NEA workshop

Innovation in water cooled reactor technologies

12 February 2015

AREVA

Gen 3 Genesis

Three Miles Island	• **Modifications on operating plants (human factor, severe accidents)** • **Considerable R&D on severe accidents**
Chernobyl	**Eliminate the risk of experiencing consequences on populations similar to the Chernobyl disaster** (incl long term consequences)
Operating experience	• **30 years of experience of French and German fleets** • **Probabilistic Safety Assessment of current plants**
9/11	**Ensure that a terrorist attack will not cause a severe accident in the context of nuclear technology diffusion worldwide**

The EPR / ATMEA design includes, from its origin, all safety progresses.

AREVA

EPR safety objectives

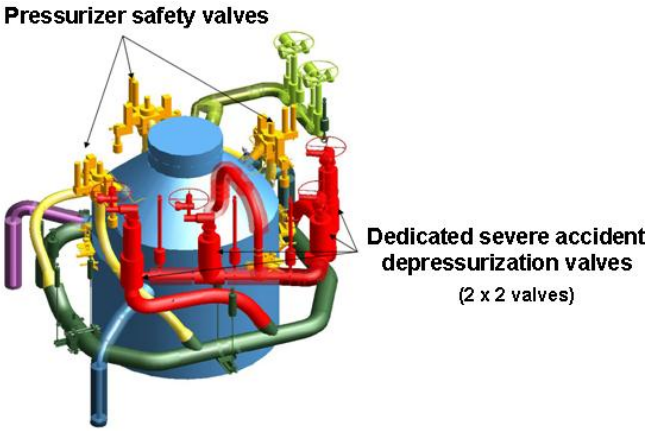
- **Reduce core damage frequency by a factor 10**
- **Reduce radiological releases in case of an accident**
  - design basis accidents : no protection measures for the population
  - practical elimination of scenarios leading to large and early releases (*hydrogen explosion, core melt under pressure, steam explosions)*
  - in case of a severe accident, only protection measures limited in area and time can be tolerated (eg no permanent relocation)
- **Increase robustness against terrorist attacks**
  (eg large commercial aircraft crash)

Severe accident mitigation is included in the design.

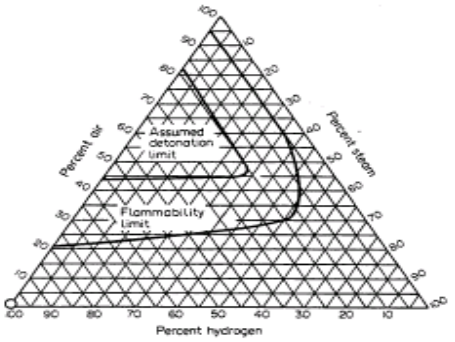
These objectives define the Gen 3 (or 3+) reactors.

Severe accident mitigation

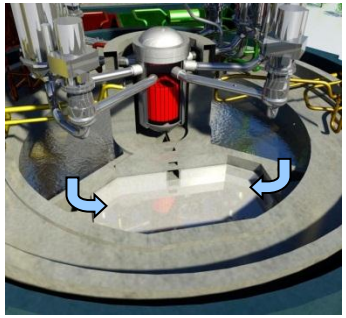
Prevention of high pressure core melt

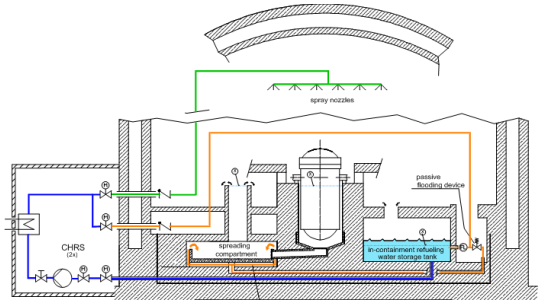


Elimination of H2 risk

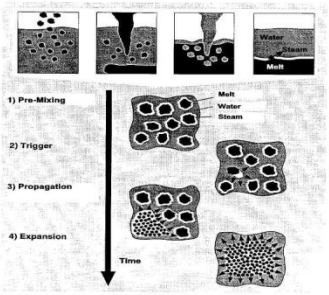


Short and long term function of containment ensured





Prevention of steam explosions



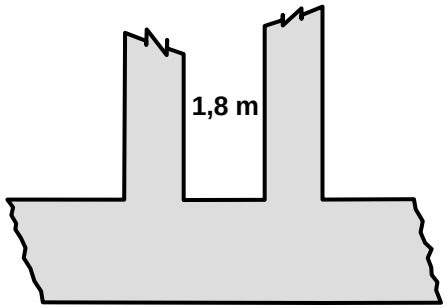
A comprehensive and deterministic severe accident approach.

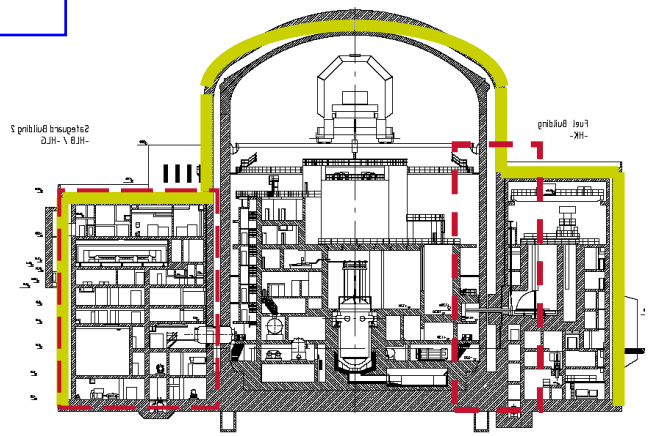
A dedicated, independent and qualified line of defence in depth

AREVA

EPR resistance to external hazards

- Strong resistance to earthquakes
- Protection against malvolant action
- Watertight buildings and doors





Margin assessment show with a high level of confidence that

• a Fukushima quake would have not led to a severe accident

• buildings would have resisted the tsunami and kept the safety systems operable

AREVA

Flooding protection

Bâtiment combustible Tranche 2 niveau - 8.50 m Local K 054
Trémie électrique éventrée

Blayais (1999)

Fukushima (2011)

Fort Calhoun (2011)

Flooding can be caused by a variety of phenomenon, in many places of the world, even in the absence of outstanding tsunami.

AREVA

Support system : power

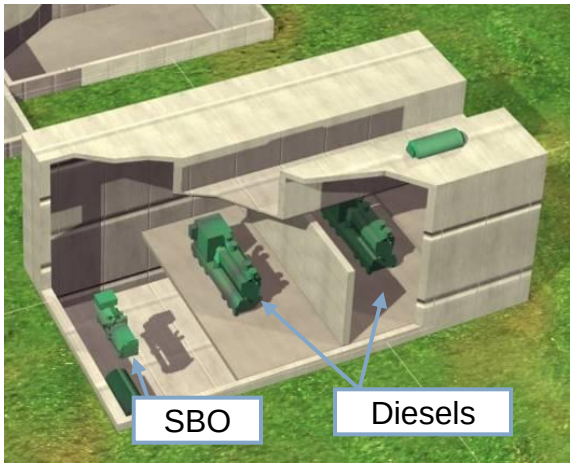
Physical protection

- **Diesels & fuel tanks housed in reinforced buildings**

Physical separation

- **2 buildings located on each side of the reactor building**

Redundancy & diversification



- **4 main 100% redundant diesels**
- **2 additional SBO diesels**
- **batteries:** 12h autonomy

6 emergency diesels plus batteries: redundant, diversified and protected

AREVA

Support system : heat-sink

- **Water intake is a system, to be protected**
- **Heat-sink is also a part of the environment**

water can turn into mud, disappear, be loaded with debris, ice etc…

Unit 3 Sea Pump Area

Unit 5,6 Intake Screen Area

Because heat-sink can be impaired by changes in the environment, there is interest to consider an alternate heat-sink.

AREVA

Main Coolant Pumps

- ✓ 220 MCP built by AREVA
- ✓ Excellent track record
- ✓ Innovation on seals
  - Stand Still Seal System
  - Hydrodynamic Seals

Leak tight MCP seals (without injection) make a significant safety step

AREVA

Digitalized I&C

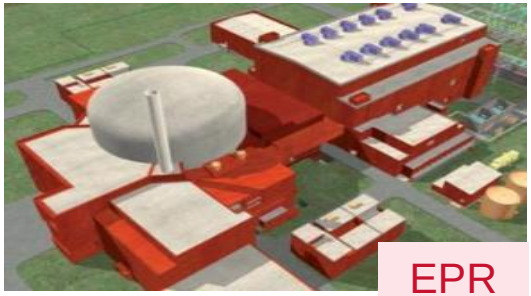
- Major breakthrough in nuclear since N4
- Much enhanced analysis and synthesis capabilities
- User friendly (HMI) and much suited to the young generations

A major safety progress in the human factor field

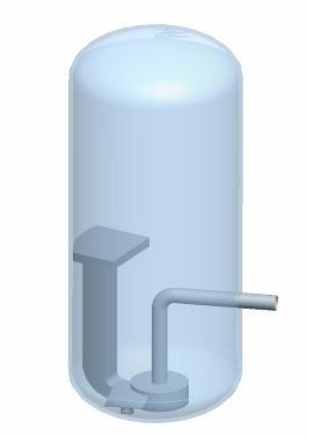
AREVA

ATMEA

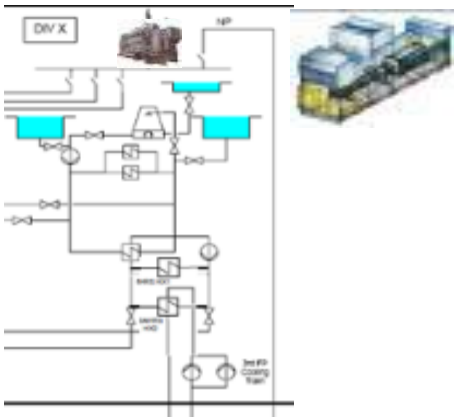
APWR



EPR



SAFETY INJECTION SYSTEM
ADVANCED ACCUMULATOR



DIVERSITY IN HEAT SINKS & EPS
(DIVISION X)

ATMEA1 benefits from EPR and APWR innovations

AREVA

Conclusion

The major innovation in Gen 3 / Gen 3+ is expected in the safety philosophy and objectives.

Technology and engineering innovation to be evaluated in this respect

AREVA