IRSN views on future research for nuclear safety

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RIC 2015

Nuclear safety and future research

- **Research paves the way of safety enhancement process**
  - **Safety is science-based**
    - Ground for decisions, consolidation of decisions and… revision of decisions
- **Safety research shall anticipate tomorrow's safety questions**
  - **Today's nuclear safety research is tomorrow's excellence in expertise**

Context (1/2)

- **Societal dimension (Risk perceptions, Legislative safety objectives)**
  - **Post 2014 EU Nuclear objectives**
    - Art 8a: « Member States shall insure that the national nuclear safety framework requires that nuclear installations are designed,.... ,with the objective of … preventing accidents, and **should an accident occur, mitigating its consequences and avoiding:**
      - **Early radioactive releases that would require off-site emergency measures, but without sufficient time to implement them**
      - **large radioactive releases that would require protective measures that could not be limited in area or time.** »
    - Art 7 requires Member States to ensure the availability of adequate expertise and skills for nuclear safety and on-site emergency preparedness

Context (2/2)

- **Industrial dimension**
  - **French nuclear energy policy to be fixed in 2015, after conclusions of the legislative debate on energetic transition**
    - Energetic mix horizon : gradual reduction from 75% to 50% of "nuclear electricity"
  - **58 PWR in operation, 1 in construction (EPR)**
    - Most of the them (54) will reach the age of 40 years between 2019 and 2032
    - ASN should make its decision on the extension of life beyond 40 of the oldest ones (PWR 900 MWe) by the end of this decade

- Gen II life extension
- Dismantling
- Gen III implementation
- Gen IV design
- Waste disposal

R&D strategic main lines

- **Three main driving forces (not totally independent) :**
  - **Fukushima lessons**
  - **Forthcoming challenges to be faced (tightly linked with societal and industrial dimension)**
  - **Preservation of knowledge, development/preservation of competences**
- **Two important supports**
  - **International collaboration**
    - Strategic agendas
    - Joint projects
  - **Implication of academic research organizations**
    - Advanced modelization approach (multi-scale)
    - In depth investigations

R&D needs (1/3, societal & industrial context dependent)

- **Safety of Long Term Operation of Gen II reactors :**
  - **Ageing of non replaceable components => FOCUS N°1**
  - **Gap reduction with Gen III (mitigation of SA consequences)**
- **Safe implementation/operation of new or future technologies/reactors**
  - **Integration of advanced digital technologies (Inst. & Contr.)**
  - **Advanced fuel**
  - **GEN IV (SFR) and ITER (Fusion)**
  - **Implementation extension of the passive systems**
- **Dismantling**
- **Safety of (geological) deep waste disposal at short and long term**

R&D needs (2/3, Fukushima lessons)

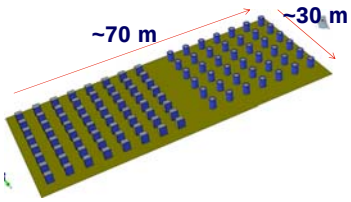
- **Better understand hazards (external and internal)**
  - External Events (EE: seism and structure behavior, flooding, harsh weather, …)
  - Fire R&D (Focus on malfunction of electrical components, on cables tray fire and on release of Pu during fires) => FOCUS N° 2
- **Better understand the interactions between the nuclear plants and external systems**
  - Electric grid reliability and interface with NPP
- **Better understand success or failure elements in human and organizational factors during normal or emergency operations**
- **Improve emergency preparedness operational toolbox**

R&D needs (3/3, timeless)

- **Development and assessment of tools**
  - Safety codes (knowledge capitalization) => FOCUS N° 3
  - Methodologies
- **Preservation of experimental capabilities**
  - Source of knowledge development
  - Reinforced international coordination of efforts

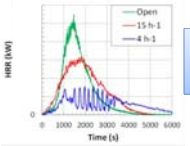
Focus N°1: ODOBA project

- **Investigation of the long term effect of chemical stressors such as alkali-aggregate reaction or delayed ettringite formation…and their coupling**
- **« Concrete blocks farm » 2000 m2 with:**
  - « model » concrete (for analytical investigations)
  - blocks representative of NPP containment concrete
- **Other features:**
  - Application of accelerated ageing process (additives, management of environmental conditions,…)
  - Set-up of instrumentation for concrete pathologies monitoring
  - A 15 years experimental program, with first results in 2018



Focus N°2: Fire under confined conditions

- **Lack of knowledge on fire in confined and ventilated conditions**
- **Particular case of electrical cables:**
  - **Significant contributors to fire risk**
  - **Major topic of OECD program PRISME2**
    - Effect of ventilation on fire spreading over cable trays and the fire consequences
    - Fire tests highlighted both distinct combustion behaviours and fire consequences according ventilation renewal rate
  - **Experimental results showed in confined environment a behaviour that challenges the cable classification**



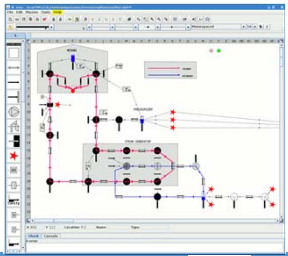
Decreasing the ventilation may assist the development combustion instabilities and of large pressure oscillations that could impair the fire confinement

Focus N°3: ASTEC a multipurpose safety tool (1/2)

- **ASTEC SA code developed by IRSN in the frame of a collaboration with GRS**
- **Repository of all the knowledge acquired durig the last decade in the frame of the NoE SARNET**
- **A reference code largely used in Europe, in particular by TSOs, and beyond Europe (about 40 partners, including China, Russia, India, Canada…)**
  - **Key tool in international projects: EURATOM projects (CESAM, JASMIN, …), OECD BSAF project (interpretation of Fukushima-Daiichi accidents), etc…**
  - **Multi-NPP design tool:**
    - PWR (incl. EPR, SMR), BWR and PHWR
    - Current extension to Spent Fuel Pool accidents
    - *Applicable to fusion installations (ITER..)*
    - *Current adaptation to SFR Gen IV (in the frame of JASMIN EURATOM project)*

Focus N°3: ASTEC a multipurpose safety tool (2/2)

- **Two-tier development approach**
  - **1/ Detailed simulation tool, repository of knowledge, with mechanistic models at state of the art**
  - **2/ Fast-running and numerically robust code for "industrial" plant applications, thanks to XASTEC interface**
- **XASTEC**
  - **Makes easier any NPP scenario calculation through:**
    - Automatic selection of default models and parameters in the input deck, thus very simplified
    - User-friendly graphic interface (pre- and post-processing)
  - **While an experienced user may access to all models and parameters for R&D purpose**



Conclusions

- **Nuclear safety's scientific basis has to be promoted and enhanced**
  - **Reinforcement of international collaboration (under the coordination of networks and international organizations as NEA/CSNI, ETSON…)**
- **R&D efforts must converge to enhance the reactor safety design and prevent the reoccurrence of a major accident and to improve emergency preparedness**
- **A special attention should be paid to:**
  - **Gap reduction between GEN II and GEN III**
  - **Better understanding of success/failure elements in human and organizational factors during normal or emergency operations**
  - **Knowledge capitalization and dissemination through data basis and computation tools**
  - **Preservation (or replacement) of experimental facilities**