supporting activities
      - ✓ Performing an air analysis during the implementation of work in places with a risk of explosive concentrations, dangerous substances or otherwise unbreathable air
      - ✓ Implementation of alternative fire-fighting measures during a malfunction, or shutdown of installed firefighting systems
      - ✓ Cooperation and coordination of the activities during transportation of nuclear material
      - ✓ Monitoring of the external spaces of the respective location, or the internal spaces of the relevant construction objects during the prevention of occurrence or resolution of emergency situations related to OPP
    - ✓ Good practice recognized by WANO
      - ✓ Activity in fire detection switchboard, software, hardware, used technique, exit cards
      - ✓ Reducing of dispatch time for fire brigade

- **The most significant good performance**
  - **Transfer of industrial experience – high-pressure water mist system**
    - **Safety concept**
      - ✓ Ensuring system independent from external source of water (own storage of water)
      - ✓ High efficiency
      - ✓ Low space requirement
      - ✓ Seismic qualification
      - ✓ In line with national legislation
      - ✓ The state of the art
    - ✓ **Verification of the system**
      - ✓ Applied international recognized standard NFPA
      - ✓ Testing by manufacturer
      - ✓ Verification by calculation
      - ✓ Verification by seismic test and seismic analyses
      - ✓ Validation by functional test
    - ✓ **Good practice** – Extra validation
      - ✓ Additional full scale test of vertical shaft and horizontal tunnel
      - ✓ Confirmation of the concept
      - ✓ Independent expert companies and regulatory body

- **The most significant good performance**
  - **Fire prevention**
    - **Activity of fire technician**
      - ✓ Announce of all deviation related to fire safety
      - ✓ Warning, prohibition and information signs and symbols
      - ✓ Carries out preventive fire inspections
      - ✓ Determines the locations of the fire hazard and the number of members of the fire watches
      - ✓ Cooperate with fire brigade after fire
      - ✓ Inspection activity of fire closures
      - ✓ Inspection during hot works – can be interrupted by fire technician
      - ✓ Inspection of dumps – can be cancelled by fire technician
    - ✓ **Announcement of fire as per internal procedure**
      - ✓ Immediately to
        - ✓ Director
        - ✓ Fire authority (by phone, in written form)
      - ✓ All incidents including fire event
        - ✓ Nuclear regulatory body
        - ✓ WANO
        - ✓ IRS *(IAEA)*
      - ✓ Internal procedure, database

Fire safety analysis

Fire safety analysis (FSA)
(cf TS 02.3)

Spent fuel storage

- **Types of analysis**
  - **Deterministic analyses**
    - Fire protection design (fire risk, compartments, detection & protection, escape routes, etc.)
    - Analyses (single postulated fire, combination fire and other events)
    - Verification of heat in case of fore in any place
  - **Probabilistic analyses**
    - Assessment of impact of fire on nuclear safety
    - Assessment of risk of RAW release to the working and external environment
  - **Fire hazard analyses**
    - For selected buildings – condition for effective intervention and evacuation
    - Given quantity of required fire staff, amount of fire means, capacity of water sores for fire-fighting and cooling

- **Objectives**
  - **Fire in any place in NPP:**
    - Not compromised essential safety function of SFS (heat removal, radioactive release limited)
    - Fire safety requirements are met
    - Fire will not cause non-compliance with general safety condition
  - **Defense in depth** (Prevention, Detection & Protection, preventing the spread fire)

Fire safety analysis

Fire safety analysis (FSA)
(cf TS 02.3)

Spent fuel storage

- **Main assumptions:**
  - Only one fire can occur in any given SFS fire compartment
  - A fire can occur in SFS at any place where a fire load occurs. Ignition and subsequent ignition of the occurring fire loads are considered
  - The spread of a fire from a fire compartment to a neighboring fire compartment is considered only in cases where it is not demonstrable that the fire will be extinguished in the fire compartment where it originated
  - Simultaneous occurrence of other initiation events – simultaneous occurrence of natural phenomena – earthquake with fire is not expected
  - The occurrence of two or more fires at the same time in different buildings in the JAVYS area is not postulated
  - The occurrence of fire and another occurrence at the same time is not postulated, unless it is clear from the analysis that the fire may cause an accident or, conversely, when such a risk arises on the basis of an examination of other internal risks
  - Simultaneous occurrence of internal initiating events, e.g. leakage of cooling water from the SFS pool with fire is not assumed, it is analyzed only if it is the result of a fire

- **The most penalizing cases:**
  - Loss of operability of the pool cooling system,
  - Loss of operability of the SFS ventilation systems.

The total calculated frequency of RAW release into the working environment due to fire is 2.68 × 10-7/year

Active fire protection

Fire detection (cf TS 03.2.1)

Spent fuel storage

- **Strategy for location of fire detectors:**
  - The ESSER FDPS designed in accordance with the Decree No. 726/2002 Coll. and STN EN standards

- **Characteristic of the fire detection system**

  Electric detection system in use
  - Optical/thermal detectors – combined detector with optical and thermal sensors
  - Thermo-differential detectors
  - Push button detectors
  - Detectors are located on the ceiling, push button detectors in stairwells

Active fire protection

Fire suppression (cf TS 03.2.2)

Spent fuel storage

- **Main fire suppression means**
  - Portable and mobile fire extinguishers
  - Internal fire water distribution along with hose reels
  - External fire water distribution together with underground or above-ground hydrants
  - Permanent fire fighting brigade

- **Strengths**
  - Verified fire resistance of building structures
  - Power cables for selected safety devices in flame-retardant (IEC 332) and functional fire resistance (IEC 331) materials
  - Permanent fire fighting brigade

- **Some recommendations for increasing the level of fire protection**
  - Completion of the replacement of fire hydrants on the fire water distribution system
  - Replacement of the cable connection of individual FDPS control panels by creating redundancy
  - Re-evaluation the use of voice alarm in SFS civil structures
  - Re-evaluation the possibility of controlling important fire equipment (HVAC equipment, ventilation of protected escape routes, fire doors, power shutdown) via the FDPS
  - Development of operational cards for intervention in the SFS construction
  - Development of clear system of marking of fire closures

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Thank you for the attention