GENERAL QUESTIONS TO THE COUNTRIES

Thematic: FIRE SAFETY ANALYSIS (FSA)

Answers provide references to a section (§) or page (p) in the NAR. In some cases a generic reference to the NAR is given where a certain topic and the associated questions are treated. Where necessary further information is provided.

Type of installation: Nuclear Power Plants (NPPs)

General questions: The experts of the Fire Safety Analysis group, after their analysis of the National Assessment Reports, consider necessary to transfer to all countries the following questions. If this information has already been provided somewhere in the NAR, the country may simply answer providing the section and the page number(s) of the NAR where the answer is found.

1. *Screening criteria* used in the fire analysis for those NPP that have not explicitly identified these.

Screening criterions are used in the probabilistic analyses, namely in Tasks 4 -qualitative screening- and 7 -quantitative screening- according to the NUREG/CR-6850 methodology.

Qualitative screening is used to identify:

- PAUs that don't contain any PSA equipment or associated cables;
- PAUs that don't contain equipment whose failure could lead to initiating events;
- PAUs where fire will cause an automatic reactor shutdown (or any other fire-induced initiating events).

Quantitative screening is based on the (relative) contribution of the analyzed PAUs to the overall CDF. Compartment with a low contribution are excluded from further refined analysis and the (conservative) calculated risk is retained in the final risk quantification.

2. *Defence in Depth (DiD)*: Regarding the level of fire DiD and the assumptions in the Fire Safety Analyses (FSA) the following questions arise:
    a) Has the failure of the fire protection means (features such as structures, systems and equipment, but also human failures in active fire protection) been taken into account in the fire analysis for the safety demonstration of the fire protection structures, systems and components (SSCs)?
    Failure of passive fire protection (compartmentalization) is evaluated in the deterministic fire risk analysis taking into consideration the actual fire load in the impacted fire room(s) and the fire rating of the compartment. If fire severity and duration exceed the fire rating of the compartment, fire propagation is considered.
    Failure of the active fire protection (including detection and suppression, automatic and manual) is considered through the introduction of a non-suppression probability factor in the probabilistic fire risk analysis (Fire PSA).

    b) Both in the deterministic and probabilistic FSA, under which assumptions is this failure considered: full burnout in the fire area and failure of all SSC therein, functions of failure probability for the different SSCs, no damage due to the fire?
    Deterministic: full burnout of all fire load. SSC failure when affected.
    Probabilistic: functions of failure probability for the different SSCs

c) Under these considerations, do you consider your Fire PSA conservative or realistic?
Conservative (initially excessively conservative: see §2.1.1.2)

d) Is the single failure criterion considered in the fire analysis? If it is, on which regulatory basis and how is it considered?
No, not in the FSA. The safety studies, that cover fire related incidents, SFC is considered.

e) Are the spurious actuation of signals by a fire and the false operation of fire protection SCCs considered in the analyses? In what way?
§1.2.1.1: Fire protection systems shall be designed and installed such that their operation in the event of real fire, as well as their spurious operation, inadvertent start-up or failure does not prevent the structures, systems and components from completing their safety functions.

f) Provide information on which combinations of fires and other events have been included in the fire analysis with their justification. Please refer to Appendix I of the IAEA SSG-64 to address possible combinations of events.
See §2.1.2.1

g) With regard to these combinations of fires with other events in the analysis, is the failure of the fire protection features (for detection or suppression) caused by combined hazards – such as earthquake and consequential fire or a fire occurring coincidentally with a long-lasting external flooding – considered? What are the qualification requirements ensuring their required function during and after these events?

See generic question on active fire protection: Fire protection system are not seismically qualified for their functionality.
Ongoing studies on seismically induced fires (SIF) may result in additional improvements in this field.

No impact of flooding of active fire protection feature has been identified.

h) Consideration of the different Plant Operational States (POSs) and/or operating status and modes in the deterministic FSA.
See §2.1.2.1

3. *Fire resistance/fire hazard rating*: The fire resistance rating of fire compartments, or fire hazard level, is often determined based on the fire load density (MJ/m²) in every fire area or compartment accounting for both permanent and transient fire loads and potential ignition sources.
   a) Provide details on the rationale followed.
   b) Fire load criteria values may differ amongst facilities and countries depending on the regulatory framework. How are these respective criteria justified?
   c) Are they justified knowing that fires in nuclear facilities are generally under-ventilated?

   See §3.3.1.1. In particular it is noted that use has been made of international standards and guides (European and the United States) that is, when available, specific to nuclear power plants.

4. *Qualification of cables*: As far as qualified cables (typically FRNC) are available, in how far are they taken into account as fire load and fire source? How is the qualification of those cables been considered in the fire analysis and for what objective? In how far are protected cables (e.g., protected by protective coatings) considered as contributors to fire propagation in the fire analysis?

See p44. Furthermore, cables have been considered in the analysis and this has led to some actions for improvement. The main aim is to prevent a fire spreading from one cable to another cable or from one compartment to another compartment via a cable/cable penetration.

5. *Transient combustibles and ignition sources*: In how far and how have transient combustibles and ignition sources (by e.g. hot works) been included in the fire analysis and what are the hypotheses related to their inclusion?
   See p48 and further for hot work and mobile fire loads. These have not been included in the general fire analysis – instead the general fire analysis impact on the extent to which hot works or mobile fire loads are allowed and whether or not this requires additional fire analysis.

6. *Direct fire effects*: Are direct fire effects (either by smoke, pressure, temperature, soot, etc) onto SSCs important to safety considered in the fire analysis (including reliability of human actions, fire pressure effects on fire doors, fire overpressure effects on cascade flow and pressure gradients of the dynamic confinement system, …)? Some detailed information about the regulatory requirements applicable and the way such effects are taken into account regarding design/conception/construction/modifications would be appreciated.
   Regulations, see §1.2.2, generally refer to "effects and possible consequences of fire" covering in principle all direct and indirect effects.

   Where applicable, the impact of some fire effects is considered in the analyses (deterministic and/or probabilistic):
   - If manual actions are required, the rooms must remain accessible
   - Impact of soot and other fire by-products is considered by lowering the damage threshold of target SSCs
   - Impact of fire-induced pressure effects on static confinement is currently not evaluated, it is assumed that the fire dampers will close and that the dynamic confinement in non-impacted areas is maintained.

7. *Electrical fires*: Have electrically induced fires (including fires by high-energy arcing faults, HEAF) been considered in the fire analyses?

   Electrical equipment is considered as ignition source in both deterministic and probabilistic fire risk analyses.
   Ignition frequency bin for HEAF events for high-voltage equipment is considered in the PSA, based on NUREG/CR-6850

8. *Fire Brigade*: How have the response times of the fire brigade (onsite, offsite brigades) been taken into account in the fire analysis? This question is more relevant in those installations that do not have a dedicated onsite fire brigade.
   Belgian NPP sites have either a dedicated on-site fire brigade (KCD) or an external fire brigade that is located on the other side of the street (CNT), so response times are sufficiently short.

9. *Radiological consequences of fires*: Please provide more details about the methods of addressing the radiological consequences of the fires in the fire analysis and the radiological criteria of acceptance and the corresponding threshold values applicable.
   See: Safety Generic Position (fgov.be) and TR SD.

10. *Analytical methods*:
    a) For the installations that do not provide enough detail on the tools and models used in the fire analysis, please provide a more detailed description.
    b) In cases where computational tools have been used within fire safety analyses, provide information on the sensitivity and uncertainty analyses carried out.
    c) The use of calculation tools is growing. What are your review processes to identify the needs and advantages/disadvantages of adopting such tools? What are the outcomes of these prospects?
    d) How are you facing to this (understanding of the corresponding studies by the stakeholders)?

    See §2.1.1. It can be noted that several tools are used in parallel thus allowing for a cross-check. Even when qualified or recognized tools are used, the accuracy of the data used for the analysis remains a point of attention.

11. *Operating Experience*: Provide a detailed description on if and how the operating experience from both (i) fires and (ii) other events (whether reportable or not) with degradation or failure of fire protection features in the installation analysed –and, as far as available, also from other nuclear installations– is considered in the fire analysis.

    The NPPs are operated by the same licensee and has an internal experience sharing process. See also §3.4.1 and §2.1.6.2.

    All events and any incident reports are reviewed by Bel V. The high-level lessons learned are shared with all licensees of class I facilities. For example, it was noted that the number of notifications related to fire-rated penetrations was found to be elevated and this triggered a response by the RB.

12. *Additional analyses*: Following the accident at the Fukushima NPP, stress tests were defined for European NPP. Has there been followed a similar approach regarding beyond-design-basis fire events for nuclear power plants in your country?

The stresstest was carried out for all Belgian class I nuclear facilities. It included the DEC scenario of an aircraft crash with kerosine fire as well as, where relevant, external (bush)fire.

13. *Results of the Fire Safety Analyses, revisions and actions*: Please provide details about:
    a) A more elaborated description of the results of the analysis since for some plants the description is not very detailed.
    b) Please provide results for the fire contribution to CDF / LRF / LERF.
    c) The process carried out to update the fire analysis and the reasons for that.
    d) The procedure and responsibilities to design and establish compensatory measures when non-conformities or weaknesses have been identified.
    e) The use of the fire analyses by the regulator.
    f) The influence of international reviews on the Fire Safety Analysis.

See §2.1.1

14. *Strengths/weaknesses*: In cases that no strengths and weaknesses have been explicitly mentioned in the NAR, please confirm that neither strengths nor weaknesses have been identified.

See §2.1.6