Assessing the safety of new reactors in France - EPR and ATMEA1

K. Herviou (IRSN), R. Catteau (ASN)

IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

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Initial considerations

Need of a significant improvement of the safety level, in particular in the field of severe accident (i.e. with core melt)

Choice of an “evolutionary” approach regarding existing reactors, aiming an enhancement of the safety level

- *Use of a large operating experience on PWR plants, notably on the French and German ones (periodic safety reviews, events analysis for French PWR)*
- *Use of the results of in-depth studies performed on French nuclear existing reactors, particularly Probabilistic Safety Assessment studies*
- *Use of knowledge progress from R&D, in particular the R&D on melt core accident that have been engaged after the TMI 2 accident*

Introduction however of some important innovations to meet the objectives

Safety framework for Gen III PWRs (2/3)

Definition of safety goals and of a set of safety requirements for Gen III PWRs

1992-1993	Definition of general French-German safety objectives, issued in 1993
1994-2000	Assessment of main technical options of the EPR project
October 2000	Publication of “Technical Guidelines for the design and construction of the next generation of nuclear power plants with pressurized water reactors”
	Contains all objectives, principles and recommendations issued by the French and German safety authorities between 1994 and 2000
September 2004	Official transmission of the “Technical guidelines” by the French safety authority to Electricité de France (EdF) that should serve as a basis for the EPR design and construction
	Assessment of the EPR FA3 on the basis of French regulation and the “technical guidelines”

Safety framework for Gen III PWRs (3/3)

Definition of safety goals and of a set of safety requirements for Gen III PWRs

2010-2011	Assessment of the ATMEA 1™ reactor basic design (10CFR50, NUREG, ASME) / "Technical guidelines"
2011-2017	Review of the technical guidelines to take into account the feedback of the EPR and ATMEA1™ safety assessments, lessons learned from the Fukushima accident and WENRA recommendations
	Guide for the design of PWRs (Guide n°22) - 2017
2016	Assessment of a new EPR design submitted by EDF on the basis of the Guide n°22

EPR and ATMEA1™ general features

	EPR FA3	ATMEA 1™
Power	4500 MWth - 1600 MWe	3150 MWth - 1000 MWe
Number of loops	4	3
Number of safeguard trains	4	3
I&C	Digital	Digital
Reactor building	Double containment with liner Aircraft shell	Single containment with liner Aircraft shell
Severe accident management features	Core catcher, H_2 recombiners, containment heat removal system…)	Core catcher, H_2 recombiners, containment heat removal system…
Life duration	60 years	60 years

Safety goals for the next generation of PWRs (1/2)

I. For normal operation and abnormal occurrences, one objective is the reduction of individual and collective doses for the workers, which are largely linked to maintenance and in-service inspection activities. Consideration must also be given to the limitation of radioactive releases within the corresponding dose constraints, and to the reduction of quantities and activities of radioactive wastes

II. Another objective is to reduce the number of significant incidents, which involves seeking improvements of the equipment and systems used in normal operation, with a view to reducing the frequencies of transients and incidents and hence to limiting the possibilities of accident situations developing from such events

III. A significant reduction of the global core melt frequency must be achieved for the nuclear power plants of the next generation. Implementation of improvements in the "defence-in-depth" of such plants should lead to the achievement of a global frequency of core melt of less that 10^{-5} per plant operating year, uncertainties and all types of failures and hazards being taken into account

Safety goals for the next generation of PWRs (2/2)

IV. Moreover, an important objective is to achieve a significant reduction of potential radioactive releases due to all conceivable accidents, including core melt accidents:

- For accident situations without core melt, there shall be no necessity of protective measures for people living in the vicinity of the damaged plant (no evacuation, no sheltering)

- Accident situations with core melt which would lead to large early releases have to be "practically eliminated": if they cannot be considered as physically impossible, design provisions have to be taken to design them out. This objective applies notably to high pressure core melt sequences.

- Low pressure core melt sequences have to be dealt with so that the associated maximum conceivable releases would necessitate only very limited protective measures in area and in time for the public

Reinforcement of the Defence-in-depth

- Reinforcement of the “defence-in-depth” compared to existing plants:
  - extensive consideration of the possibilities of multiple failures
  - use of diversified means
  - substantial improvement of the containment function
    - including core melt situations
  - reduction of the frequencies of accidents (including core melt) by:
    - reducing the frequencies of initiating events
    - further improving the availability of safety systems
  - special attention given to shutdown states
  - severe accident management features
  - establishment of an engineering program for human factors integration at the beginning of the design
  - due consideration to in-service inspection and testability of equipment
    - maintenance and testing activities are essential to maintain the safety of the plant throughout operation

Enhancement of the robustness of the safety case

- The safety demonstration for the NPP of the generation III PWRs in France
  - is achieved in a deterministic way
  - supplemented by probabilistic methods
  - based on appropriate research and development work (core catcher…)
- Single initiating events examined in a deterministic way, using conservative assumptions including aggravating failures
- Complementary to the single initiating events, analyze of multiple failure situations as well as internal and external hazards
- Assessment of severe accident situations
- Possible links between internal and external hazards and single initiating events have also to be considered
- The "practical elimination" should be justified by deterministic considerations completed by a probabilistic insight

Technical challenges faced by ASN and IRSN

- Ambitious safety goals and many safety requirements to be fulfilled by the design ▶ increase of the complexity of the design and of the demonstration / use of new technologies
  - Use of sophisticated methods for accident studies / qualification of calculation codes
  - Digital I&C – offer large opportunities to increase safety but the design and development of the I&C should be extremely rigorous
  - …

▶ **Need to develop and maintain very high level competence skills in different technical domains in order to be able to deeply assess the design of the plant and accidental studies**

▶ **Need to anticipate the potential impact of design options on the plant safety during operation**

Technical challenges faced by ASN and IRSN

- There was no construction of NPP in France for more than 10 years – partial loss of the experience gained in the 70's and 80's

- New construction technologies for nuclear power plant are available and the new builds should take benefit of this possibility to enhance the robustness of the plant – but these technologies should be qualified

- New design, innovative solutions are proposed by vendors and operators
  ▶ codes and standards of construction should be adapted

- Existing reactors experience feedback shows the importance of the compliance of the plant with safety requirements from the commissioning phase: the quality of manufacturing is essential for safety

Need to carefully follow up the construction activities and the manufacturing of its components to assess the plant safety

Global strategy for assessing the EPR safety

EPR
Flamanville 3

Safety requirements (2000)

EDF files assessment

Detailed design
+ operating principles
+ environmental qualification

Control of the construction

Inspections by ASN

Checking compliance to SAR hypotheses

Follow-up of the commissioning tests

Balance/effective improvement in terms of safety and radiation protection

Particular follow-up of first operating years

Design assumptions and features are confirmed only if they are correctly implemented and maintained in the plant

Systems performances, reactor core behaviour…

Other challenges… and opportunities

- The international cooperation

Opportunities

  - To exchange between experts to make the safety assessment more robust and to increase the safety level
  - To identify earlier potential technical issues likely to arise during design review
  - To get feedback on design, environmental qualification difficulties, commissioning, operation for NthOK reactors
  - To develop joint assessment on specific subjects
  - To develop consistency between regulators

Challenges

  - To accept to call in question its practices
  - To accept to be challenged by foreign regulators
  - To find a consensus, at the end of the assessment

Other challenges… and opportunities

- Openness to civil society:
  - Legal requirements for transparency in the nuclear field and access to information on nuclear safety enhanced by the European framework (with Aarhus convention) and French acts
  - Establishment of a continuous technical dialogue on sensitive issues dealing with nuclear safety of new installations
  - Need to explain positions and recommendations to the public
  - Interest in the questions raised by the civil society

Conclusion

- Different challenges are faced by regulators in licensing new reactors
  - Design assessment
  - Construction and manufacturing issues
  - Counterparts

- Opportunities to call into question our practices and improve the safety of existing reactors in the frame of the periodic safety reviews
  - Effective dialogue between safety authorities when assessing in parallel a same design (MDEP initiative)
  - In France, the overall objective for the 4th periodic review of the 900 MWe plant is to get closer to the safety goals defined for the Generation III PWRs, i.e. the EPR reactor

Thank you for you attention