CONTINUOUSLY IMPROVING SAFETY OF NUCLEAR INSTALLATIONS: AN APPROACH TO BE REINFORCED AFTER FUKUSHIMA ACCIDENT

Michel SCHWARZ
Scientific Director
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- Nuclear Safety approach in France
  - Institutional framework
  - Role of IRSN in licensing process
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Nuclear safety approach in France
Institutional framework (1/2)

- Long maturation of the French organization in nuclear safety and radiation protection

- Nuclear transparency and security (TSN) act of 16 June 2006: establishing the nuclear safety authority (ASN), and the rights and responsibilities of operators and stakeholders.

- TSN act imposes Periodic Safety Review (PSR) of all nuclear installations, every ten years or less:
  - Review compliance with safety reference of installation
  - Update safety reference according to operating experience feedback and progress in knowledge
Institutional framework (2/2)

- **Operator**: Responsible for security and safety
  - EDF, AREVA, CEA

- **Technical and scientific assessment**: TSO

- **Nuclear Safety Authorities**: Defining and enforcing regulation
  - ASN, DSND

- **Societal vigilance**: Public
  - CLI, HCTISN

**Institutional framework (2/2)**

- **Operator**: EDF, AREVA, CEA
- **TSO**: IRSN
- **Public**: CLI, HCTISN
- **Nuclear Safety Authorities**: ASN, DSND
- **Technical and scientific assessment**: TSO

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**Institutional framework (2/2)**

- **Operator**: EDF, AREVA, CEA
- **TSO**: IRSN
- **Public**: CLI, HCTISN
- **Nuclear Safety Authorities**: ASN, DSND
- **Technical and scientific assessment**: TSO
Role of IRSN in licensing process (1/2)

- **IRSN**: a public body with industrial and commercial activities, under the joint supervision of the Ministers of Ecology, of Industry, of Research, of Defense and of Health

- Its main missions: research and risk assessment, in particular for ASN, in nuclear safety and radiation protection

- **1700 employees**, including more than 1000 specialists: researchers, engineers, biologists and Ph.D. students, post-docs

- A budget of €300 million with 45% committed to research

- Operating experimental facilities and having access to research reactors (CABRI, PHEBUS, recriticality facilities...)

Role of IRSN in licensing process (2/2)

- Regulatory framework not as prescribed as in other countries, mainly for historical reasons

- Thus, safety analysis performed by IRSN not just based on compliance to regulations:
  - IRSN analysis progressively focused on highly safety relevant points of safety demonstration provided by operators
  - Following defence-in-depth approach
  - Counter-calculations performed by IRSN when judged necessary using often its own computer codes (ASTEC...)

- Importance of:
  - Quality of contradictory dialog with operators
  - Competence of IRSN experts based on analysis of operating experience, research, safety studies (e.g. PSA) to identify any possible weakness
  - Technical review of IRSN analysis by independent experts groups
MAJOR SAFETY IMPROVEMENTS IN FRENCH NPPS
AFTER TMI2 (1/2)

- Procedures “H” to manage beyond design situations for “plausible” durations, for instance:
  - H1 to cope with LOHS
  - H3 to cope with SBO

- Deployment of H3 boosted by “le Buget 4” SBO in 1984:
  - Adding turbo-alternator using steam produced by SG
  - Adding a 3rd electro-generator (diesel/gas turbine) per site

- H1 used at “Cruas 4” in 2009 during LOHS for 10 hours

Such LOHS probability rated $10^{-5}$, occurred after 1500 operating reactor year!
AFTER TMI2 (2/2)

- Procedures “H” completed by SAM procedures (named “U” for “ultimate”), for instance:
  - U5 to cope with spray failure in containment, calling for containment venting 24 hours after core melt onset

- Plant modifications:
  - Higher reliability of valves used to depressurize primary circuit
  - Containment venting line with metallic and sand filters (Cs filter performance: 99.9%)
  - H2 passive recombiners
RECENT SAFETY IMPROVEMENTS

After Le Blayais flooding (1999):
- Revisiting flooding risk assessment
- Rising dam around NPPs
- Cofferdam in rooms with equipments important for safety
- Revising guides to assess flooding hazards

Planned 900 MWe Plant modifications (after PSR 3):
- H2 concentration measurements
- Vessel melt-through detector
- Reinforcement of lock bolts
SAFETY IMPROVEMENTS FOR GENERATION III PLANTS

- General safety objectives approved by German and French Safety Authorities in 1993

- Calling for significant plant improvements in order to achieve significant reduction of:
  - global core damage frequency ($<10^{-5}$) for all type of failures and hazards and with uncertainties
  - radioactive release even in case or core melt-down (no emergency evacuation, limited sheltering nearby plant, no long term consumption restrictions)

- IRSN contributed to implement technical guidelines

- Used as reference for Flamanville 3 EPR
SAFETY IMPROVEMENTS CONSIDERED FOR LTO

- EDF information to ASN in 2009: intent to seek licence for extending plant lifetime significantly beyond 40
- Generation II and generation III plants on French territory for decades
- Thus strong societal request (already before Fukushima) to raise safety reference for generation II plants level with LTO as close as possible to generation III
- IRSN R&D programs orientated towards this objective
IMPACT OF FUKUSHIMA
French Prime Minister requested ASN to perform complementary safety reviews (CSR) of NPPs on March 23rd

European Council called for stress tests (ST) of NPPs on March 26th

French CSR based on WENRA specifications (as ST) issued April 21st and extended to fuel cycle plants, test reactors...

Main objective is to assess:
- Installation robustness in case of external hazards (earthquake, flooding, earthquake and induced flooding, industrial risks...)
- Installation robustness in case of SBO, LOHS, both
- SAM robustness and
- By using progressive approach (in intensity, duration, accumulation, one to multi-units concerned on a site) to identify possible cliff edge effects (core damage, recriticality...)
- Highlighting possible improvements
AFTER FUKUSHIMA (2/3)

- CSR reports for 80 installations sent by operators (EDF, AREVA, CEA, ILL) on September 15th

- CSR analysis by IRSN (500 p. report) reviewed by experts groups on November 8 - 10

Main conclusions:
- Huge efforts in short time for operators and IRSN
- Continuous safety improvement process has contributed to make plant safer than originally
- Some local no-compliance identified to be promptly corrected
- At some locations, external hazards evaluation needs to be revisited
- Significant safety improvements still required to cope with extreme beyond design situations
Proposal to design a “hard core” of robust, well protected and secured SSCs crucial to controlling plants safety during extreme hazards in order to
- Prevent core damage
- Limit as much as possible radioactive release

2012 devoted to identify this “hard core”

“Hard core” easier to design for EPR

Note that learning from Fukushima will take years!
INTERNATIONAL COOPERATION BETWEEN TSO
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Networking TSOs, already recognized at the time of “nuclear renaissance” even more strongly needed after Fukushima to:
- share lessons learned
- harmonize safety analysis tool
- share R&D load and results
- train new generation of experts

European initiative:
- ETSON
- Bel V (Belgium), GRS (Germany), IRSN (France), LEI (Lithuania), UJV (Czech Republic), VTT (Finland), VUJE (Slovakia)
- Associated members in 2011: JNES (Japan), SSTC (Ukraine)

IAEA initiatives:
- Creation of “TSO forum” under consideration
CONCLUSIONS
Continuously safety improvement approach in France, in particular at the occasion of the PSR, has contributed to make NPPs safer

Approach to be reinforced in France after Fukushima considering extreme hazards

Importance of the scientific and technical assessment by a public body of highly competent experts as enhancing nuclear safety is based on progress in science and technology

TSO networking to share experience, perform cooperative research, harmonize practices and train new generations of experts even more strongly necessary after Fukushima
Thank you for your attention

www.irsn.fr

Enhancing nuclear safety