AUTORITÉ DE SÛRETÉ NUCLÉAIRE

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TOPICAL PEER REVIEW II
COUNTRY REVIEW WORKSHOP
FIRE PROTECTION

NATIONAL PRESENTATION OF FRANCE

Christophe QUINTIN
Chief inspector, ASN

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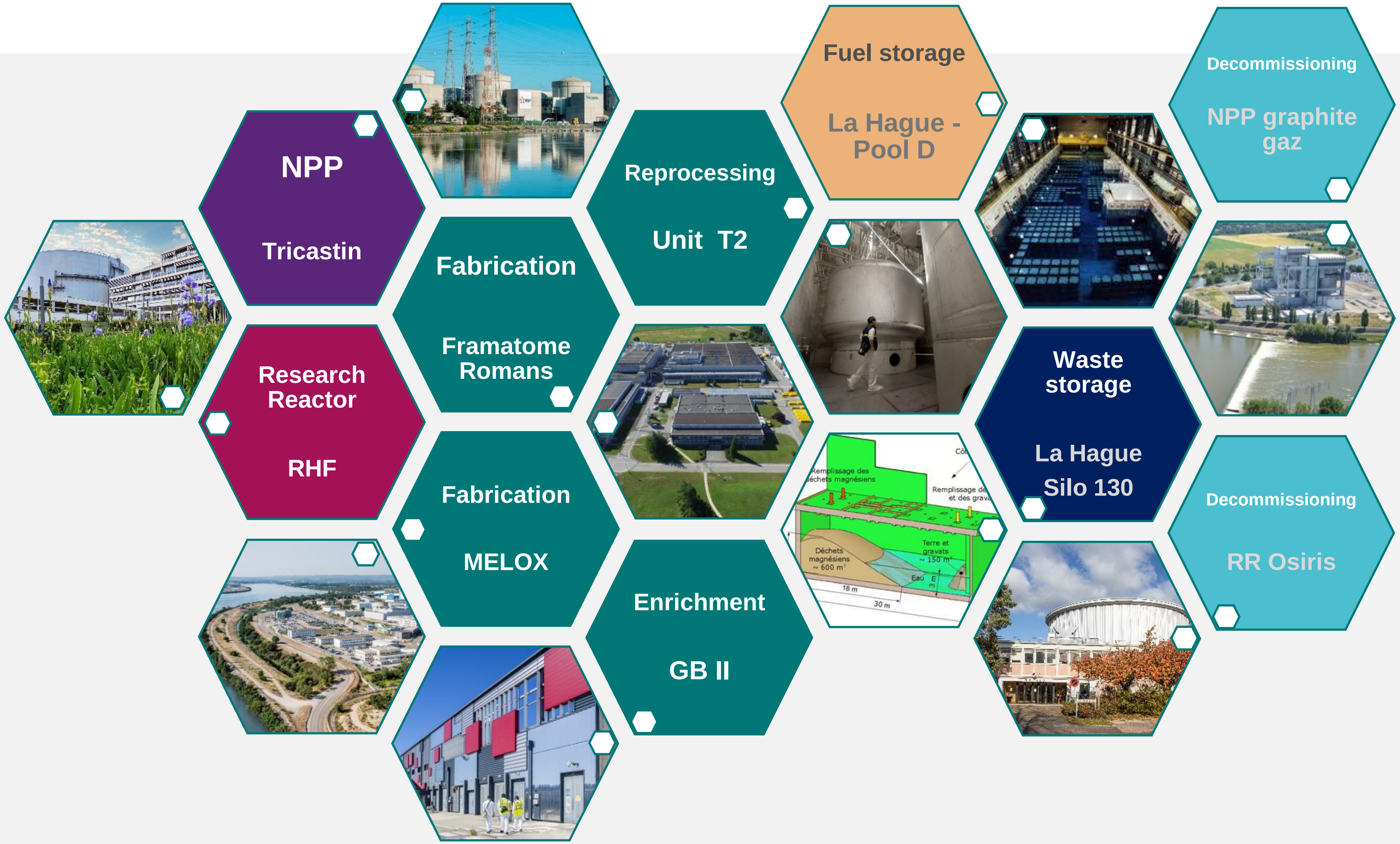
Candidate installations/regulation

TS 01.1 & 01.2

10 Candidate installations



Candidate installations/regulation

TS 01.1 & 01.2 **List of candidate installations and their related regulators for fire (nuclear & non-nuclear)**

Insurers activities (e.g "inspections…)

Regulators

- The Environment Code requirements related to fire and the requirements from ASN resolutions are controlled by ASN in all nuclear installations
- The Labour Code requirements related to fire are controlled by Labour inspectors (inspectors from ASN for NPPs or from Ministry of Labour for the other nuclear facilities)

Insurers activities

- Insurance companies carry out **regular controls of facilities**. Their recommendations can led to improvements to fire protection systems
- APSAD (Plenary Assembly of Damage Insurance Companies) **provides rules** for fire protection. Insurance companies provide as well rules

1.

NUCLEAR PLOWER PLANT

EDF

Fire safety analysis (FSA)
(cf TS 02.1)

NPP
Tricastin 1

Objectives, scope and main assumptions for the deterministic safety analyses

- **Approach proportionate to the issues** and different methods for the radiological risks and the non-radiological (conventional) risks.
- With regard to the **radiological risks**, **protection against fires** guarantees the **performance** of the **fundamental safety functions** needed to control the radiological risks
- The Fire Risks Management Case (DMRI) based on the principle that a fire postulated in a deterministic manner should **not simultaneously disable redundant equipment** performing the same safety function

Scope

- All possible states of the reactor: at power, in shutdown conditions including refueling

Single failure

- Applied on active equipment
  - ✓ Fire dampers and fire door control mechanisms controlled by the fire detection system
  - ✓ Active equipment of fixed extinguishing systems
  - ✓ Fire fighting pumps
- Sensitivity studies with failure of passive equipment (no cliff edge effect)

Fire safety analysis (FSA)
(cf TS 02.1)

NPP
Tricastin 1

Operator actions

- In the **main control room, following a fire alarm or call reporting a fire,** the operator apply its **procedure** (called Fire and rescue guidance sheet - DOIS):
  - ✓ the actions required concern the safety of the installations (not related to fire response actions)
  - ✓ to be conservative, a conventional time is assumed in the safety analyses:
    - ❑ An intervention time for the operator in the main control room of 20 minutes
    - ❑ Local intervention time of 25 minutes in the electrical building or the immediate vicinity
    - ❑ 35 minutes for actions in other areas
  - ✓ a sensitivity study is performed to check no cliff edge effect for an operator time of 30 minutes in control room and 1 h on the configurations identified as the most sensitive
  - ✓ The operator applies its procedure (called FAIop : operator fire action sheet) and ,if necessary, follows protected routes which have been defined by FSA
- In the event of **a confirmed fire in certain electrical rooms** supplying safety equipment, incidental or accidental rules of conduct, which **define actions and guidelines** to be followed in order to return to a safe state using only equipment not likely to be affected by the fire (FAIop (for Fiche action incendie opérateur – operator fire action sheet).
  - ✓ Typical actions:
    - ❑ Preventive electrical cut-off rules, e.g. preventively switching off equipment to avoid alarms or spurious actions (automatic trip or ECCS start) or by amending CIA rules because of equipment that may be unavailable or giving information that has become unreliable as a result of the fire. in the event of fire.
    - ❑ Opening of valve for startup of extinguishing systems
    - ❑ Shutdown of certain ventilations

Credit for fire safety units

- First recon team, second intervention team and fire brigade are not credited in the fire safety analyses

Fire safety analysis (FSA)
(cf TS 02.1)

NPP
Tricastin 1

Consideration of induced phenomena (soot, pressure effects,…)

Extensive series of tests and modelling of induced phenomena

- **Effects induced by smoke:** analysis of the effects induced by smoke from fire on the most sensitive equipment (electronic equipment) by **adopting criteria** (temperature, smoke zone, exposure duration) reflecting the possibility of the deposition of soot
- **Pressure effects induced by the fire:** analysis of the pressure rise phenomenon in the rooms in the event of a fire and its potential effect on the compartmentation elements
- **Re-ignition of unburned gases in the ventilation ducts:** analysis especially for the fire safety zones not equipped with fire dampers (additional fire risk assessments with fire models demonstrating that there is no risk or functional analyses demonstrating that there is no impact on safety)
- **Flame jet:** in the event of a fire leading to the loss of containment of systems carrying hydrogenated fluids, the compartmentation studies were supplemented by the addition of heat loads and an assessment of the risk of creating a flaming jet of hydrogen.

Fire safety analysis (FSA)
(cf TS 02.1)

NPP
Tricastin 1

PSA scope

- **level 1 fire PSA**, which assesses the risk of core melt
- **level 2 fire PSA**, which assesses the risks associated with radiological consequences.
- for **all the buildings** and **all operating states**, with core in vessel, in which a fire is liable to generate a thermohydraulic transient
- assessment of the fuel storage building (BK) when core is in the spent fuel pool (risk of uncovering the fuel)

Contribution of Fire PSA

- Fire PSA: one of the main contributor of core melt risk, close to the internal event core melt risk; significantly reduced after the 4th Periodic Safety review
- The Fire PSA highlights the **preponderant contribution of the Electrical Building** to the risk of core melt following a fire when the reactor is at power
  - ✓ preponderant scenarios: incipient fire constituting a hazard for the instrumentation and control (I&C) of the Pressuriser Relief Valves (SDP) triggering unwanted opening of the SEBIM valve tandems

Fire detection (cf TS 03.2.1)

NPP
Tricastin 1

Strategy for the location of the detectors

Installed in all rooms **with a fire risk** or containing equipment itself **containing radioactive or toxic materials in significant quantities**

Characteristics of detectors

- **providing their location:** addressable and distributed in rooms to monitor and grouped in detection zones covering geographically defined areas, with information transmitted to control room
- **initiation of automatic actions:** premises permanently monitored by a general fire detection network which ensures:
  - ✓ Rapid detection of an incipient fire
  - ✓ Activation of the fire alarm
  - ✓ Locating of the fire outbreak
  - ✓ Memorisation of the first fire
  - ✓ Control of the compartmentation components slaved to the fire detection:
    - ➢ Closure of certain fire dampers,
    - ➢ Starting of certain fire protection systems installed at fixed stations (spraying of the diesel generator sets for example)
    - ➢ Closure of certain fire doors that were kept open for ventilation purposes.
  - ✓ Monitoring of progression of the fire

Fire detection (cf TS 03.2.1)

NPP
Tricastin 1

Strategy for the location of the detectors

Installed in all rooms **with a fire risk** or containing equipment itself **containing radioactive or toxic materials in significant quantities**

Characteristics of detectors

- **providing their location:** addressable and distributed in rooms to monitor and grouped in detection zones covering geographically defined areas, with information transmitted to control room
- **initiation of automatic actions:** premises permanently monitored by a general fire detection network
- **withstanding hazards and ambient conditions:** fire protection equipment required by the safety case robust (functional) to SSE level
- **thermal cameras** installed on **worksites** or in case of **the failure of a detector**, with different detection zone. **Monitoring** is carried out in the control room; an alarm is triggered either on a programmed temperature or a change in temperature

Fire suppression (cf TS 03.2.2)

NPP
Tricastin 1

Strategy for the selection of the location of the fire extinguishing systems and their characteristics (gas, foam, water…)

- **Several types** of fixed extinguishing system **depending on the risk** and the equipment to protect:
  - ✓ water sprinkler systems with/without foam system
  - ✓ pre-action sprinkler systems
  - ✓ total flooding systems.
- Fixed extinguishing systems **installed** in certain rooms when **necessary on account of safety compartmentation**
  - ✓ in the rooms with fire duration exceeding 1 hour and 30 minutes forming part of a safety fire volume
  - ✓ when they are necessary for the justification of certain safety fire zones
  - ✓ when they are necessary for addressing common modes
- Based on the safety case:
  - ✓ No **active equipment** for the fixed extinguishing systems in the fuel buildings, the operations building and the electrical building.
  - ✓ Only fixed **sprinkler systems with active equipment** in the nuclear auxiliary buildings, the reactor building and the diesel generator set buildings (failure postulated)

Compartmentation (cf TS 03.3.1)

NPP Tricastin 1

Methods for determining suitable fire barriers:

- **Safety fire sectors:** The safety fire sector is the option to choose in priority
  - ✓ created to physically separate the safety equipment items ensuring functional redundancy
  - ✓ fire resistance rating of the walls separating the redundant equipment items must not be less than 1 hour 30 minutes. Active or passive fire protection means to guarantee their integrity beyond this period.

If not possible (e.g. RB)

- **Safety fire zone:** ensures the absence of propagation and common mode by geographical separation by a zone created to separate the redundant safety equipment
  - ✓ Boundaries of these zones and distance between the components to protect guarantee the integrity of the safety functions for the time necessary to extinguish the fire (for example based on the duration of the reference file). Means of fire protection (shield, extinguishing system) installed if necessary.
  - ✓ Demonstration by modelling of non-propagation and the lack of common modes between adjacent fire zones
- **Real time information** about compartmentation available to the **operator** and the **fire response team's** to be able to identify the need for compensatory measures in case of outages, accidents or hazards to keep the compartmentation
- Implementation on **door-open alarm** on the doors representing a safety risk:
  - ❑ Buzzer within 1 minute
  - ❑ Alarm in the control room within 5 minutes

NPP Tricastin 1

Strategy for the shutdown/isolation of the ventilation and closure of dampers

- There is no automatic closure of ventilation on fire detection except in special cases (air fan fire for example)
- The fire dampers are closed :
  - ✓ by passive systems to guarantee safety sectorization
  - ✓ and by pressing a push buttom
  - ✓ For the particular case of the Access Fire Zone (ZFA), by interlocking to the fire detection system to minimize the propagation of cold smoke and to guarantee safety sectorization

Maintenance of fire dampers (inspection , functionality testing, lessons learnt)

- Monitoring programmes define the **maintenance of flaps fire dampers** of the ventilation systems:
  - ✓ inspection of the actuators,
  - ✓ inspection or replacement of intumescent seals,
  - ✓ integrity of the damper,
  - ✓ verification and replacement of fuses every 5 years,
  - ✓ etc.
- Interlocked fire dampers undergo periodic manoeuvrability and closure tests following triggering of the fire detection system

TS 01.3 and TS 04

NPP
Tricastin 1

Significant improvements resulting from

- **PSR**
  - Development of a new method called PEPSSI (Principle of Evaluation for the Sufficiency of Fire Sectorisation Elements) to check the robustness of fire safety volume compartmentation elements
  - Identification of doors representing a safety risk that will be equipped with "door open" alarms aiming to ensure they are kept closed
  - Measures for improving the fire resistance of certain components or reducing the scale or intensity of potential fires (i.e. replacing fire compartmentation components by components with greater fire resistance)
  - Separation of Emergency Feedwater pumps
  - A modification to avoid unwanted opening of the Pressuriser Relief valves following a fire in the RHRS (Residual heat removal system) not connected states
  - Following these studies (flame jet) , EDF is implementing a modification on the 900 MWe plant series, which is the automatic closure of the H_2 isolation valve of the H_2 supply system if a fire is detected by the fire detection system in certain premises
  - Multiple fire wraps for important cables

TS 01.3 and TS 04

NPP
Tricastin 1

Significant improvements resulting from

- **OPEX**
  - Automatization of transformer fire extinguishing system on fire detection
  - Post Fukushima : the fixed extinguishing of the nuclear island (outside the reactor building) is reinforced to the SSE
  - Bitumen fires on roofs : changes to safety instructions for roofing worksites, use of thermal cameras for surveillance, new waterproofing technology for certain roofs
- **New requirements**
  - **ASN "Fire Resolution"** (fire risk management case as safety case, new notion of "protected access routings" (rooms, stairs and corridors needed to have access to the places required to place and maintain the facility in a safe state), signalization of fire compartmentation)
    - See PSR improvements
  - **Post- Lubrizol request**: following Lubrizol fire in 2019, ASN asked nuclear operators to reconsider the adequacy and efficiency of the barriers put in place within their facilities to control the risks associated with the storage of hazardous substances, as well as their knowledge of the nature and quantities of hazardous substances present
    - List of hazardous substances is kept up to date
    - Modelling of the dispersion of fire smoke in the environment is carried out
    - EDF led the national working group for the drafting of the guide on fire smoke decomposition products for the chemical and petroleum industries
- **Insurers requests**
  - Moving an isolation valve allowing rapid emptying of hydrogen from the main alternator in turbine hall

Strengths

- **Fire protection design approach: complete and extensive, deterministic and probabilistic, periodically improved**
- **Identification, thanks to the PSA, of the rooms or equipment with the greatest fire safety implications and definition of operational measures in these premises**
- Incorporation of non-radiological risks into the Fire Risk Management Case
- Integrated protection against fire risks from the design stage; reinforced fire prevention, detection and fighting on all the units (material and organisational aspects) as a result from the Fire Action Plan (1999-2006), the following plans and from the successive fire safety analyses
- Fire protection measures:
  - **The fire detection equipment and the fixed fire extinguishing systems of the nuclear island and the conventional island are robust to the revised SSE**.
  - **The robustness of the fire sectorisation (doors, fire dampers) and its resistance to the SSE**
  - The prohibition on storing fire loads in the fire safety sectors identified as representing a "major fire risk".
- The robustness of the facility against the risks of re-ignition of combustion residues in the ventilation ducts.
- EDF has set up an organisation:
  - Each NPP has a department in charge of risk prevention. The organisation in place for the preparation and tracking of hot work permits is robust.
  - There is a sectorisation officer on each NPP responsible for fire sectorisation management in order to prioritise the addressing of anomalies.

TS 01.3 and TS 04

NPP Tricastin 1

Weaknesses

- **Management of the temporary and permanent storage areas, some of which do not meet all the requirements concerning fire loads, particularly during plant unit outages. Awareness-raising actions have been carried out with those concerned**
- Application of hot work permits (management of disabling permits, inappropriate risk analyses)
- Better operational management of the sectorisation anomalies to bring greater reliability of this level of defence
- Concerning fire-fighting response:
  - Heavy reliance on the external emergency services in the fire-fighting strategy.
  - On several sites, the on-site fire-fighting personnel must work more closely with the external fire services in order to improve fire-fighting effectiveness
    - **Launch of a fire-fighting enhancement project to improve the efficiency of the organisation as a whole and to reinforce the operational coverage**

2.

RESEARCH REACTOR

RHF ILL

Fire safety analysis (FSA)
(cf TS 02.2)

Research Reactor
RHF

Objectives, scope and main assumptions for the deterministic safety:

- Application of the principle of defence in depth to the control of fire risks,
- Fire Safety Objectives defined in the light of preventing **nuclear accidents only**, following deterministic approach.
- Steps in the risk analysis approach:
  - ✓ approach to identify the protection or interests equipment (PICs) to be protected from a fire
  - ✓ identification of potential targets of the fire
  - ✓ vulnerability study
  - ✓ risk quantification method per room (whether or not containing PICs)

Scope

- During outages, where many works occur, an additional fire risk analysis are systematically part of global risk analysis performed before works are authorised.

Single failure:

- full burnout in the fire area and therefore failure of all PIC's (redundant detectors included)

Operator action and fire safety unit actions: e.g. shutdown ventilation, manual sprinkler

Fire detection (cf TS 03.2.1)

Research Reactor
RHF

Strategy for the location of the detectors

- detectors in all rooms in radiological areas
- redundancy of detectors for rooms with PIC

Characteristics of detectors

- **providing their location:**
  - ✓ All installed detectors addressable, allowing fast, easy and precise locating of any fire outbreak
- **initiation of automatic actions:**
  - ✓ FES (gas ou sprinkler) actuation
- **withstanding hazards and ambient conditions:**
  - ✓ Fire detection system designed to the "hardened safety core" earthquake standards
  - ✓ Fire detection system backed up by battery with a 12-hour operating autonomy.
  - ✓ Fire control panels energised by an electrical network backed up by diesel generator sets premises permanently

Fire suppression (cf TS 03.2.2)

Research Reactor

RHF

Strategy for the selection of the location of the fire extinguishing systems and their characteristics (gas, foam, water…)

- Important fire loads and presence of PICs without redundancy
- Design feasibility
- Important consequences in case of fire event

Methods for determining suitable fire barriers:

- Approach to separate redundant equipment and to protect SSCs important for safety
- When general approach not applicable (e.g. BR)
  - ✓ more detailed analyses, including modelling.
  - ✓ specific protections provided, like fire sprinklers, reduction of fire loads, electrical cables wrapping, two redundant trains with caulking

Ventilation management (cf TS 03.3.2)

Research Reactor
RHF

Strategy for the shutdown/isolation of the ventilation and closure of dampers

- No "sub-fire sector" inside the containment constituting the reactor building:
  - In case of fire outbreak in the reactor building, nuclear ventilation is cut off and containment isolation is triggered
- Fire dampers from the only fire sector room of radioactive sources situated outside the reactor building close automatically when the temperature in the room rises

Maintenance of fire dampers (inspection , functionality testing, lessons learnt)

- The functioning of the fire dampers is checked annually

Significant improvements resulting from

- **PSR**
  - introduction of compartmentation despite the old design of the reactor
  - implementation of automatic or manual sprinkler systems
    - ✓ **Auto sprinkler all over all of level C of the reactor building**, providing fire stability margins for certain metal structures (polar crane and slabs of the reactor building) and controlling the growth of a fire in the reactor experimentation hall (project ongoing);
    - ✓ **Manual sprinkler in the bunkers of reactor building level C**, in order to prevent a fire impacting the thimbles retaining flanges (project ongoing).
    - ✓ **Manual sprinkler in the radiological zone rooms housing the most important PIC-S** in order to make to make up for the difficulty of intervention when reactor in operation
  - renovation of the detection system and implementation of a fully addressable detection system for all the 600 rooms
  - new and diversified tanks for firefighting water
  - arrangements for nearby and off-site fire-fighting services to support the on-site incident response team
  - protection on electrical cables at the reactor building concrete containment penetrations (prevent fire spread)
  - heat screen between the electrical cabinets and the gaz tank of the Horizontal cold neutron source (containing Deuterium gas)
  - fire protection on one of the trains of the “Hardened safety core” backup systems, to ensure separation of the trains in the event of impact by a fire

Significant improvements resulting from

- **New requirements**
  - **ASN "Fire Resolution"** (fire risk management case as safety case, new notion of "protected access routings" (rooms, stairs and corridors needed to have access to the places required to place and maintain the facility in a safe state), signalization of fire compartmentation)
    - see PSR improvements
  - **Post- Lubrizol request**: following Lubrizol fire in 2019, ASN asked nuclear operators to reconsider the adequacy and efficiency of the barriers put in place within their facilities to control the risks associated with the storage of hazardous substances, as well as their knowledge of the nature and quantities of hazardous substances present.
    - ✓ **Setting up a fire water recovery system:**
      - identification of volumes to be recovered according to the size of the building and rain conditions
      - setting up a wastewater collection system (barriers, cofferdam, isolation tape)
      - use of a collection and isolable water network
      - setting up a 1000 m^3 wastewater collection tank

Significant improvements resulting from

- **OPEX**
  - New fire analysis resulting of use a new methodology: Fire study results which requires **additional detector or passive protection**
  - New requirement from the regulator: **Modification of the risk quotation for a chemical product**

- **Insurers requests**
  - Reinforcement of the fire passive protection of cross penetration in a conventional building (no radioactive materials, no safety system in the building) to limit the internal consequences in the building in case of fire event

Research Reactor RHF

Strengths

- Fire protection concept of applying the four levels of defence
- **The renovation and upgrading of the fire safety systems over the years**
- **Fire risk assessment updated introducing the new method for the RHF which takes into account the hazard risk for the PIC-S (important safety component).**
- Management of fire loads and ignition sources:
  - Prior to modifications, analyses on the impact on the fire load or the ignition sources present and any compensatory measures necessary to ensure compliance with the Fire Risk Management Sheet (FGRI)
  - FGRIs of the experimental areas include quantitative limits for the use of inflammable gas cylinders or the use of inflammable liquids
- Robust design approach and strategy in terms of fire detection and alarming,
- Fire suppression system:
  - Reactor I&C (fire sector of the building adjoining the reactor) equipped with an automatic gas extinguishing system.
  - Automatic gas-type extinguishing systems suited to sectors which may be confined and ensure the protection of equipment
- Fire response:
  - All the ILL personnel are trained in the use of fire extinguishers

Weaknesses

- **No effective fire sectorization due to the configuration of the experimental halls** :
  - not feasible, for reasons of available space, to fit out a zone or to protect a PIC with a passive protection system, such as a fire-resistant partition for some experimental zones situated in the reactor building
  - to cope with this weak point, ILL put in place good practices with regard to the room-based fire load management and the management of hot work permit
- **Complex control of the heat loads due the large number of experiments carried out**
  - limitations on the quantity of combustible material authorized per zone defined by the licensee
  - users must be regularly reminded of them.
- Many areas not equipped with automatic fire-extinguishing systems due to the initial design of the facility
- Fire response: no own fire-fighting force beyond the first ILL aid team members

3.

FUEL FABRICATION FACILITIES

ORANO MELOX

FRAMATOME ROMANS

Fire safety analysis (FSA)
(cf TS 02.2)

Fuel fabrication facilities
MELOX

Objectives, scope and main assumptions for the deterministic safety:

- Application of the principle of defence in depth to the control of fire risks or detrimental effect
- Steps in the risk analysis approach
  - ✓ Identification of the PIC to be protected from the effects of fire to maintain the safety functions
    - ❑ PICs directly performing static and dynamic containment protection functions
    - ❑ *PICs performing protection functions to maintain sub-criticality by geometry control, moderation and poisoning*
    - ❑ *PICs participating in fire detection and the corresponding auxiliary systems, in extinguishing and in fire sectorisation.*
    - ❑ *Identification of the structures of buildings containing or supporting safety targets, which must be stable in the presence of a fire*
  - ✓ Identification of the local actions needed to bring the installation to and maintain it in a safe state.
    - ❑ Monitor the filtration systems for the gases extracted upstream of the stack discharges and, if necessary, configure the network.
    - ❑ Locally actuate the required fire-fighting devices (fire dampers on the ventilation networks, ventilation valves, activation of fixed gas extinguishing systems). These local actions are carried out if the remote-control system is unavailable or has failed.
  - ✓ Identification of fire risks and risk control provisions for each room (or group of rooms)
    - ❑ presence of potential safety targets previously identified
    - ❑ potential fire sources (fuels, oxidising substances and ignition sources)
    - ❑ definition of the prevention and mitigation provisions
- Probabilistic analysis is also performed for the generalised fire scenario in a production room using nuclear material in powder form

Fire safety analysis (FSA)
(cf TS 02.2)

Fuel fabrication facilities
MELOX

Scenarios (quantification of radioactive dispersion and release due to fire, combination of hazards..):

- Different scenarios
  - ✓ Verification of the fire robustness of a sectorisation panel: fire in the biological shielding located on the glove boxes, with evaluations of the effects of temperature
  - ✓ Verification of fire stability of the floor: fire in the biological shielding located on the glove boxes to evaluate the modelled effects of a realistic fire on the ceiling of the rooms of a unit
  - ✓ Analysis of the fire resistance of the rooms classified as fire sector and containment sector: fire from polycarbonate (glove box panels) and cellulose materials
- Potential consequences scenarios
  - ✓ all of the mobilizable quantity of nuclear material is considered to be dispersible by the fire.
  - ✓ the factors governing return to suspension are taken from the literature or from scientific tests and vary according to whether or not there is static containment of the nuclear material.
  - ✓ the first level of filtration is considered to be lost
  - ✓ the last level of filtration is considered to be operational, with a decontamination factor of 5.10^{-4}
  - ✓ the fire duration postulated is set at two hours
- Acceptability of radiological consequences with regard to the values defined by the general safety objectives

Methods for determining suitable fire barriers:

- The sectorisation is based on partitions, walls and floors and the components blanking the openings (doors and valves, sealing of penetrations) with a fire rating of EI 120.
- **Fire sectors**: rooms containing a fire load density of more than 400 MJ/m^2 and less than 1800 MJ/m^2 (1100 MJ/m^2 for locations containing nuclear material).
  - ❑ Equipped with fire detection systems and may have a fixed extinguishing system.
  - ❑ Fire sector access doors equipped with a door closer.
- **Protected sectors:** designed to prevent a fire that develops in the vicinity of a room from being propagated to the interior of that room with a fire rating of EI 120.
  - ❑ The access doors and hatches are rated EI 60. The doors are equipped with a door closer
- **Containment sector**: serve to contain any nuclear materials that could come from the fire sectors if fire breaks out in them
  - ❑ Air locks for the personnel and equipment, ventilated by different ventilation ducts from those of the fire sector rooms.
  - ❑ Ventilation to be maintained in the air lock in the event of fire and therefore to ensure negative pressure with respect to the adjacent rooms. These air locks are equipped on the fire sector side with an EI 120 door and on the external side with a minimum-leakage metal door.

Ventilation management (cf TS 03.3.2)

Fuel fabrication facilities MELOX

Confinement provisions used in case of fire (static or/and dynamic confinement)

- Containment based on **passive** (walls, buildings…) and **dynamical** (ventilation) provisions.
- The management of ventilation in a fire situation to:
  - ✓ control the dispersion of nuclear materials by ensuring for as long as possible the dynamic containment achieved by high negative pressure (HNP) extraction, maintaining negative pressure cascades between the rooms of containment enclosures and preserving the effectiveness of the last filtration levels (DNF)
  - ✓ control of the fire by limiting the introduction of air, by protecting the extraction networks from the fire and by allowing removal of the heat and effluents from the fire.

Strategy regarding the maintenance of dynamic confinement considering the risk of fire propagation through ventilation systems

- Controls and maneuvers of the fire dampers tested annually
  - ➩ Maneuverability tests cannot be carried out on the dampers of the glove boxes ventilation networks (nitrogen and THD) because they would lead to the dispersion of nuclear material in the rooms.

TS 01.3 and TS 04

Fuel fabrication facilities
MELOX

Significant improvements resulting from

- **PSR**
  - Mechanical reinforcement of the doors resulting from the consideration of pressure effects
  - Implementation of sensors so as to be able to detect abnormal temperature in several room after an earthquake
- **OPEX**
  - Implementation of temperature sensors in the production rooms containing nuclear material and in the extraction ventilation ducts of the MOX pellet interim storage rooms
- **New requirements**
  - **ASN "Fire Resolution"** (fire risk management case as safety case, new notion of "protected access routings" (rooms, stairs and corridors needed to have access to the places required to place and maintain the facility in a safe state), signalization of fire compartmentation)
    - updating of safety analyses by considering safety targets
    - consideration of the protected paths/routes
  - **Post- Lubrizol request**: following Lubrizol fire in 2019, ASN asked nuclear operators to reconsider the adequacy and efficiency of the barriers put in place within their facilities to control the risks associated with the storage of hazardous substances, as well as their knowledge of the nature and quantities of hazardous substances present.
    - status of storage plans available to response teams

Fuel fabrication facilities MELOX

Strengths

- Consideration of the common mode risk: The redundancy of the PICs to be protected from the effects of the fire and their physical separation
- Consideration of the risk of internal failure: plausible failures of fire protection provisions considered to no cliff-edge effect and unacceptable consequences
- **Control of hydrogen proportion in argon and inerting glove boxes**
- Broad coverage by the AFD network, fostering early fire detection.
- Transmission of alarms to a permanently manned station in order to rapidly mobilise the firefighting personnel and to place and maintain the facility in a safe state in a fire situation.
- **The on-site presence of a service specialised in firefighting with the personnel and technical means of the MELOX site**

TS 01.3 and TS 04

Fuel fabrication facilities
MELOX

Weaknesses

- Certain partitions separating a production room and a passageway constitute a single wall situated both at the boundary of a fire sector and at the boundary of a containment sector. They have a fire resistance rating and a sealing requirement
- **As the facility uses materials that present a criticality risk, the use of water as an extinguishing agent is strongly restricted in many premises, which means that particular attention must be paid to fire protection measures to prevent fires from starting and spreading**

Fire safety analysis (FSA)
(cf TS 02.2)

Fuel fabrication facilities
Framatome Romans

Objectives, scope and main assumptions for the deterministic safety

- Application of the principle of defence in depth to the control of fire risks or detrimental effect
- Steps in the risk analysis approach
  - ✓ Definition of the plausible scenario, for each room depending on the combustible materials and ignitions sources without credit of extinguishing means
    - ❑ Qualitative analysis for rooms with limited safety implications
    - ❑ *Specific analysis for the rooms with significant safety implication*
  - ✓ Definition of the reference scenario (with the most severe effects)
  - ✓ Analysis of the vulnerability of the targets (targets to be protected)
  - ✓ Check the robustness of the safety case considering
    - ❑ a failure, e.g. fire door or fire damper
    - ❑ generalised fire for rooms with significant quantities of radioactive materials with regard to consequences outside the site (toxic, thermal effects, overpressure (explosion))
- Plausible combination of events (lightning, earthquake, freezing, loss of electrical power supplies, etc.), whether or not they are possible triggers of a fire, taken into account. Combinations considered if confirmed dependency relationship and that no design provision is capable of ruling them out.

Fire safety analysis (FSA)
(cf TS 02.2)

Fuel fabrication facilities
Framatome Romans

Scenarios (quantification of radioactive dispersion and release due to fire combination of hazards..)

- Evaluation of the radiological consequences
  - ✓ the source term released into the environment is calculated using the inventory of radioactive materials present and dispersible affected by the fire in the room.
    - ❑ The fraction of material present and dispersed depends on its physico-chemical form, the nature and means of its containment and the intensity of the postulated fire. This fraction is evaluated on a case-by-case basis.
    - ❑ The suspension coefficients are chosen consistently with the data in the literature. As a conservative measure, re-deposition of the material in suspension on the walls of the rooms or in the ventilation ducts is not generally considered.
    - ❑ Filtration (from first to last level of filtration) not systematically credited.
    - ❑ Direct releases outside the building are also considered to account for i) rare situations of fire compartment with an opening leading to the outside of the building and ii) not ventilated buildings.
  - ✓ the height of the release
  - ✓ the meteorological conditions (diffusion and wind speed)
  - ✓ the distance between the measurement point and the release point
  - ✓ the targeted population
  - ✓ the exposure duration.
- Acceptability of the radiological consequences evaluated with regard to the reference value of 1 mSv at the perimeter of the site (annual effective dose limit for the population defined by the regulations (Public Health Code))

Compartmentation (cf TS 03.3.1)

Fuel fabrication facilities Framatome Romans

Methods for determining suitable fire barriers:

- Fire sectors made up of physical fire walls (walls, floor, ceiling), openings (doors, hatches, etc.) and fire dampers. Fire-resistance rating of 2 hours
- Fire sectors or fire zones are defined within the buildings:
  - ✓ rooms with **high fire loads** and presenting **a high fire risk**, such as electrical rooms (no propagation)
  - ✓ rooms containing **large quantities of radioactive materials** (storage areas, process room(s) (protection of these materials)
  - ✓ rooms of the Last Filtration Level (DNF) -> protection the DNF HEPA filters (containment function)
  - ✓ rooms in which **significant quantities of radioactive materials** in the form of **readily inflammable powders** (e.g. non-oxidised uranium-bearing powders) (no propagation and both protect these materials)
  - ✓ the **protection important components** against the effects of a fire and ensuring functional redundancy (e.g. the ventilation system extraction fans) in different fire sectors.
  - ✓ If this requirement cannot be satisfied, these components can be separated by a firewall,
- Penetrations (ventilation, fluids, cables) are sealed so as to restore the fire-resistance rating of the fire sector.

Compensatory fire protection measures

For buildings or rooms that do not meet these rules, special compensatory measures are taken, such as:

- ✓ verification of the low level of movable fire loads present in the rooms
- ✓ protection of the load-bearing elements situated nearby or in the plume of the potential fires
- ✓ installation of an automatic extinguishing system over the zone or equipment representing a particular risk with respect to the stability of the building
- ✓ definition of fire zones associated with substantiations and complementary measures, such as zones where the storage of fire loads is prohibited.

Ventilation management (cf TS 03.3.2)

Fuel fabrication facilities
Framatome Romans

Confinement provisions used in case of fire (static or/and dynamic confinement)

- Containment based on **passive** (walls, buildings…) and **dynamical** (ventilation) provisions.
- Depending on the required level of containment for the equipment or the rooms, ventilation networks are equipped:
  - ✓ with HEPA filters constituting a First Filtration Level (PNF)
  - ✓ with HEPA filters constituting the last filtration level (DNF) before discharge at the chimney. These filters withstand 200°C for 2 hours with a head loss of 2000 Pa)
  - ✓ Extraction fans are situated downstream of the DNF filters
- In the event of a fire, automatic protection actions aim to maintain dynamic containment in the building for as long as permitted by the development of the fire.
  - ✓ These protection actions are local, that is to say they are geographically limited to the room or rooms concerned
  - ✓ Closure of the openings and fire dampers in the blowing direction limits the introduction of fresh air to the fire.
  - ✓ Maintaining extraction helps to remove smoke and limit the rise in temperature and pressure in the room by extracting the smoke and hot gases
  - ✓ Lastly, maintaining the extraction in the building allows the recovery of the radioactive fumes which can escape by leakage from the seat of the fire room

Strategy regarding the maintenance of dynamic confinement considering the risk of fire propagation through ventilation systems

- Items of equipment involved in the control of the fire risks undergo periodic inspections and tests. Fire dampers are tested annually
- The tests consist of:
  - ✓ verification of operation for fire dampers interlocked with fire detection
  - ✓ verification of operation of open and closed positions (remote information and locally, visually)
  - ✓ local and remote manoeuvrability
- All fire dampers are accessible

TS 01.3 and TS 04

Fuel fabrication facilities
Framatome Romans

Significant improvements resulting from

- **PSR:** led to significant updates for the buildings containing uranium-bearing materials

- Improvement of the dynamic containment and the operational management of this containment in the event of fire
- Installation of new walls preventing any fire propagation
- Reduction in the quantity of combustible materials present in the premises, notably by reorganisation entailing the removal of equipment or furniture, or replacement by equipment with a better reaction to fire, or even non-combustible when possible; moving combustible elements away from ignition sources;
- Improvement of the operational condition of the automatic extinguishing system actuators
- Replacement of old equipment by new equipment compliant with the applicable regulations and standards
- Surveillance to ensure that combustible materials are not accumulated in the rooms
- Installation of automatic extinguishing systems for the electrical cubicles and cabinets (CERCA)
- Installation of fire-proof cabinets for storage of combustible materials (documentation, small combustible objects, etc.) and to protect pressurised gas bottles at risk
- Sectorisation of the equipment storage rooms, the electrical rooms or the rooms for storage of uranium-bearing materials
- Installation of fire shields or flame arresters between equipment for which there is a risk of an outbreak of fire or between fire zones which are not sufficiently far apart
- Fire-break protection of building structural load-bearing elements
- Installation of smoke vents
- Protection of the detection system of criticality accident by distribution of the sensors around different fire volumes to prevent their simultaneous failure caused by the same fire.

Significant improvements resulting from

- **OPEX**

Starting fire and fire events which occurred at Framatome Romans in recent years led to the following actions:

- **In terms of prevention:**
  - Personnel training: focuses on fire in the “Safety Culture” dispensed to all the personnel and skills enhancement of the safety engineers.
  - Process modifications (for easily flammable metals: inerting with argon of operations with easily flammable metals, permanent water spraying, metallic containers…)
  - Improvement of the hot work permit
  - Creation of “sensitive activities” to enhance their reliability
  - Enhancement of the account of the coupling between ignition sources and fire loads in the FRAs
- **In terms of protection:**
  - Installation of fire-proof waste bins for the safe disposal of a canister suspected of heating
  - Deployment of the fire protected routes in the buildings housing uranium-bearing material

Significant improvements resulting from

- **New requirements**
  - **ASN "Fire Resolution"** (fire risk management case as safety case, new notion of "protected access routings" (rooms, stairs and corridors needed to have access to the places required to place and maintain the facility in a safe state), signalization of fire compartmentation)
    - the robustness of defence in depth, notably the provisions for fire prevention and fire-fighting operational organisation, means and training
    - the management of hazardous chemicals and the assessment of the associated risks
  - **Post- Lubrizol request**: following Lubrizol fire in 2019, ASN asked nuclear operators to reconsider the adequacy and efficiency of the barriers put in place within their facilities to control the risks associated with the storage of hazardous substances, as well as their knowledge of the nature and quantities of hazardous substances present.
    - Inventory of the chemicals with, for each of thrm, its nature, location, quantity, etc.

TS 01.3 and TS 04

Fuel fabrication facilities
Framatome Romans

Significant improvements resulting from

- **Insurers requests**
  - Some insurer requests which can be linked to nuclear safety issues:
    - Equip (drying) ovens with a security thermostat that automatically stops the heating on high temperature threshold and is independent of the regulation thermostat
    - Attention should be paid to Lithium Ion batteries and other batteries: during charging, security distances free of fire load are recommended for small electrical tools, industrial trolleys and electrical vehicles
    - Metallic waste bins shall be used to collect rags soaked with oil or flammable liquid

- **Potential updates since the NAR production**
  - List of undertaken actions:
    - Personnel training: focuses on fire in the “Safety Culture” dispensed to all the personnel and skills enhancement of the safety engineers
    - Account of the coupling between ignition sources and fire loads included in the documentation
    - Monitoring of transient fire loads in the buildings housing uranium-bearing materials
    - Fire risk verification points added to the safety engineers' patrol rounds
    - Protected routes in the buildings housing uranium-bearing materials

TS 01.3 and TS 04

Fuel fabrication facilities
Framatome Romans

Strengths

- The processes linked to control of the fire risks, whether in the design, production, operation and in-service monitoring phase, are robust and tried and tested
- **The independent safety organisation maintains an effective surveillance over the risks as a whole**
- The site is a partner of the inter-licensee working group on the fire theme. This group shares experience on topical subjects, such as singular events
- Distance between the buildings accommodating nuclear materials and the structure of these buildings enable a fire-resistance rating of at least 2 hours to be achieved with respect to an external fire
- Structural load-bearing elements of the main buildings housing nuclear materials are stable to fire for at least 2 hours.
- The site is equipped with a fire safety system (FSS), an automatic fire detection system and automatic safeguarding systems deployed in all the buildings, and constant monitoring on a centralised site by dedicated personnel
- **The site has human resources, including firemen, who are trained and undergo periodic refresher courses, and it has emergency response equipment. These human and material resources are available and maintained on the site at all times to intervene in a fire situation**
- A robust emergency organisation is in place, with the periodic organisation of exercises, some carried out jointly with the external emergency services and the other stakeholders
- **The site has shared and formalised design rules concerning fire sectorisation and ventilation.**
- The large majority of the actionable safety devices (fire doors, other openings, fire dampers, etc.) are covered by automatic systems (by interlocking or by design)
- The fire sectorisation elements and the safeguarding measures are subject to periodic inspections and tests
- **The fire-fighting devices that can be used by the personnel are stowed within the facility in a protected building designed to earthquake standards.**

TS 01.3 and TS 04

Fuel fabrication facilities
Framatome Romans

Weaknesses

- The culture with respect to fire risks, especially their prevention, must be further developed at all hierarchical and activity levels.
- **There are difficulties in freeing up resources to acquire knowledge on the new or emerging risks associated with new battery technologies (lithium-ion, etc.), to establish robust and shared recommendations and to implement them.**
- **Particular attention must be paid to minimising the fire loads present in the facility**
- The site's fire standard must be updated with regard to the applicable regulations and good practices
- The FDS currently in service, and its communication network, will soon be obsolete, which will create system maintenance problems (software, spare parts)
- The organisation of the site does not include the FSS coordination missions
- **Two buildings must undergo improvements in order to retain and recover fire extinguishing effluents. If water runs off to the exterior of the buildings, it is taken up by the stormwater drainage network and retained in stormwater tanks.**
- The time taken to deploy the improvement measures identified following the recent updates of the DMRIs should be reduced
- Although the design rules of the sectorisation and ventilation components are formalised, there is substantial variability between the site buildings housing uranium-bearing materials, notably for historical reasons requiring procedures specific to each building, particularly regarding ventilation management in fire situations
- Protected paths must be defined and deployed for the buildings housing uranium-bearing materials

4.

SPENT FUEL STORAGE

ORANO LA HAGUE

Fire safety analysis (FSA)
(cf TS 02.3)

Spent fuel storage
La Hague – Pool D

Objectives, scope and main assumptions for the deterministic safety analyses (combination of hazards)

- Application of the principle of defence in depth to the control of fire risks
- In a fire situation, the main objective is to verify that the safety functions remain functional
- Combustion of all the combustible materials postulated as soon as a source of ignition is present, in order to check the adequacy of the lines of defence with respect to the targets to be protected from the effects of a fire
- Fire risk(s) induced by an event (falling load, earthquake, etc.) are taken into account by means of specific provisions (verification of a floor's resistance to falling loads, automatic seismic detection and shutdown system, etc.)

Fire detection (cf TS 03.2.1)

Spent fuel storage
La Hague – Pool D

Strategy for the location of the detectors

- Strategy based on objective criteria such as the functionality of the premises (synonymous with high heat load density), the presence and vulnerability (to thermal effects for example) of an important element to ensure a safety function, the importance of the areas of intervention
  - ⇘ No automatic fire detector installed in a room with little or no heat load and electrical equipment

Characteristics of detectors

- **providing their location:**
  - ✓ Addressable detector technology is used to make detection localization more reliable
- **withstanding hazards and ambient conditions:**
  - ✓ equipped with an automatic linear smoke detection system, adapted to the ambient conditions

Fire suppression (cf TS 03.2.2)

Spent fuel storage
La Hague – Pool D

Strategy for the selection of the location of the fire extinguishing systems and their characteristics (gas, foam, water…)

- **The use of water as a fire-fighting agent during interventions is compatible with the safety-criticality objectives**
  - ✓ Fire extinguishers are provided
  - ✓ Dry riser

Significant improvements resulting from

- **PSR**
  - Replacement of some fire control panels equipment due to ageing with recent technologies
  - Improvements from PSR:
    - installation of fire doors,
    - an AFD system for the pool D hall
    - an automatic linear smoke detection system for the pool D hall
    - a thermal shield between the redundant electrical equipment items and fire protection around at least one of the two channels providing electrical power to these equipment items

TS 01.3 and TS 04

Spent fuel storage
La Hague – Pool D

Significant improvements resulting from

- **New requirements**
  - **ASN "Fire Resolution"** (fire risk management case as safety case, new notion of "protected access routings" (rooms, stairs and corridors needed to have access to the places required to place and maintain the facility in a safe state), signalization of fire compartmentation)
    - Reinforcement of the typology of rooms identified in the design: Additional room types with an identical fire risk were defined
    - Commitments are taken account by licensee after each PSR
  - **Post- Lubrizol request**: following Lubrizol fire in 2019, ASN asked nuclear operators to reconsider the adequacy and efficiency of the barriers put in place within their facilities to control the risks associated with the storage of hazardous substances, as well as their knowledge of the nature and quantities of hazardous substances present.
    - Implementation of a chemical products management computer tool to know the maximum quantities

TS 01.3 and TS 04

Spent fuel storage
La Hague – Pool D

Strengths

- **No rooms with significant fire loads necessary for operation (consumables) or resulting from operation (combustible waste).**
- The rooms necessary for operation are situated in the T0 unit, which greatly limits the risks of the pool hall suffering fire damage.
- Pool D Building equipped with EI 120 doors separating it from the adjacent building
- Consolidation of the categories of rooms
- Fire alarms transmitted to the T0 unit/pool D operational control room and to the PSM's control and monitoring room. The chosen ergonomics enable the location of the fire alarm triggered in the pool D building to be identified rapidly and with certainty.
- **24h/24 presence of the PSM service fire-fighting teams enables fire-fighting to begin immediately with heavy-duty means without waiting for the external emergency services**

TS 01.3 and TS 04

Spent fuel storage
La Hague – Pool D

Weaknesses

- **The building comprises just 3 rooms presenting a low fire load. Due to their design functionality, these rooms (pool hall and below pool) have large dimensions and cannot have any fire walls**
- For the fire prevention, the pool D building does not have rooms with significant fire loads necessary for operation (consumables) or resulting from operation (combustible waste) because they have been grouped together in dedicated and identified rooms in the T0 unit (e.g. consumables storerooms, rooms for interim storage of waste). However, the pool-side passageways are narrow, which can complicate the positioning of the equipment used for maintenance and operation.
- **The fire control panels in T0 that were installed when the T0 unit was built should be replaced due to ageing**
- The passive fire risk control systems are satisfactory. The licensee must redouble its sectorisation efforts to achieve an adequate level of passive protection

5.

WASTE

ORANO LA HAGUE SILO 130

Fire safety analysis (FSA)
(cf TS 02.4)

Waste
Silo 130

Objectives, scope and main assumptions for the deterministic safety analyses (combination of hazards)

- Application of the principle of defence in depth to the control of fire risks
- Owing to the specific nature of the silo and the specific risks linked to the waste retrieval operations (RCD), the analysis of the fire risk consists of two steps:
  - ✓ Study of the fire risk in silo 130 (determination of the sensitivity of the room, identification of PIC (equipment, route for evacuation…) that could be impacted by fire
  - ✓ Specific study of the fire risk linked to the RCD process, due to the presence of the waste stored in the pit:
    - ❑ Uranium hydride (UH3) in divided form,
    - ❑ Magnesium (Mg) and uranium (U) in flammable chemical form
    - ❑ Graphite
    - ❑ Technological waste (plastics in particular)

  This study carried out jointly with a research and development (R&D) and tests programme

Fire detection and fire suppression (cf TS 03.2.1/TS 03.2.2)

Waste
Silo 130

Strategy for the location of the detectors

- Strategy based on objective criteria such as the functionality of the premises (synonymous with high heat load density), the presence and vulnerability (to thermal effects for example) of an important element to ensure a safety function, the importance of the areas of intervention
  - No automatic fire detector installed in a room with little or no heat load and electrical equipment
- Fire detection in silo 130 based on two types of detection:
  - ❑ temperature in the ventilation duct
  - ❑ Cs137

  as conventional detectors cannot be maintained in the silo environment.
- Camera confirmation: video and thermal cameras

Strategy for the selection of the location of the fire extinguishing systems and their characteristics (gas, foam, water…) and their potential harmful effects

- Implementation of an automatic extinguishing system with argon

Waste
Silo 130

Methods for determining suitable fire barriers

- Each building has a strong compartmentation into premises which makes it possible to reduce the heat load within each of them by dividing it and already insulating it in a robust manner.
- Fire sectors: premises whose heat load density exceeded 600 MJ/m²
  - ❑ electrical premises, IT premises, control room, etc.
  - ❑ equipped with fire walls of degree two hours
  - ❑ all the crossings and openings of such a room with same qualification
- Combustion of all the combustible materials postulated
- As soon as a source of ignition is present, in order to check the adequacy of the lines of defence with respect to the targets to be protected from the effects of a fire.
  - ❑ Use of data from the normative reference framework established on the basis of outbreaks in an open environment (oxygen necessary for complete combustion of the fuel)
  - ❑ Envelope approach for a confined and under-ventilated environments available under these conditions.

TS 01.3 and TS 04

Waste
Silo 130

Significant improvements resulting from

- **PSR**
  - Upgraded facility for the waste recovery project (2020)
- **OPEX**
  - New automatic extinguishing system (argon)
- **New requirements**
  - **ASN "Fire Resolution"** (fire risk management case as safety case, new notion of "protected access routings" (rooms, stairs and corridors needed to have access to the places required to place and maintain the facility in a safe state), signalization of fire compartmentation)
    - Commitments are taken account by licensee after each PSR
  - **Post- Lubrizol request**: following Lubrizol fire in 2019, ASN asked nuclear operators to reconsider the adequacy and efficiency of the barriers put in place within their facilities to control the risks associated with the storage of hazardous substances, as well as their knowledge of the nature and quantities of hazardous substances present.
    - Implementation of a chemical products management computer tool to know the maximum quantities

TS 01.3 and TS 04

Waste
Silo 130

Strengths

- Implementation of waste retrieval and packaging, designed in accordance with the most recent fire protection principles, have considerably reinforced the fire risk control. Its Implementation of WRP have considerably reinforced the fire risk control
- Fire detection ensured now by several fixed means by a fire detection system specific to pit 43 and surveillance cameras whose images are transferred to the Silo 130 unit operational control station for viewing
- **Comprehensive tests in order to confirm the factors limiting the risks of an outbreak of fire in the pit during the retrieval operations were performed**
- **24h/24 presence of the PSM service fire-fighting teams enables fire-fighting to begin immediately with heavy-duty means without waiting for the external emergency services**

Waste
Silo 130

Weaknesses

- The **original design** of the storage pit comprised no fire detection or extinguishing systems
- **Initial design** of the silo did not take into account the fire risk associated with the types of waste stored
- Part of the fire risk is due to the composition of the waste, not always fully characterised when removed from the pits, means that controlling the fire risk imposes constraints on retrieval operations that can slow down the rate (need for identification or characterisation) or limit productivity (limited filling of drums).
- In an earthquake situation, the functioning of the existing means cannot be guaranteed as Silo 130 is not designed to withstand this extreme hazard.
    - In this case the detection of a fire in silo 130 relies on detection by personnel during the site diagnosis patrol round which is planned in the first phase of emergency management after an extreme event.
    - In case of occurrence of a strong earthquake, the maintenance of the watertightness of silo 130 cannot be demonstrated but the latter would still ensure containment of the waste
- **Part of the effectiveness of the active fire-fighting systems is dependent on the personnel and their skills.**

6.

DECOMMISSIONING

CEA OSIRIS

TS 02.6, TS 03.2, TS 03.3

Decommissioning
RR Osiris

Adaptations to the fire protection strategy in operation when moving to decommissioning

- A decommissioning strategy with priority on the actions that suppress fire loads or fire risks:
  - ❑ Some major equipment such as the main Diesel generators and their fuel tanks as well has unnecessary I&C cabinets suppressed shortly after OSIRIS reactor shutdown.
  - ❑ Underwater operations chosen (like cutting, packaging and storage of waste under water) with very positive significant impacts on fire risk.
- Transition from the operating to the decommissioning phase: revision of the existing FSA due to:
  - ❑ the change in activities (from a reactor in operation to decommissioning activities)
    - ➷ transient fire loads include storage areas (nuclear waste, etc.) and all fire loads needed for generic decommissioning activities (plastic decommissioning airlocks, etc.).
    - ➷ new fire sources such as hot-spot works
  - ❑ the reduction in staff numbers (security duty watch system was introduced after stopping the shift teams)
  - ❑ implementation of complementary detectors
- Complementary analyses necessary to consider the risks induced by dismantling operations

Management of fire loads and ignition sources

- Management of fire loads:
  - ✓ A file with the inventory of fire loads carried out for each room
  - ✓ File updated periodically. If significant changes in fire loads due to remediation work, decommissioning, a transient fire load analysis is carried out
- Management of ignition sources:
  - ✓ In the event of hot-spot works, a hot work permit is delivered.
- Before specific decommissioning activities, specific fire safety analyses are also carried out considering transient fire loads of the associated activities

New systems put in place

- Implementation of new fire detection linked to future equipment like dismantling air-locks or in new storage area

Significant improvements resulting from

- **PSR**
  - PSR led to several fire risk prevention measures being put in place:
    - ✓ Automatic fire detection systems installed in 30 rooms
    - ✓ Installation of fire-resistant cabinets adapted to chemical substances
    - ✓ Installation of new portable fire extinguishers
    - ✓ Installation of metal retentions for fuel oils
    - ✓ Sealing of electrical and mechanical penetrations
  - Authorization to use water as a means of extinguishing in areas that no longer contain fissile material

- **OPEX**
  - Improvements in the tracking of the periodic tests and maintenance work resulting from the feedback of the event concerning the failure of the automatic fire detection system in the ISIS reactor hall
    - ↳ Corrective measures such as updating of procedures and replacement of obsolete components

Significant improvements resulting from

- New requirements
  - **ASN “Fire Resolution”** (fire risk management case as safety case, new notion of “protected access routings” (rooms, stairs and corridors needed to have access to the places required to place and maintain the facility in a safe state), signalization of fire compartmentation)
    - See PSR improvements
  - **Post- Lubrizol request**: following Lubrizol fire in 2019, ASN asked nuclear operators to reconsider the adequacy and efficiency of the barriers put in place within their facilities to control the risks associated with the storage of hazardous substances, as well as their knowledge of the nature and quantities of hazardous substances present.

    Quantity of toxic or dangerous products involved in the facility extremely low, however
    - Creation of a map of dangerous substances
    - Strengthening the inventory procedure of hazardous chemicals
    - Installation of fire-resistant cabinets adapted to chemical substances
    - New procedure for using chemical substances
- Insurers requests
  - Fire-resistant expanding foam performance through lifetime

Strengths

- Approach of fire safety analysis that enables the provisions to be adapted to the safety issues
- Numerous provisions, such as fire dampers and fire doors, for limiting the propagation of a fire in the zones housing the electrical rooms and equipment associated with nuclear ventilation
  - Openings and penetrations are sealed with materials that are non-combustible and/or fire resistance rated
  - Particular attention is paid to the sealing of the penetration between different areas
- **Renovation of the fire safety system in 2016. The technology used allows rapid detection and intervention of the FLS.**
- The calorific potential (fire load) per unit surface area checked annually in the sensitive rooms and every three years in the non-sensitive rooms .
- The management of the hot work permits for the facility's worksites is clear and duly traced
- **As part of the decommissioning preparation work, worksite air locks and radioactive waste temporary storage zones are set up, bringing changes in the fire risk (introduction of fire loads, ignition sources, dispersibility of the radioactive inventory, etc.)**

TS 01.3 and TS 04

Weaknesses

- Complex nature of the fire safety analysis and scale of the human resources and expertise needed
- **The fire risk study sets out a diagnosis of the risk control and several actions have been started but are still to be finalised.**
- In the particular case of the hot cell fire detectors, the lack of accessibility complicates the periodic inspections and any necessary maintenance operations. The periodic operating checks are carried out applying specific procedures
- **By virtue of their design, the nuclear zones are not partitioned. Nevertheless, the risk analysis substantiates the adequacy of the measures adopted**
- The list of equipment contributing to the control of propagation of the fire risk (fire doors, smoke removal systems) is presented in the fire risk management study, but some of these equipment items are not subject to any periodic operating checks
- Procedures for checking the detection systems and proving performance of the checks to be specified by the licensee.

Adaptations to the fire protection strategy in operation when moving to decommissioning

- When the facility is decommissioned, the fire analyses are entirely overhauled to design the provisions in line with the issues raised by the dismantling works. They are reviewed by ASN as part of the process of obtaining the decree for the dismantling of the facility
- These analyses are regularly updated to take account of changes in the facility as a result of the progress of the dismantling works
- A review (PSR) is carried out every 10 years and examined by the ASN. This reassessment takes into account the state of the installation for the following 10 years and the feedback gathered

Management of fire loads and ignition sources during hot works

- **Fire loads**:
  - ✓ EDF has a procedure and a digital tool for nuclear facilities undergoing decommissioning that enables heat loads to be closely monitored to ensure compliance with the safety demonstration limits
  - ✓ Toxic and flammable products must be stored in fireproof cabinets
- **Hot works**:
  - ✓ for work involving hot spots, the organisation provides for an application for a "fire permit" including a risk analysis and the definition of associated **countermeasures** (e.g. installation of spark arresters, fire screens) and **controls** (e.g. reinforced surveillance during the worksite; a round is carried out one hour after the end of the activity to check that there is no smouldering fire)

New systems put in place

Fire detection:

- ✓ Fire alarms are reported to the Alarm Monitoring Station, where a permanent presence is maintained during working hours
- ✓ These alarms are also relayed to Saint-Laurent B, where they are monitored outside working hours

TS 01.3 and TS 04

Decommissioning
NPP graphite gaz

Significant improvements resulting from

- **OPEX**

✓ Implementation of provisions to protect containment functions in the case of a nearby worksite or the presence of a insufficient distance between the safety equipment and the worksite,

✓ Updating of operating instructions for storage areas for intermediate-level waste packages to limit or prohibit the use of internal combustion engines in certain areas.

✓ Introduction of additional measures to improve control of the risks associated with hot-spot work:

  - raising the awareness of those involved in the analysis of the risks associated with fire permits,
  - implementation of associated countermeasures;
  - detailed analysis if liquid waste is present,
  - ….

TS 01.3 and TS 04

Decommissioning
NPP graphite gaz

Significant improvements resulting from

- **New requirements**
  - **ASN "Fire Resolution"** (fire risk management case as safety case, new notion of "protected access routings" (rooms, stairs and corridors needed to have access to the places required to place and maintain the facility in a safe state), signalization of fire compartmentation)
    - The preservation of static containment makes it possible to guarantee the safe state for INB 46.There is no intervention required to maintain the safe state. There is no need to define protected paths (protected paths exist for the safety of workers)
  - **Post- Lubrizol request:** : following Lubrizol fire in 2019, ASN asked nuclear operators to reconsider the **adequacy and efficiency of the barriers** put in place within their facilities to control the risks associated with the storage of hazardous substances, as well as their **knowledge of the nature and quantities of hazardous substances present**.
    - The inventory of hazardous substances at facilities undergoing deconstruction is very limited. This inventory is stored in fireproof cabinets and monitored by the heat load management tool
- **Insurers requests**
  - No request up to now

asn

TS 01.3 and TS 04

Decommissioning
NPP graphite gaz

Strengths

- The centralisation on the Saint Laurent site provides an overall view of the site's installations as a whole in a fire situation and allows better coordination of the means. The fire exercises and discussion meetings with the external emergency services enables certain issues to be planned for in advance and ensure a fast and proportionate response
- As EDF facility, use first and foremost of the experience feedback and lessons learned from its BNIs, as well as from other external sources whether French or international

TS 01.3 and TS 04

Decommissioning
NPP graphite gaz

Weaknesses

- **The improvements concerning the hot work permits must be continued, more specifically in the lifting of the hold points on the decommissioning worksites**
- **The changes in the facility due to its decommissioning necessitate vigilance with respect to the fire risk, particularly when setting up and putting into operation the containments associated with the worksites**
- The presence of carboxide and hydrogenated carboxide deposits, which cause risks of fire, explosion and poisoning during thermal cutting operations

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