ENSREG
European Nuclear Safety Regulators Group

National Presentation of Belgium

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National Presentation Outline

FANC
FEDERAAL AGENTSCHAP VOOR NUCLEAIRE CONTROLE

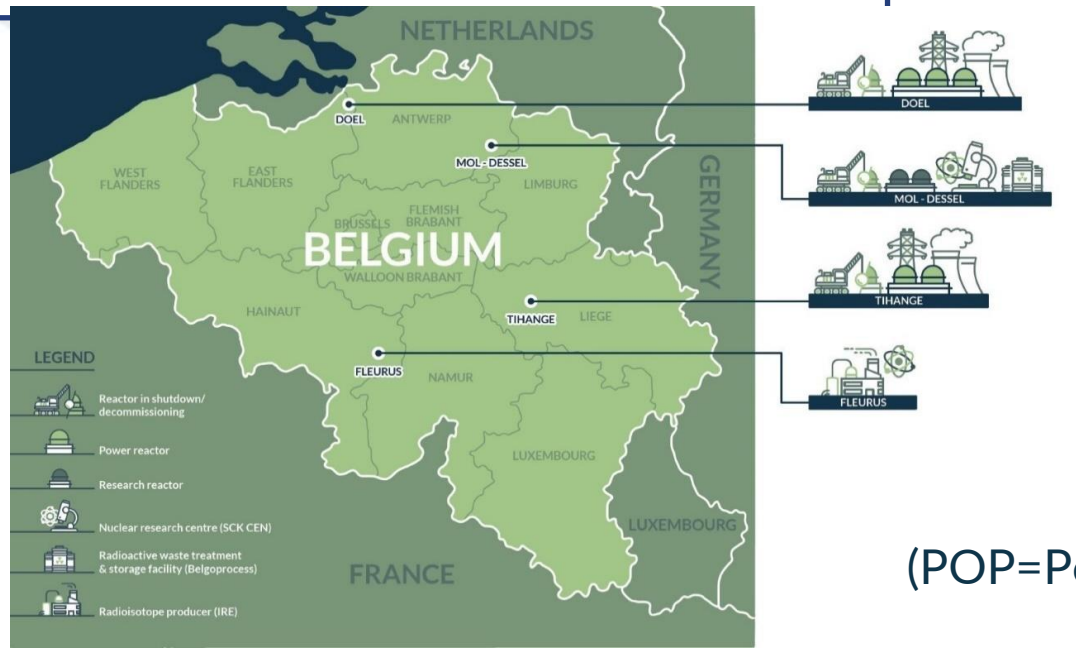
BEL V

List of candidate installations and their regulation

1. **NPP**
2. **Decommissioning**
3. **Dedicated spent fuel storage**
4. **RR**

Candidate installations/regulation

TS 01.1 & 01.2: Nuclear Installations in Belgium



(POP=Post Operational Phase)

- Site of Doel: 4 NPPs (1 in POP) and 2 dry SFSs (1 in construction).
- Site of Tihange: 3 NPPs (1 in POP) and 2 SFSs (1 dry/1wet).
- Area of Mol-Dessel: 4RRs (various power, 1 in DECOM) and a dedicated site for centralized waste storage that hosts 1 installation for SFS.
- Note: Two nuclear fuel production facilities were dismantled and released from regulatory control in 2019 and 2022 respectively.

TS 01.1 & 01.2: Selected, represented and excluded installations

Candidate	Type	Site location	Status	Represented installations
CNT3	NPP	Tihange	operation	All other operating NPPs (CNT1 and 2 KCD 1,2 and 4) DE Tihange (wet SFS)
KCD3	NPP	Doel	Decommissioning (in POP since Oct. 2022)	(and CNT2 which went into decommissioning in February 2023)
BR2	RR	Mol	operation	BR1
SCG	SFS	Doel	operation	Doel SF2, Tihange SF2

- Excluded: BR3 and VENUS RRs (SCK CEN, Area Mol-Dessel)
- Excluded: Spent fuel storage (Belgoprocess, Area Mol-Dessel)

- **Note:** BR1, KCD1-2, SF2 and site-specific differences for NPP were explicitly treated in the NAR when relevant

TS 01.1 & 01.2: Regulatory Framework

FANC
FEDERAAL AGENTSCHAP VOOR NUCLEAIRE CONTROLE

BELV

- In Belgium nuclear installations have to conform to, amongst others, the “RD SRNI-2011”, which:
  - Implements the WENRA SRLs (quite literally)
  - Implements most WENRA NPP SRLs **generically** to all nuclear installations.
    This includes SRLs related to fire protection, except for SRLs on :
    - Probabilistic fire hazard analysis
    - Coverage of hydrants

    which apply only to NPPs.
  - A.o.: specific arrangements on notifications (incl. fire) as well as an extensive REX system by licensees and by regulator

- For historical reasons, some fire protection systems have been established using non-national standards such as the NFPA standards. Currently and wherever possible, use is made of the Belgian or European standards. In addition, licensees use international standards and guidelines, in particular those by US NRC.

- Non-nuclear regulations on:
  - Basic fire and explosion prevention standards with which buildings must comply;
  - Fire prevention at work;
  - Explosive environments;
  - Fire prevention and explosion hazard on the workplace.

TS 01.1 & 01.2: Other remarks

- FANC together with its technical subsidiary Bel V carry out inspections, assessment, etc. and form the nuclear regulatory body.
- FANC/Bel V and also licensees are internationally active in many areas and subject to international peer reviews.
- Note: in 2011 the stress-test was applied to all nuclear installations and included man-made hazards (aircraft crash and explosion) as well as external fire.

- Insurers, in particular NEIL for the NPPs, also provide standards, guidances and perform inspections.

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

FHA

- Mandatory (Belgian Regulation) and methodology is mainly based on IAEA SRS No. 8 & NUREG/CR-6850, finished in 2017. (update in PSR – LTO 2025)

- **Objective**: To assess the potential safety consequences of fire events through the capability to perform specific safety functions (FHA objectives) for all operational states.

- The FHA study assesses the safety impact of the enveloping scenarios:
  - Cold shutdown after LOOP to cover all operating modes
  - LBLOCA and ECCS in recirculation to cover all DBA's
  - Cold shutdown after a Safe Shutdown Earthquake (SSE).

→ Resulted in 76 actions

- The FHA identified the following weaknesses:
  - Loss of spent fuel pool cooling function (pumps);
  - Loss of ventilation of pool area in the post accidental phase

→ Installation of additional fire detectors

DBA:Design Base Accidents
ECCS: Emergency Core Cooling System
LOOP: Loss Of Offsite Power
LBLOCA: Large Break LOCA
SSE: Safe Shutdown Earthquake
SFP: Spent Fuel Pools

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

FHA: Software tool ‘Safety Reports’ integrates all fire related data

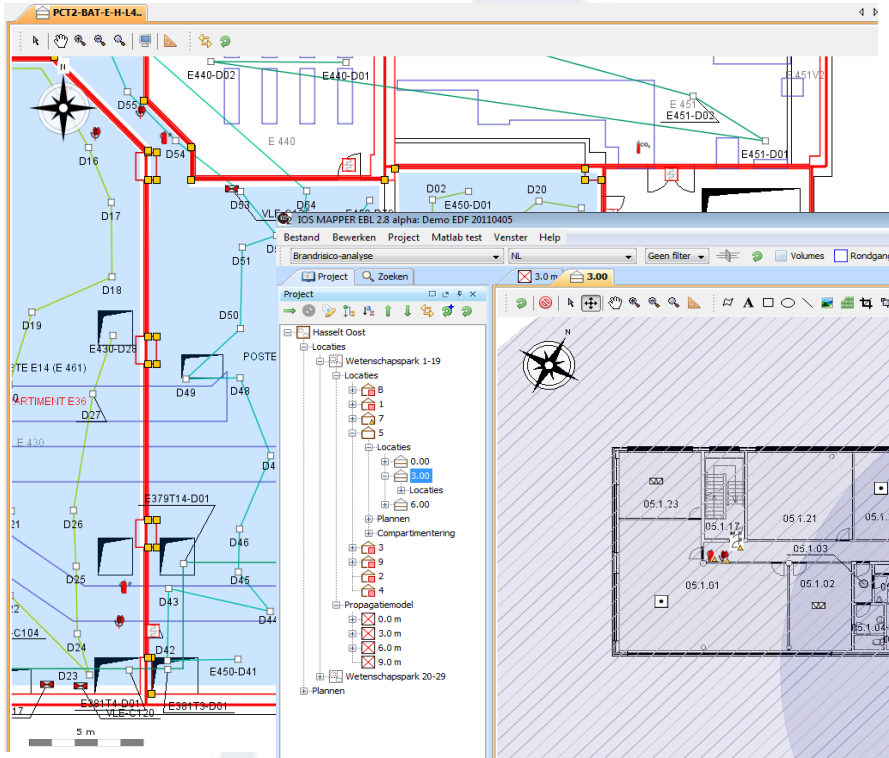
- The software tool ‘Safety Reports’ collects all data related to fire protection (fire doors, fire load, fixed and manual fire extinguishing systems, …) in 1 database.
- The software tool has an easy and good tool to make an automatically fire containment calculation, by calculating the fire load and fire propagation in a specific room or building.
- The tool allows to make easily an evaluation of the adequacy of the fire protection measures. This makes it also possible to see immediately the impact on the fire risk if a fire protective equipment is unavailable. The tool helps to identify the correct compensatory measures if fire protection equipment is unavailable.
- The tool is used in all units (decommissioning and operation) in Doel NPP and Tihange NPP

Fire safety analysis

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

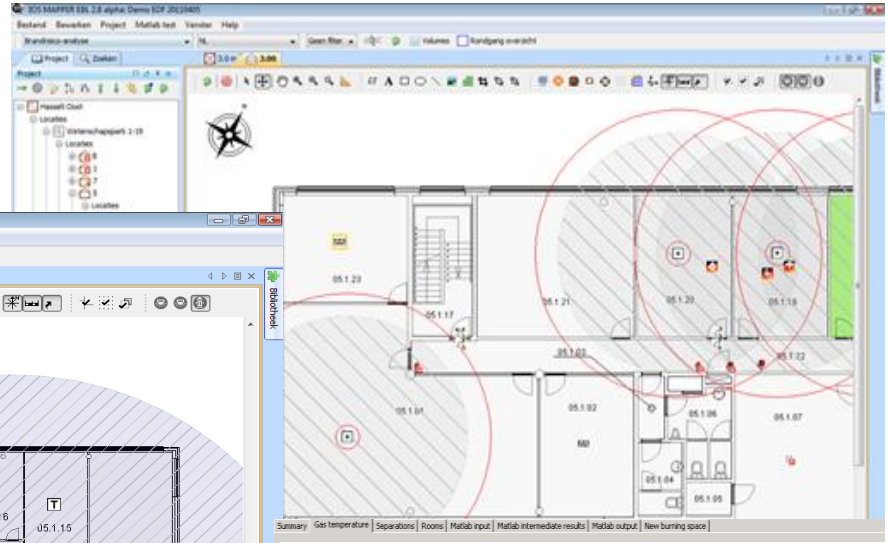
FHA: Software tool ‘Safety Reports’ integrates all fire related data

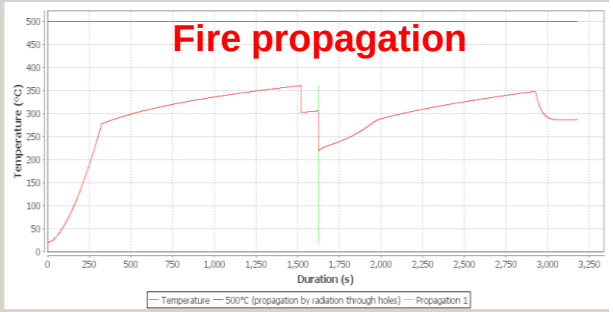


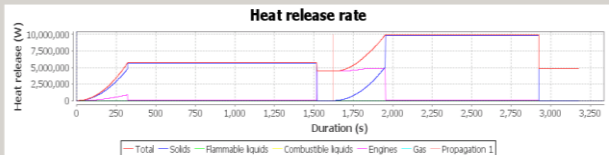
Fire protection

Local fire fighting equipment covered zones

Fire extinguishing covered zones







Fire safety analysis (FSA)
(cf TS 02.1)

NPP

Fire PSA L1 & L2

- **Objectives**: To complement FHA & to quantify the fire risk

- **L1 FPSA:** mandatory (Belgian Regulation) and based on NUREG/CR-6850 & NUREG/1921 (2017)
  - Reactor (CDF):
    - **Result**: Fire hazard is the dominant internal risk:
      - Fire on the cables of main transformers
      - Spurious opening of a valve in shutdown mode, leading to loss of primary inventory
  - Spent Fuel Pools (FDF):
    - **Result:** Fire hazard is not the dominant risk

- **L2 FPSA** study for CNT3 is completed and ready for discussion (2024)

SIF: Seismic Induced Fire
SFP: Spent Fuel Pools

Seismic qualification of fire protection equipment

- **Doel NPP and Tihange NPP**:
  - The fire detection and sprinklers are not seismically qualified
  - The fire main loops are seismically qualified.

- **Doel NPP**:
  - The fire pumps are seismically qualified, are redundant and installed in the bunker building.
  - The water ponds to supply the fire extinguishing system, are seismic category I
  - Fire trucks are stored in 2 different buildings. The second building (GUM) is seismically qualified.

- **Tihange NPP**:
  - Fire hydrants with a preceded manual isolation valve are installed on the raw water and ultimate water circuits, which are seismic Category I.
    - These hydrants guarantee the ability to extinguishing a fire after a seismic event
    - These arrangement is in accordance with RG1.189.
    - The CEI pumps have been seismically tested, however were never formally qualified

GUM: Building of ultimate means

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

Seismic Induced Fire (SIF)

- SIF = Fire caused by a seismic event
- In the previous FSA, the combination of fire and SSE did not cover seismically induced fires. (no LTO planned at the time the studies started)
- A specific methodology is developed in the framework WENRA-2014 SRL's and is based on the EPRI documents (**probabilistic approach**). This approach not only covers the design-based situation, but also the situations relevant from a seismic PSA (Reactor) point of view, and therefor cover the Design Extension Conditions (beyond SSE).
- The objective is to achieve this in order to comply with the LTO Belgian Regulation which requires that all studies be carried out for the T0 of units going towards LTO (Q3 2025)
- Study is ongoing for reactors CNT3 and KCD4 (LTO-2025), first results are shared with the authorities.

SIF: Seismic Induced Fire
SSE: Safe Shutdown Earthquake

Active fire protection

Fire detection (cf TS 03.2.1)

NPP

- Fire detection is organized by area or zone
- The detection system is often designed to automatically initiate suppression.
  When the actuation of a fire protection feature is likely to interact with a classified safety-related system, the manual confirmation by the main control room operator is required to start the actuation.
- According to the OLC's, alternative means shall be put in place in case of impairment on the fire detection functionality, by installing a specific mobile detection system or by the organization of a fire watch.

Active fire protection

Fire suppression (cf TS 03.2.2)

NPP

- The automatic extinguishing systems are installed according to the requirements of the BTP 9.5.1 and the requirement of the insurer. (water, powder and gas systems)
- The main area where the automatic fire protection are installed are:
  - Turbine building; Main control room; Transformer; Diesel engines, fuel tank & lube oil system; Cable galleries; Engine/Motor oil; Charcoal filters; Warehouse; Archive rooms; Electrical cabinet; Server rooms; …
- Breakage or spurious start does not compromise the safety functions of the structures, systems and components for the safe reactor shutdown.
- Manual fire extinguishing systems that protect the equipment which is needed for the safe reactor shutdown (RHR, …), are seismically qualified.
- If a fire extinguishing system is unavailable or is taken out of service, compensatory measures must be provided (OLC's).
- A fire truck to spray water on top of the reactor building is available for both sites.

RHR: Residuel Heat Removal system

Fire doors

- Visual inspection of the fire doors is done every year.
- In the framework of LTO, an assessment of ageing phenomena has been done. This resulted in the replacement of fire doors in critical rooms is ongoing.
- In case of impairment of a fire door, availability of fire detection system is evaluated, or fire watch rounds are organised.
- If a work requests to keep a fire door open, an assessment of possible alternatives is made. If no alternative is possible, a process to block the fire doors open exists:
  - Dedicated wedged need to be collected at the main control room to block open fire doors
  - This practice gives the main control operators a clear overview of the actual compartmentation
  - The number of wedges is limited

Fire penetrations

- General principle: No fire-rated penetrations may be opened during power operation of a reactor unit.
- Procedures describe the process to open and close fire penetrations (done by dedicated team)
- A verification and inspection process of the condition of the seals in fire resistant concrete slabs is implemented.
- Inspection of the ageing effect of fire penetrations:
  - Fire penetrations are inspected visually with a frequency specified in the OLC's

    &
  - Investigation is ongoing to see if there is an ageing effect ongoing of the material used to seal the penetration (Study of the specifications of the materials used) in the framework of LTO

Passive fire protection

Ventilation management (cf TS 03.3.2)

NPP

- Systematic tests are done with a certain frequency as defined in the OLC’s
- Maintenance is done with a predefined frequency as required by the constructor
- Every 5 years, the condition of the intumescent seals inside of the fire dampers is subject to maintenance
- The results of the FHA and Fire PSA for CNT3 led to the improvement of the fire protection of the cables related to the Ventilation of the Annular Space and the spent fuel pool building

Weaknesses

- A verification and inspection process of the status of the seals in fire resistant concrete slabs is implemented but not yet integrated in all the maintenance procedures.

Improvements

- Replacement of the entire fire detection system in CNT3 by a new system to anticipate the risk of obsolescence of the fire detection system.
  (Planned for KCD4 in the short term)

- A process to control the fire water system supply and a procedure to flush polluted parts (water from the river is used in the extinguishing system) to ensure the long-term performance of the fire water supply

- The evaluation of the impact of plant modifications on the outcomes and the conclusions of the FHA has been included in the standard modification process

Strength: Lockout process for the fire resistant (RF) doors:

- If a plant operation requires to keep a fire door open, only dedicated wedges can be used
- These wedges are available in the MCR and give the operators a clear view on authorized blocked open fire doors at any time.
- The number and location of open RF-doors resulting in compartmentalization unavailability is kept under permanent supervision.
- The process allows people in the field to verify if it is allowed to block open the fire door.

- This process has been evaluated as a Strength during the last WANO PR.

MCR: Main Control Room

Strength: Intervention teams

- A first intervention team (OPS, RP, …) is present 24/7 to react rapidly on events.
- The second intervention team (24/7) will reinforce the first intervention team for certain events, such as fire, …
- The second intervention team members are obliged to be a member of a public rescue service
- Both teams have proper equipment and receive appropriate trainings

- External firefighters are quartered in the same street opposite of the CNT site, which allows for a rapid intervention;

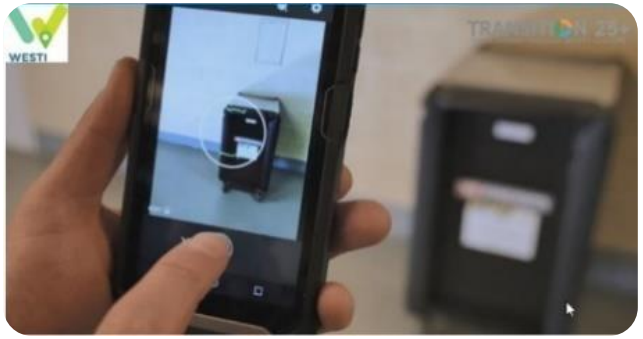
OPS: Operations
RP: RadioProtection

Strength: Fire Network Port of Antwerp

- Cooperation with 4 other SEVESO companies in the harbour of Antwerp:
  - Exchange of firefighting equipment
  - Exchange of experiences in the search for alternatives for PFAS containing foams

Strength: Management of transient fire loads and other non-combustible materials (WESTI)

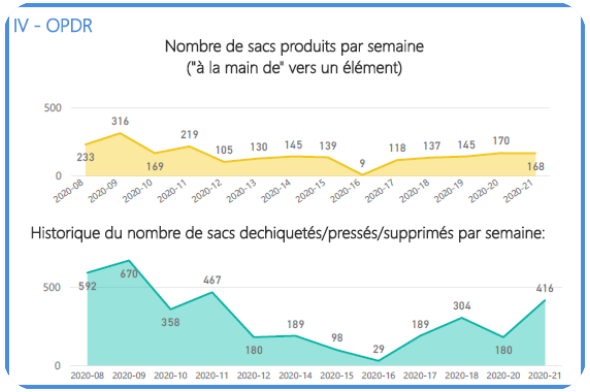
- A mobile scanner (PDA), an IT tool, stickers with bar code, a docking station for synchronization and a desktop interface.



- The tool helps to:
  - Trace fire load,
  - Verify the allowed fire load in a storage area,
  - Monitor and trend the collected data

- Cabinets for chemical and flammable products are included

- If violations are found, a notification can be immediately created and sent to the owner.



Conclusion

TS 01.3 and TS 04

NPP

Strength: Management of transient fire loads and other non-combustible materials (WESTI)

Permanent storage locations:

- Are registered in the tool
- Have a unique identification plate and barcode at the location
- The plate indicates the max allowed fire load and the most common stored products

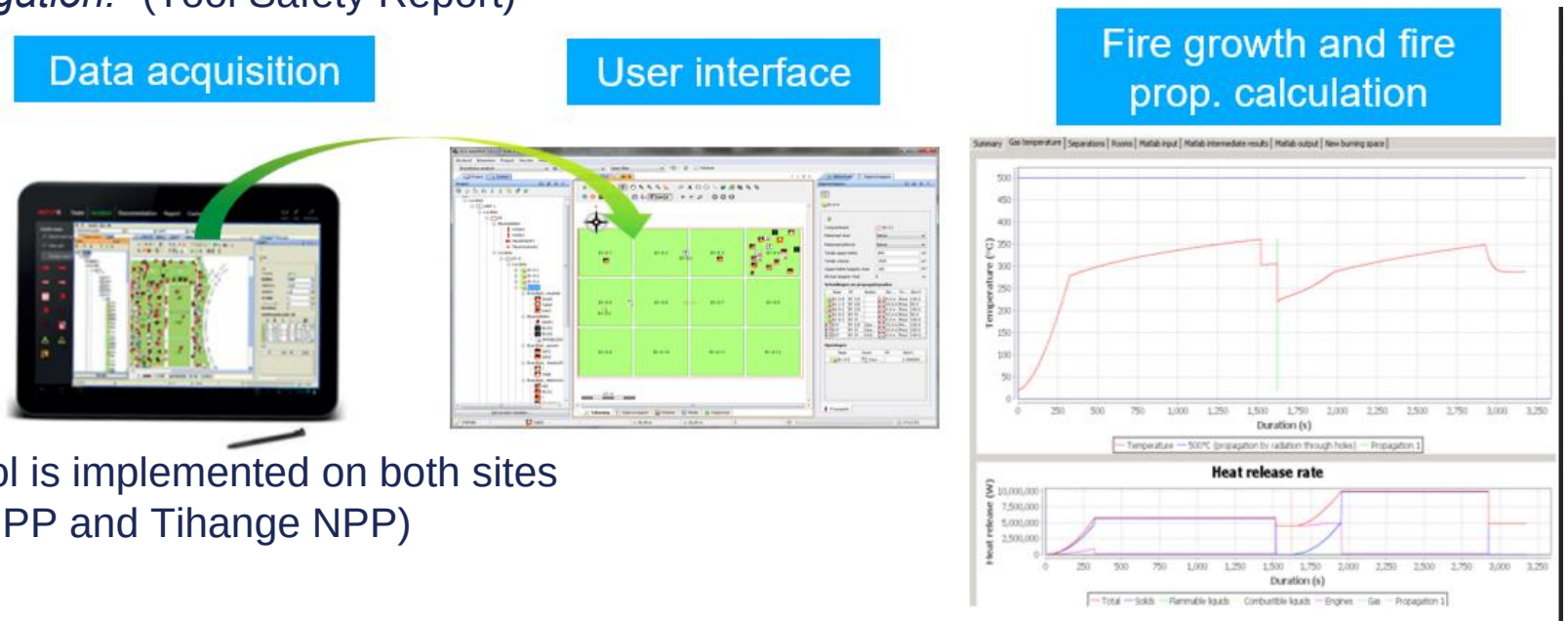
Temporary storage locations

- Materials stored must be registered
- The fire load of combustible material is evaluated, and the total fire load for the storage area is tracked.
- In the controlled area, dose estimation in relation to the waste bag

Strength: Software tool ‘Safety Reports’ integrates all fire related data

- OSART-2023:

  “The plant has developed an integrated tool to support fire hazard analyses which includes assessments for the fire resistance of a separation barrier, calculations for fire propagation in multi-compartment configurations and an algorithm for taking extinguishing systems into account in the calculation of fire growth and propagation.” (Tool Safety Report)



- This tool is implemented on both sites (Doel NPP and Tihange NPP)

Fire Preventive measures

- The fire preventive measures installed for NPP in operation are still applicable unless otherwise can be justified:
  - Reduction of fire compartment when all the turbine oil has been removed

FHA & FPSA

- FHA (2017):
  - Update included specific fire risks in the decom activities.
  - **Conclusion**: The installation is adequately protected against internal fire hazards during decommissioning activities.
  - **Improvement:** Additional fire detection has been added in the SPG

- L1 FPSA SFP (2017):
  - L1 FPSA was done for the SFP (FDF)
  - **Conclusion**: The risk is low.
  - **Improvement:** Strengthening the protection of the Pool Loop cooling pumps by improving the automatic fire detection in the compartment.

SFP: Spent Fuel Pools
SPG: Spent Fuel Building
FDF: Fuel Damage Frequency

Conclusion

TS 01.3 and TS 04

Decommissioning

- **Strengths:**
  - Operational procedures (e.g. fire load management, fire permits, …) remain valid which contributes significantly to the reduction of fire risks
  - A specific FHA study was developed before entering POP

- **Improvements:**
  - The replacement of several fire doors in critical rooms is finalized

POP: Post Operational Phase

Fire safety analysis

Fire safety analysis (FSA) (cf TS 02.3)

Spent fuel storage

- FHA:
  - A Fire Hazard Analysis was carried out using the same methodology and methods as for the NPPs
  - An adequacy check and system analyses have been performed but given the minimal (or non-existent) fire loads and the absence of fire compartmentalization in the main storage area, it was justified that performing calculations using FCA or FIA has little added value.
    (Due to the similarities with SCG the same conclusion was drawn for SF2).

FCA: Fire Containment Approach
FIA: Fire Influence Approach
SCG: Spent Fuel Container Building
SF2: 2nd Spent Fuel Container Building

Active fire protection

Fire detection (cf TS 03.2.1)

Spent fuel storage

- A fire detection system is installed in the staff areas and gives alarm in the surveillance room, which is staffed 24/7
- Flame detectors are installed against the wall to detect a fire in the trailer used for the transport of the casks
- No fire detection is installed in the area where the casks are stored

Active fire protection

Fire suppression (cf TS 03.2.2)

Spent fuel storage

- No fixed fire extinguishing system
- Portable fire extinguishers in the staff areas (powder) and in the electrical rooms (CO2)
- Fire hydrants in the loading hall
- 5 hydrants around the SCG building
- Fire brigade on side 24/7

- The spent fuel storage casks have a very high level of protection against a fire
  → resistance to a fire of 600° C for at least 1 hour of the fuel containers

SCG: Spent Fuel Conatiner Building

Conclusion

TS 01.3 and TS 04

Spent fuel storage

- For SCG we concluded that the fire risk is very low because of:
  - Limited amount of fire load in the building
  - The fire protection and detection;
  - The resistance to a fire of 600° C for at least 1 hour of the fuel containers;
  - The design of the building allowing natural convection which also allows dissipation of the smoke in case of fire;
  - All load-bearing elements have a minimal structural fire resistance of 1 hour;
  - Presence of on-site fire brigade 24/7.

SCG: Spent Fuel Conatiner Building

Fire safety analysis (FSA)
(cf TS 02.2)

RR

- **Fire safety analysis**
  - **Deterministic approach by determining intrinsic risk per room**
    - Fire load
    - Oxygen content
    - Flammability
    - Ignition sources
  - **Preventive measures defined -> residual risk score (*)**
  - **Determination of radiological risk (SSC's, Radiological impact) (**)**
  - **Taking into account potential contributions from**
    - External initiators (i.e. gas storage outside the building)
    - Presence of corrosive agents
    - Shutdown/operation (i.e. staffing, contractors)
  - **Final score based on (* and **)**
  - **Frequency of revision FSA**
    - Periodically (3-5 years) depending on final score (0-5)
    - Re-evaluation in case of modifications
  - **No PSA is performed**

Fire safety analysis (FSA)
(cf TS 02.2)

RR

- **Fire safety analysis**
  - **External hazards are taken into account as initiator for fires (i.e. seismic)**
    - BR2 is a tank in pool type reactor and spent fuel is stored under water
    - BR2 SSC mission time to safe shutdown is (+- 1 min)
      - All SSC's to shutdown safely are seismically qualified
  - **Fires can occur after an earthquake**
    - No risk for reactor safety (is already shut down)
    - Smaller peripheric fires can occur
      - No immediate safety impact (maybe operational)
      - Mobile means are available
      - Operators are trained for firefighting
    - Riser in RB is seismically qualified

Fire detection (cf TS 03.2.1)

RR

- **Location of the detectors is based on:**
  - **Result of Fire Safety Analysis**
  - **Outcome of inspections (Safety authorities, insurers)**
  - **Experience**
- **Different detectors are used**
  - **Aspiration detectors**
  - **Optical detectors**
  - **Infrared detectors**
  - **Beam detectors**
- **Type and amount of detectors is based on:**
  - **Type of asset to be protected**
  - **Automatic action or not**
    - Rule for automatic activation has to be defined to avoid inadvertent activation of the system (i.e. 2/2 rule)

Fire suppression (cf TS 03.2.2)

RR

- **Several means available**
  - **Water is preferably not used, but will be used if other means fail.**
  - **Water/mist is used for the diesel trains**
  - **Gas is used for:**
    - Sensitive equipment in habitable areas (UPS, experiments…) (chemical agent: NOVEC/SINORIX 1230)
    - Safety related equipment in non-habitable areas (i.e. hot cell) (CO2)
    - Electric cabinets (portable CO2 extinguishing devices)
  - **Foam is used for:**
    - The cable tray basement via a deluge system
    - Oil type fires
  - **New and very performant fire water mains for the whole site**

Fire suppression (cf TS 03.2.2)

RR

- **Fire water mains**
  - **Design basis:**
    - Air plane crash
    - Total loss of large industrial building
    - Forest fires…
  - **Seismic qualification**
    - Buffer tanks
- **BR2 riser**
  - **Normally fed by fire water mains**
  - **Design basis:**
    - Fire fighting in BR2 up till 30 m
    - Severe accident management
  - **Seismically qualified**
- **Redundancy implemented through**
  - **Connection to drinking water**
  - **Connection to surface water**
  - **Connection to mobile fire trucks**

Compartmentation (cf TS 03.3.1)

RR

- **Compartmentation based on**
  - Conventional requirements
  - Company policy (archives, battery rooms, workshops…)
  - Insurers requests
  - Radiological risk
- **Temporary measures**
  - Fire watches
  - Detector outage management (avoidance of false alarms)
- **Compensatory fire protection measures**
  - Increase detection
  - Decrease fire loads
  - For experiments – detection and automatic suppression system if fire load is significant

Ventilation management (cf TS 03.3.2)

RR

- **Robust ventilation**
  - **Different ventilation systems for different large buildings**
    - Reactor building
    - Process building
    - Administrative building
  - **Based on verification (no automatic actions)**
  - **Based on operator action through internal procedures or advice/order of fire brigade to actuate/stop ventilation systems**
  - **Reactor building (including control room - RCR) can be evacuated safely**
    - Safety systems can be fully operated from MCR
  - **Control of ventilation systems can be done in 2 separate locations (MCR, Ventilation building)**

Conclusion

TS 01.3 and TS 04

RR

- **Robust design w.r.t. fire events**
  - Tank in pool type
  - Spent fuel storage under water
  - Reliance on passive safety
  - Very short mission time for SSC's (± 1 min)
  - Fire retardant cables for SSC activation (60 min)
- **Effective non conformity management system**
  - Registration of all safety related events (incl. fires, unjustified fire loads, blocking/non functioning of fire suppression systems, blocking of emergency exits, interfaces safety/security…
- **Performant main fire water loop**
- **REX sharing with other nuclear operators (nuclear waste facility, EU JRC) and public fire department**
  - Fires
  - Interventions
  - Access