DE LA RECHERCHE À L'INDUSTRIE

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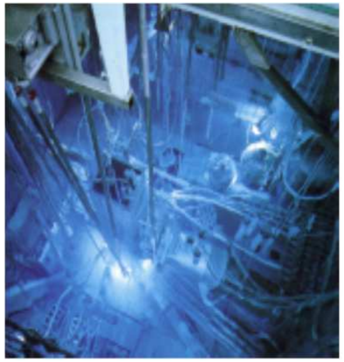
Identification and implementation of a hardened (safety) core in a research reactor in light of the lessons learned from the Fukushima Daiichi accident.

The JHR case.

ROUVIERE Gilbert

CEA

The JHR reactor context



- ✓ Essential support for nuclear power programmes over the last 40 years
- ✓ The existing MTRs will be more than 50 years old in the next decade
- ✓ European MTRs will face increasing probability of shut-down

→ FEUNMARR

(Future E.U. Needs in Materials Research Reactors)

- ✓ conclusions, October 2002 (presented at FISA 2003)

- ➯ There is a strategic need to renew MTRs in Europe
- ➯ A decision to build a first new MTR was required in a very near future
- ➯ This new MTR should establish robust technical links with current MTRs

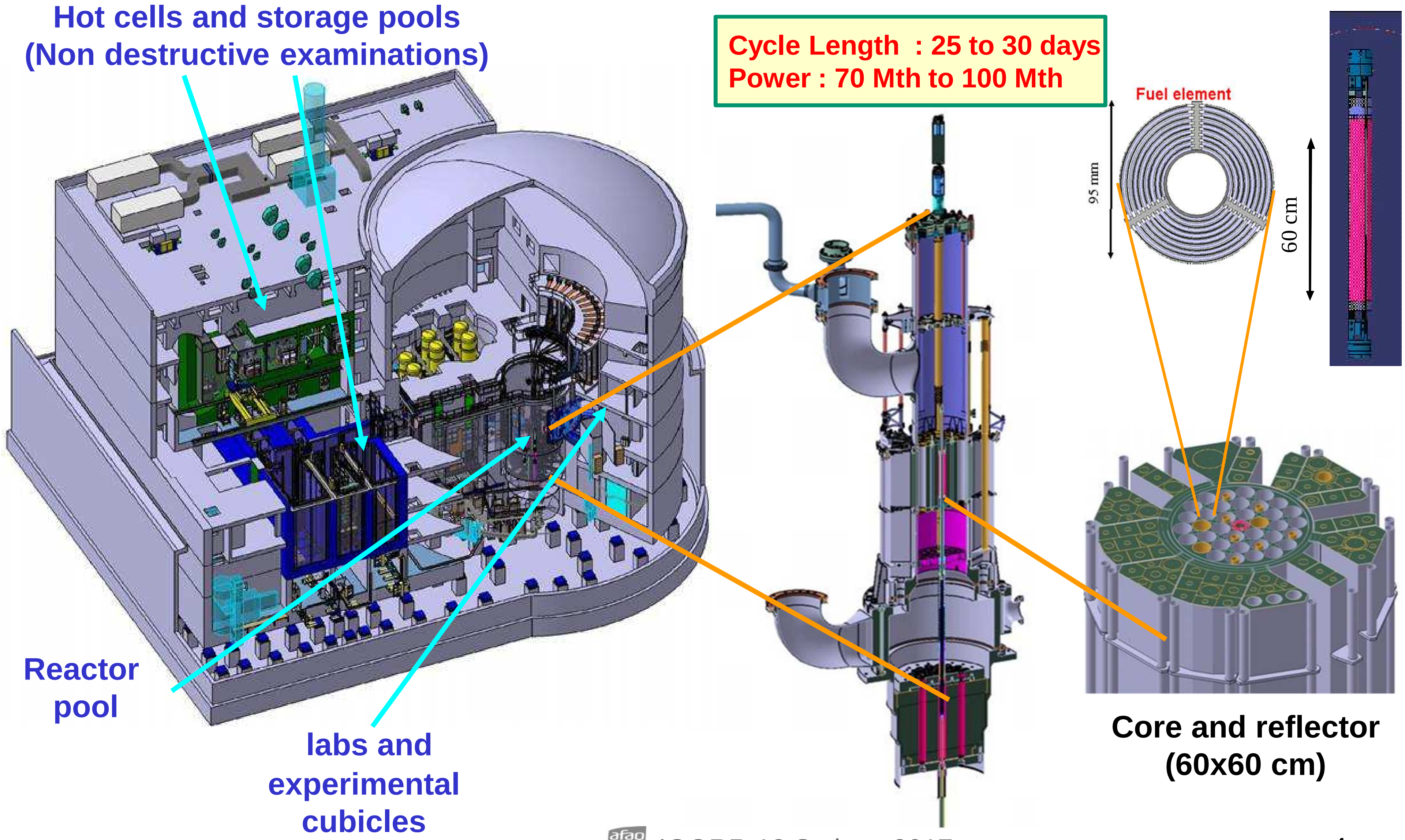
JHR Reactor / International Consortium

- JHR Consortium, economical model for investment & operation
  - ✓ CEA = Owner & nuclear operator with all liabilities
  - ✓ JHR Members owner of Guaranteed Access Rights
    - In proportion of their financial commitment to the construction
    - With a proportional voting right in the Consortium Board
  - ✓ A Member can use totally or partly his access rights
    - For implementing proprietary programs with full property of results
    - and/or for participating to the Joint International Programs open to non-members
      - To address issues of common interest & key for operating NPPs
  - ✓ Open to new member entrance until JHR completion

JHR Consortium current partnership: Research centers & Industrial companies

Studsvik AREVA EDF NATIONAL NUCLEAR LABORATORY Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas SCK•CEN STUDIECENTRUM VOOR KERNENERGIE CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE cea VTT ÚJV पऊवि DAE IAEC

Associated Partnership: JAEA


Hot cells and storage pools
(Non destructive examinations)
Cycle Length : 25 to 30 days
Power : 70 Mth to 100 Mth
Fuel element
95 mm
60 cm
Reactor pool
labs and experimental cubicles
Core and reflector
(60x60 cm)

CEA and the post-fukushima approach

- **Stress tests schedule**

- **May 5, 2011 : ASN request for stress tests**
- **July 6, 2011 : Standing advisory committee meetings on stress tests methodology**
- **September 15, 2011: JHR stress test report**
- **November 8-10, 2011 : Standing advisory committee meetings on stress test reports**
- **January 3, 2012: ASN Notices on CEA stress tests reports**
- **March 5, 2012: ASN Technical Prescriptions (draft) : request for an “Hardened Core” of SSC**
- **June 26, 2012 : ASN Technical Prescriptions**
- **June 29, 2012: JHR report Nr 2 :**
  - **Hardened core components list and design conditions (earthquake level, extra margins taken into account)**
  - **Mitigation key SSC’s robustness check**
  - **JHR Local Crisis Organization**
- **September 12, 2012: Global Cadarache Crisis Organization report**
- **April 3-4, 2013 : Standing advisory committee meetings on hardened core components**
- **January 8, 2015 : ASN technical prescription for hardened core**

Stress tests methodology

- **Evaluation of margins for initial reactor design**
- **Set of calculations and expert evaluations**

Earthquake beyond DBE (1.5)

Flooding beyond design and flooding caused by earthquake

Natural phenomena at a higher level than observed for the site (wind, tornado, lightning etc)

Loss of inner and external electrical supply

Loss of cooling sources

Cumulating of both loss of power and cooling

Accident management in such situations

identify the possible situations that may cause a cliff edge effect

Stress tests conclusion

Situations analyzed for both fuel elements and fuel samples :

1- Underwater melting **Borax taken into account**

No cliff effect = containment still efficient

2- In air melting :

In core fuel possible if uncovered by water

Evaporation ← **loss of cooling**

Loss of water ← **loss of tightness**

Fuel samples melting impossible

Essential Equipment

~~Essential equipment~~ → **Cliff effect**

Underwater melting :

SCRAM SYSTEM

ULTIMATE COOLING PUMP

NATURAL CONVECTION VALVES

ULTIMATE SUPPLY BATTERIES

No hazard may affect simultaneously several essential devices

In air melting :

SCRAM SYSTEM

POOLS / Tightness dispositions

During extreme earthquake, the polar crane and main pool platforms could fall and degrade tightness of the pools.

Hardened core identification

Stress tests → **JHR sound design OK**

ASN asked CEA to propose "hardened core" of material and organizational dispositions in order to :

-prevent a severe accident or limit its progression,

-limit large-scale releases in the event of an accident which is not possible to control,

-enable the licensee to perform its emergency management duties.

Hardened core identification

Hardened Core SSC definition

Critical components required for first safety actions are gathered in an « hardened core » capable to support beyond design basis event.

After a period (~24 hours), it is considered that external technical means are on site

Hardened core implementation
Definitions

3 categories implied in HC implementation

HC SSC **“Hardened core” Structure System and Components**	**Vital to guarantee safety functions**
S SSC **Support to HC SSC**	**Strictly required for HC SSC**
I SSC **Impact on HC or S SSC**	**SCC that can have Negative impact**

HC/S/I SSC performances

HC SSC ⟷ **Safety analysis in post-Fukushima situations**

S SSC ⟷ **HC SSC related**

I SSC ⟷ **Absence of negative impact on HC/S SSC**

HC/S/I SSC identification

HC SSC	⟷	**determined by stress tests published in an ASN Act**
S SSC	⟷	**functional analysis**
I SSC	⟷	**Inducted hazard** **Based on walk down** **Exclusion method**

HC/S SSC Sizing

New HC/S SSC → **Same methods as initial SSC**
More severe conditions

Existing HC/S/I SSC → **Robustness evaluation**

Robustness evaluation

JHR components designed with RCC-Mx Code
JHR cranes designed with FEM Code
JHR civil works designed with RCC-G or Eurocodes

Principle → **Accumulation of conservative margins Vs performances**
→ **Remain in plastic domain**

Post-Fukushima situation → **Evaluation of mechanical stress**

Within margins → **Yes** → **Ok**
→ **No** → **Alternative methods**

Robustness evaluation of the polar crane

240 tons
34 m rolling tracs diam

Robustness evaluation of the polar crane

HC earthquake → Crane or Crane components fall

↓

HC SSC or S SSC degradation

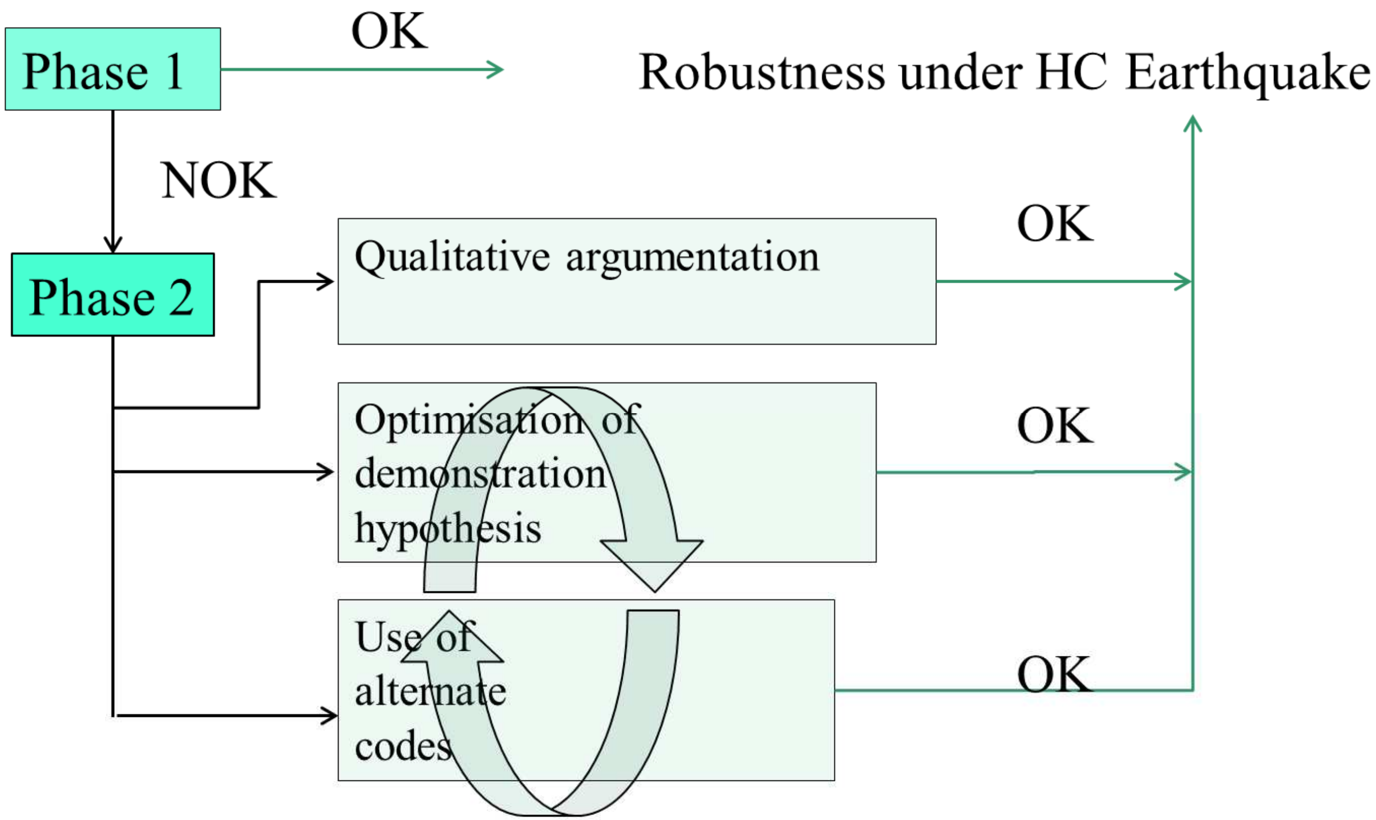
↓

Polar Crane is an I SSC

Expected performances →

No fall crane or components
No fall of handled load
Post FKS operability not expected

Robustness evaluation of the polar crane



Robustness evaluation of the polar crane

Phase 1 OK except for 3 particular points :

Polar Crane Walkway →
design margin 0.95 < 1
local stress beyond elastic domain
fall impossible
ROBUST

Polar Crane Structures →
design margins > 1 except some mec. assemblies
local stress beyond elastic domain
slightly in plastic domain largely before rupture
ROBUST

Rolling Tracks →
FEM Code margins < 1
Eurocode 3 margins >1
ROBUST

Conclusion

Lessons learned from Fukushima Daiishi taken into account for JHR

A set of HC defined

New methodologies defined to garantee HC performance during and after Fukushima situations

HC implemented without startup schedule modification


Thank you for attention
RAZEL-BEC