



RIC 2007

**Current activities on accident
consequences analysis at IRSN**

E. Raimond

IRSN / Reactor Safety Division – France

March 15, 2007

The presentation mainly concerns (EDF) operating NPPs in France

- 34 reactors : 900 MWe PWR
- 20 reactors : 1,300 MWe PWR
- 4 reactors : 1,450 MWe PWR

Accident consequences analysis

Five topics

- Safety analysis - Deterministic approach
- Safety analysis - Probabilistic approach
- Safety analysis - Plant modifications
- Research - Source term assessment
- Emergency preparedness - Accident management

Accident consequence analysis : deterministic approach

Acc. conseq. analysis : deterministic approach. General.

- For operating plants, severe accidents have not been taken into account as DBA but ...
- Status of operating plants concerning acc. consequence analysis is examined before each periodic safety review and compared to the requirements defined for the EPR
- For severe accident issues (prevention and mitigation of acc. consequences), plant modifications can be decided following pragmatic decisions based of comparison between safety improvement and costs or complexity of modifications

Deterministic approach 3 tools for acc. consequences analysis

- A “**DBA**” **reference standard** for operating plants (in preparation)
- A “**reference source term**”
 - S3 : total core meltdown with filtered releases 24 hours after an initiating event
- A “**severe accident**” **reference standard** for operating plants (in preparation)

EDF updated proposal
Technical instruction by IRSN

Acc. conseq. analysis: the DBA reference standard

- The “**DBA**” reference standard for operating plants aims at
 - providing specific radiological requirements and goals
 - provide definition of DBA and specific rules for calculation
 - describing assumptions and methods used to assess the impact of the radioactive releases on the population and the environment

Such definition of DBA and requirement already existed in the safety report

One objective of the work on “DBA” reference standard is to provide coherent rules for DBA for operating plants and EPR

The first version of this document, proposed by EDF, has been reviewed by IRSN

Acc. conseq. analysis: the “severe accidents” reference standard

- The “severe accident” reference standard for operating plants
 - will summarize SA knowledge
 - will summarize knowledge on materials behavior in SA conditions
 - will provide specific requirements for severe accidents on :
 - Probabilistic & Radiological safety goals
 - Material behavior under SA conditions

This document should provide « a plants status » for severe accident risks and clarify the requirements and objectives for further improvements.

Accident consequence analysis : probabilistic approach

Safety Analysis : probabilistic approach L2 PSA

1. Reference L2 PSAs have to be provided by the operator
2. Independent L2 PSAs are performed by the TSO (IRSN)
3. No quantitative probabilistic safety goals in France fixed by the Safety Authority
4. Level 2 PSA results are used as a complement to deterministic approach
5. Level 2 PSA results are now being used during periodic safety reviews

Safety Analysis : probabilistic approach L2 PSA

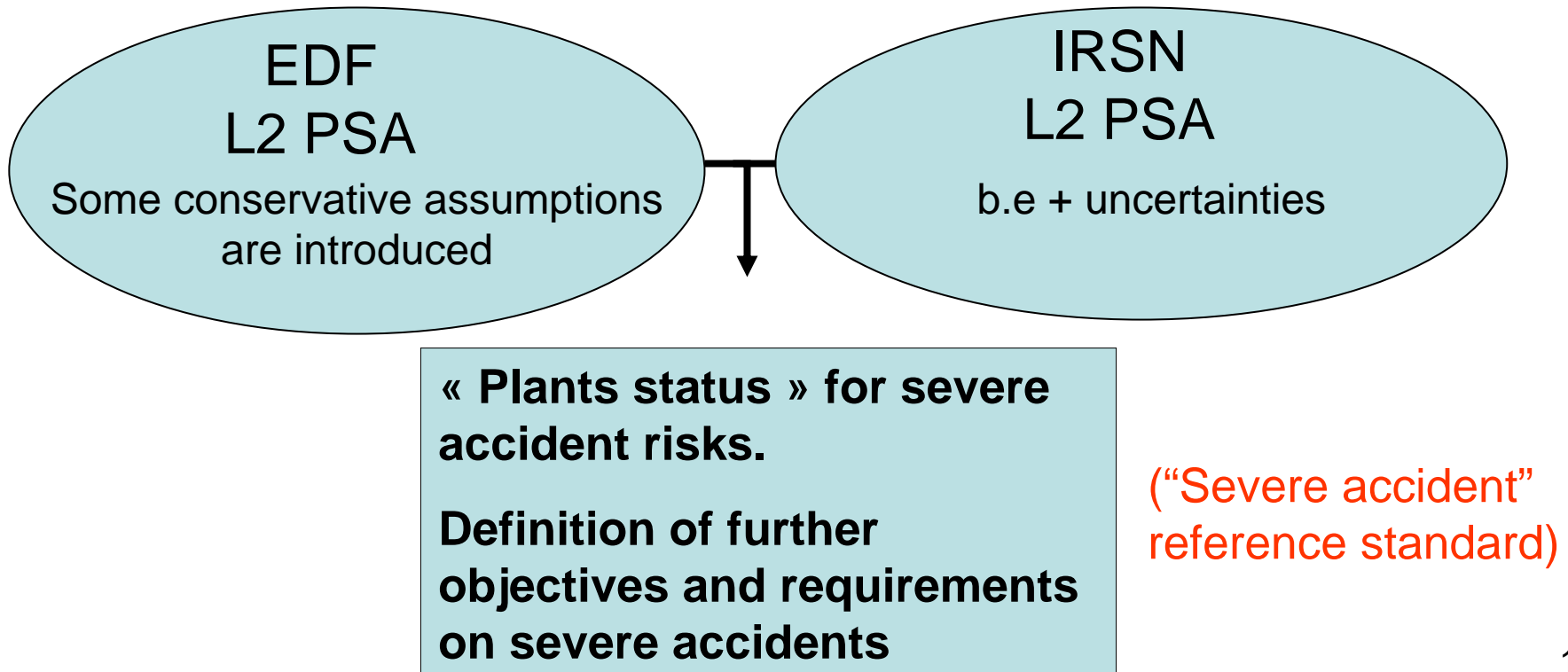
Series (reactor nb)	NP	Next Periodic Safety Review	L2 PSA EDF (Utility)	L2 PSA IRSN (TSO)
CPO (6) CPY (28)	900 MWe	2007 2009 (3rd PSR) 2010 2014 (3rd PSR)	2004 (previous) 2007 (next)	2003 (previous) 2007 (next)
P4 (8) P'4 (12)	1,300 MWe	2014 2016 (3rd PSR)	In progress End 2009 (next)	In progress End 2009 (next)
N4 (4)	1,450 MWe	2006 2009 (1st PSR)	None	None

Effort in France (EDF & IRSN) on L2 PSA for operating plants :

- to obtain a consensus on 900 PWR L2 PSAs results
- to achieve 1st versions of 1,300 MWe PWR L2 PSAs

Acc. Conseq. Analysis : probabilistic approach L2 PSA

Convergence on L2 PSA results is required for applications



Safety Analysis : probabilistic approach L2 PSA development at IRSN

- L2 PSA performed by IRSN is based on best-estimated + uncertainties methodology.
- The study covers power and shutdown states of reactor for internal events.
- The study includes assessment of projected doses for all release categories (short-term consequences).
- Dispersion calculations are performed with IRSN Crisis Center dedicated tools .

Results are used for safety analysis, emergency preparedness and research priority ranking.

Safety analysis : plant modifications

Safety Analysis : plant modifications examples

- **Recently implemented or in progress**
 - Hydrogen recombiners
 - Widening of containment pressure measurement
 - New severe accident management guide
- **900 MWe PWR (modifications decided for the next Periodic Safety Review)**
 - Reinforcement of material access hatch (closure system)
 - Corium detection in vessel pit
 - Hydrogen instrumentation
 - Modification of RCS safety valves (electrical supply)
- **Later potential modifications (discussions in progress – no decision)**
 - Specific issues for 1,300 MWe PWR series (next PSV)
 - Prevention of steam explosion in vessel pit
 - Iodine filtration in containment venting system
 - Update of severe accident management guide

Research : source term assessment

Research : ISTP

L2 PSA and updating of reference source term have conducted to the definition by IRSN of an experimental program, extended to international participation.

International
Source Term
Project – 2005-
2010

- Iodine behavior in RCS and containment building
- Impact of boron carbide on the progression of a severe accident
- Air ingress situations
- Fission products release from fuel

Reduction / quantification of epistemic uncertainties

Safety analysis
Deterministic

update

Safety analysis
Probabilistic

update

Accident
management

Research : other issues (examples)

- Steam explosion (ex-vessel)
- Impact of in-vessel flooding during core degradation phase
- MCCI
- ASTEC code development
- Containment tightness in SA conditions (1,300 MWe series)
- Materials and system behavior during long term phase of a severe accident.

Emergency preparedness – Accident management

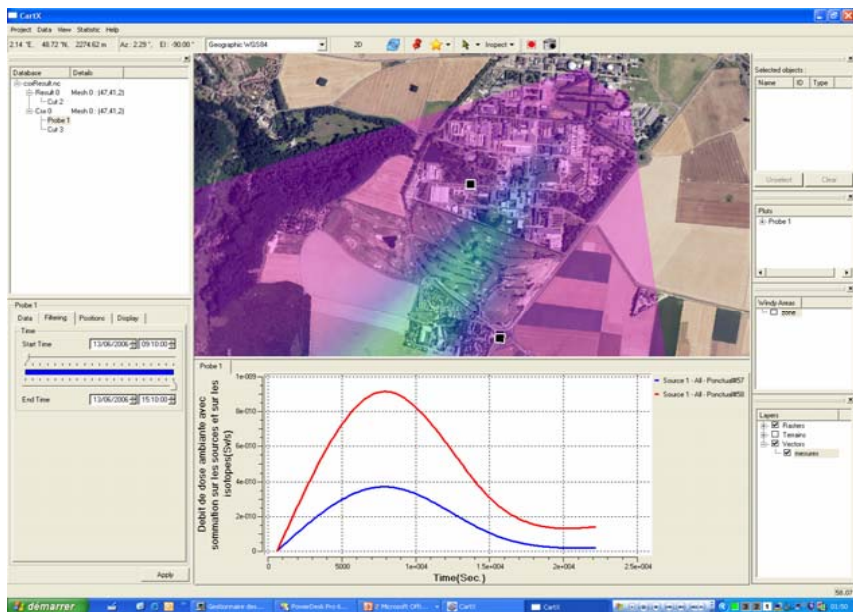
Technical Emergency Centre

Update of Technical basis of emergency planning (in progress)

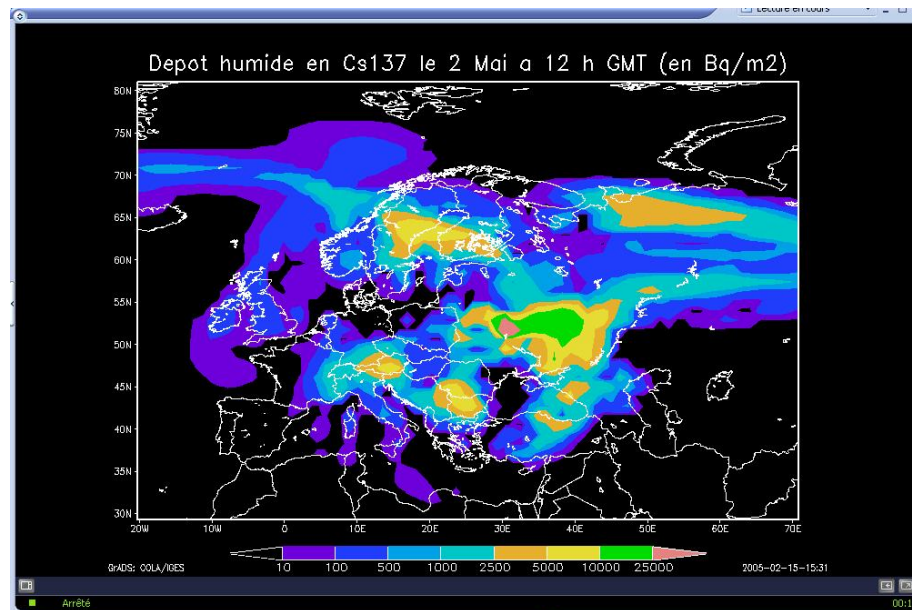
- Assessment of consequences of severe accidents on a PWR is being progressively updated (source term program, L2 PSA, deterministic analysis)
- This context conducts French organizations to reconsider the strategy for population protection during the emergency phase of an accident

Update of IRSN technical Emergency Centre tools

- New computers tools for diagnosis / forecast of a damaged plant
- For example : improvement of long-range and short-range atmospheric dispersion models



Example : short-range atmospheric dispersion



Example : large atmospheric dispersion (Chernobyl accident)

CONCLUSION

- Accident consequence analysis for operating plants is considered an important issue in France :
 - A clear status of operating plants with respect to severe accident risk is being defined through deterministic and probabilistic analysis
 - Source terms assessment are being updated to take into account recent research results
 - Still interest for research on some specific issues
 - Tools of emergency crisis center are being modernized
- Repercussion :
 - Identification of plant modifications
 - Update of severe accident management guide
 - Emergency planning

- Thanks to

- | | |
|------------------|--------------------------|
| – Mr N. Siu | US-NRC |
| – Mrs K. Herviou | IRSN – Crisis Center |
| – Mr O. Isnard | IRSN – Crisis Center |
| – M. M. Jorel | IRSN – Safety Analysis |
| – Mr B. Chaumont | IRSN – Safety Analysis |
| – Mr M. Dubreuil | IRSN – Safety Analysis |
| – Mr B. Clement | IRSN – Source term prog. |