IRSN views on post Fukushima nuclear safety evolution and R&D needs

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The French context post Fukushima Dai-ichi accident:

- On-going discussions about licensing of 58 PWR fleet beyond 40 years
- One EPR under construction, and a second EPR license application under way
- Public awareness about the possibility of a nuclear accident, and about the potentially catastrophic consequences
- The future optimal extent of nuclear energy in France is one of the themes of the next spring presidential election
- The nuclear debate is very much alive across Europe, with different approaches country by country. One common decision however, to carry out " stress tests" on the whole European reactor fleet

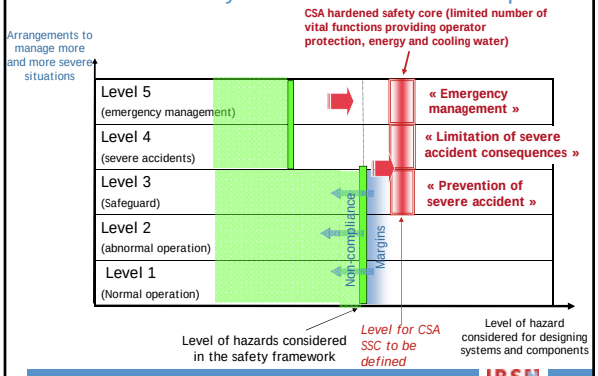
Fukushima illustrated several weak points in defense in depth, with general implications

- Current approach to BDA safety margins unsatisfactory,
- Permanent need for knowledge upgrade on external hazards,
- Severe accident mitigation capabilities need upgrading,
- Emergency preparedness at all levels, a key element,
- → Proposal to « reinforce defense in depth, by adding a « hardened core of vital safety functions » to each PWR
- → Proposal to reinforce R&D on nuclear safety in several directions

Main results from French « Stress tests »

- No safety deficiency that would justify the closure of any particular NPP
- Three identified areas for safety mprovement with respect to external hasards and prolonged SBO/ loss of heat sink
  - Improve plant conformity to license conditions
  - Review license conditions with respect to protection against external hazards in a few locations (floods, seismic risk, « domino effects » from neighbour non nuclear plants)
  - Strengthen defense in depth towards much beyond design hazards by adding a « hardened core of protected viatl safety functions »

The hardened safety core in the Defense-in-Depth



Four main goals for renewed efforts in nuclear safety R&D

- 1: Better understand relevant dangerous phenomena and associated uncertainties and cliff edge effects
  - Seimic hazards, and ground movement/plant response
  - Fuel behaviour in core: LOCA conditions, including water flow blocage, fuel relocation, fuel ejection(future CABRI international programme) or in spent fuel pools (cladding embritlment under mixed steam/air conditions); criticallity.
  - Hydrogen generation (including during reflooding sequence) and accumulation
  - Efficiency of severe accident mitigation resources: in vessel core cooling capability, fuel/corium reflooding approach, containment venting filtering devices, corium/concrete interaction and cooling capability
- 2: Improve severe accident modelling capabilities
  - International benchmarking of Fukushima accidental sequences representation
  - Further development of the ASTEC Code (including for BWR and spent fuel pool accident consequences, and improvement of iodine chemistry modelling in the atmosphere following a release)

Four main goals for renewed efforts in nuclear safety R&D

- 3: Better understand success or failure elements in HOF during normal or emergency operations
  - Subcontracting practice
  - LTO implications
  - Emergency preparedness, including operator/public authorities/local stakeholders interaction
- 4: Improve (and disseminate with decision makers) knowledge on severe accident ecomomic and societal costs, in order to better appreciate cost/benefit factors in prevention measures

A need to reinforce international cooperation

- NEA/CSNI is a key structure to facilitate cooperation and joint R&D programmes, because of its members's unique longstanding and experienced network of experts and research facilities;
- IAEA post-Fukushima action plan will also play a major role in upgrading nuclear safety international doctrine, and ensuring its worldwide diffusion
- Key nuclear countries should would also benefit from closely sharing their R&D plans, and join forces whenever practical

Conclusion

- For IRSN, the limitation of radioactive releases to the environment for any accident (with or without core meltdown) is a major objective in the continuous process of safety improvement in nuclear facilities. In France, this process is organised through:
  - The ten-yearly reviews as well as, for PWRs, the elaboration of criteria for Long-Term Operation.
  - The pursuit of safety oriented R&D programmes to inspire future operational safety improvements
  - The permanent effort to improve emergency preparedness, through R&D as well as doctrine development for larger accidents, and practice exercises
- The Fukushima accident raised many issues that need to be reconsidered on existing and future plants. European stress-tests should be considered as a preliminary step. Knowledge gaps also need to be clearly identified, and joint international R&D should aim to close these gaps as efficiently and quickly as possible.

Thank you for attention