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ESS fire- and explosion safety programme - deterministic and probabilistic conditions –case study on acceptance criteria to open smoke hatches in the instrument building.

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A number of Swedish acts and ordinances give the basic requirements of facility safety. None of these are tailored for ESS, hence interpretation is required for appropriate application.
The Licensee shall as far as reasonable possible, based on existing technical experience and economical and social circumstances, undertake measures to limit 1) production of radioactive waste, 2) release of radioactive substances and 3) exposure to environment from ionizing radiation, ref. Radiation Protection Act (2018:396).
Applicable legislative conditions go in to the design. As an example of that is the planning- and building act which requires implementation of: e.g. fire rated partitioning, emergency lights and fire alarm. The defence-in-depth approach (DID) is derived from the radiation protection act by the ESS-0001051 "Protection against fire and explosion". The DID is an important factor of justification to keep fire and explosion at the predicted frequency and consequence. The DID for fire safety sets the deterministic foundation by; 1) preventing the start of fire by housekeeping, to apply proven electrical installation standards etc. 2) quickly detecting and extinguishing the design fires 3) preventing spread of any fire that has not been extinguished. The DID for explosion safety sets the deterministic foundation by 1) preventing explosions by minimizing formation of explosive atmospheres 2) minimizing the risk of an explosion if an explosive atmosphere cannot be avoided 3) implementing design provisions necessary to limit the consequences of an explosion.
The Swedish Radiation Safety Authority has released "Special conditions for the ESS facility in Lund", ESS-0018828. The special conditions set numeric acceptance criteria for potential risk of radiation exposure to public:
- For the following event classes the reference values, shall apply as a maximum limit for radiological ambient consequences for the facility. Event class:Anticipated events (H2) –0,1 mSV, Unanticipated events (H3) –1,0 mSv, Improbable events (H4A)- 20 mSv, Events with multiple failures (H4B) –20 mSv, Highly improbable events (H5) –100 mSv.

Fire- and explosions in the vicinity of radiation sources are initiating events with the potential to expose the environment with contaminated products. Hence fire- and explosions have to be quantified regarding frequency and their potential consequences.
Statistics on fire and explosions from particle physics accelerators should justify probability of having a fire or explosion resulting in environmental consequences from ionizing radiation. Lack of co-ordination and assembled data makes it difficult to justify statistics on fire and explosions at particle physics accelerators. The "Future Circular Colllider"project elaborated on a pilot case where statistical data based nuclear power plant statistics (apriori data from OECD FIRE Database) were applied on particle physics accelerators (posteori data by the use of DOE accelerator statistics).

Case study –Is it acceptable for Rescue Leader to open the smoke hatches in case of fire in the instrument building?

Smoke hatches are installed in the roof of the instrument halls. Fire modelling is performed to optimize evacuation logistics of occupants and protection of the structural steel. A full cover wet-pipe sprinkler is installed in the ceiling. In case of a severe fire scenario the sprinkler should be activated to suppress the fire before the smoke hatches are opened otherwise the sprinkler may not succeed to suppress the fire. Manual opening of the smoke hatches from a panel at ground floor is in design. In case of a severe fire scenario radioactive particles may also be dispersed with buoyance from the fire. The question is if it is acceptable to open the smoke hatches even if there is a risk of spread of radioactive particles to the atmosphere?
An early estimation included all potential ionizing nuclides inside an instrument hall during normal operation. A conservative assumption was that all nuclides are carried out through the smoke hatches by the fire. The total effective dose is 0,04 μSv to public (From inhalation 0.032 μSv and from external gamma radiation 0.012 μSv).
An unanticipated event (H3) allows 1 mSv to public. Hence any interlock of the smoke hatches should not be necessary. However if the accident originate from the target itself, the radioactive exposure may be different. A master thesis project was performed by Ettore Carini in 2017, ESS-0190288 "Modelling and assessment of

the dispersion of particles in the ESS instrument hall". The supervisors were: Fredrik Jörud (ESS), Per Nilsson (ESS), Bjarne Husted (LTH), Anders Schmidt Kristensen (Aalborg university).
The scenario set up is based on explosion in target area resulting in further fire in electronics and combustible shielding inside the instrument building. The scenario is regarded as worst case when it comes to consider ionizing particles released in the instrument building. Probably the scenario can be regarded as a highly improbable event (H5).
The thesis provides for expected behavior of the radioactive particles and to what extent they escape from the instrument hall if the smoke hatches are open. "Ansys Fluent"is considered suitable CFD software for modelling this fire simulation.

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