

The BR2 reactor
Ageing management
3 cases
Outlook

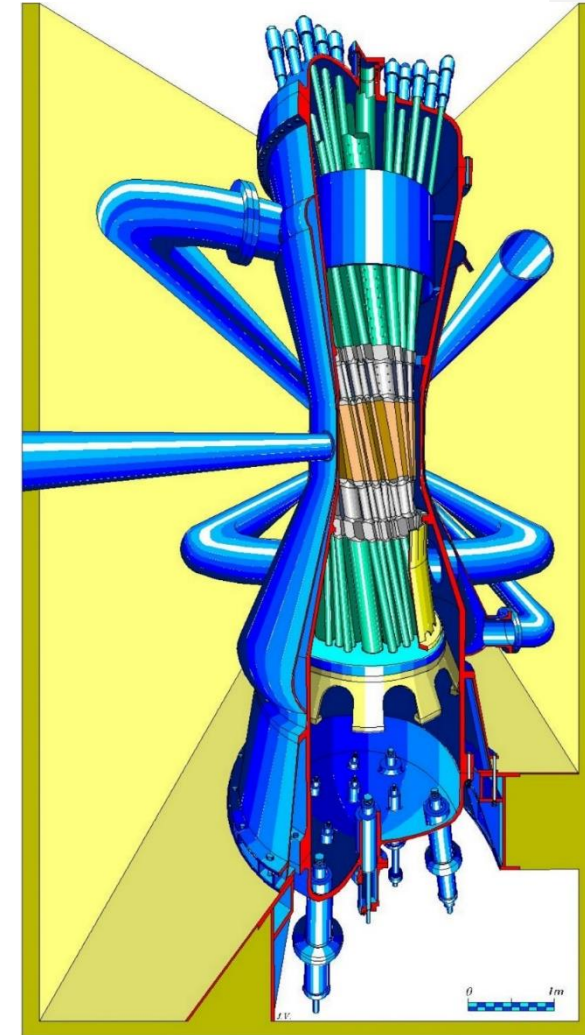


The BR2 reactor



Highlights of BR2 characteristics

- High flux material test reactor: flux range from 10^{14} to 10^{15} n/cm²s at mid plane available
- Flexible configuration and high accessibility
- Operational cycles of 3 to 5 weeks (7 per year)
- Underwater transfer between reactor, pools and hot cell possible
- Passive safety features due to decay heat removal by natural convection
- No end of life date in license – 10 year period for safety reassessment



Utilisation of BR2

- Production activities for radio-isotopes and NTD-silicon
- Leading irradiation facility for medical radio-isotopes
 - Largest capacity for Mo-99 in the world
 - High specific activity for activation isotopes
- 4 to 8 inch crystals of silicon can be irradiated, up to 40 tonnes/year
- Experimental utilisation
 - BR2 is one of the leading reactors for fuel testing today
 - MTR fuel testing up to heat flux of $600\text{W}/\text{cm}^2$ for LEU based fuel development
 - Transient testing of pre-irradiated LWR fuel pins for safety margin demonstration
 - Enhanced availability adds to attractiveness of BR2 for long term experiments
 - Development of Advanced Technology Fuel claddings
 - Selection of materials for fusion, SMRs, GEN 3+ and GEN 4





Ageing management strategy

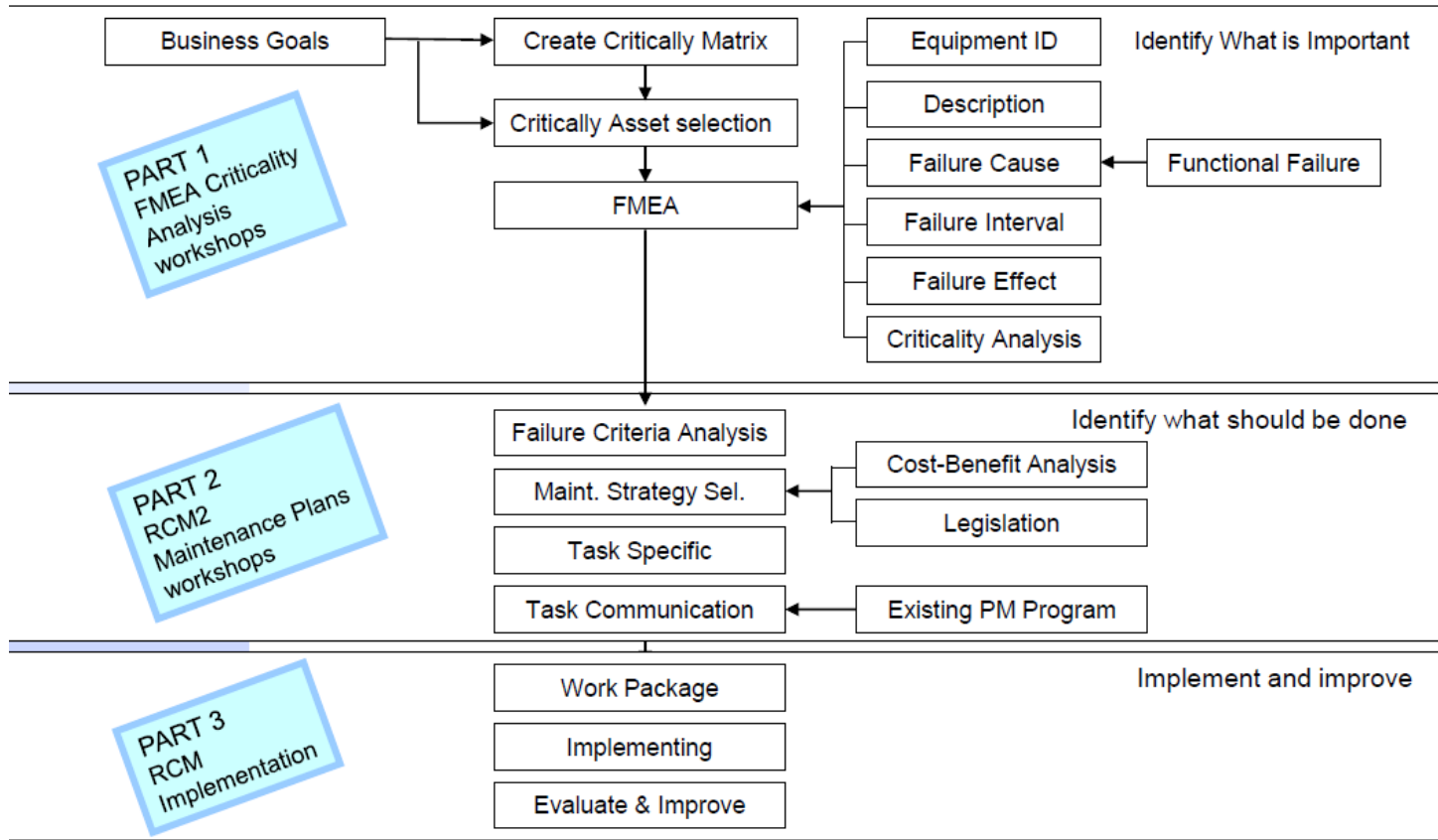
3 step process for ageing management

- Objective: maintain safety, availability and cost efficiency
- Classification of Structures, Systems and Components
 - 4 classes to apply graded approach
 - Class A: avoid critical failure by preventive inspection, testing and replacement
 - Class B: limit impact of failure by ease of repair or replacement
 - Class C: optimize cost between simple maintenance and replacement
 - Class D: no preventive measures needed
- Assessment of ageing risks
 - Identify critical failure modes, their frequency and precursors
- Define mitigating measures to reduce ageing risk to acceptable level
 - Integrate physical and economic ageing into inspection repair and replacement strategy



Plant asset management as living process

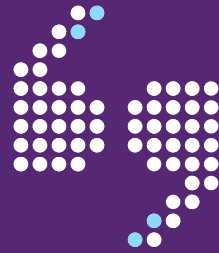
Ageing risks in a dynamic environment



- Integrate results of in service inspections
- Feed experimental data on material ageing with sufficient lead factor
- Prevent obsolescence by periodic review of standards, regulation and technology

Review of PAM as part of PSR

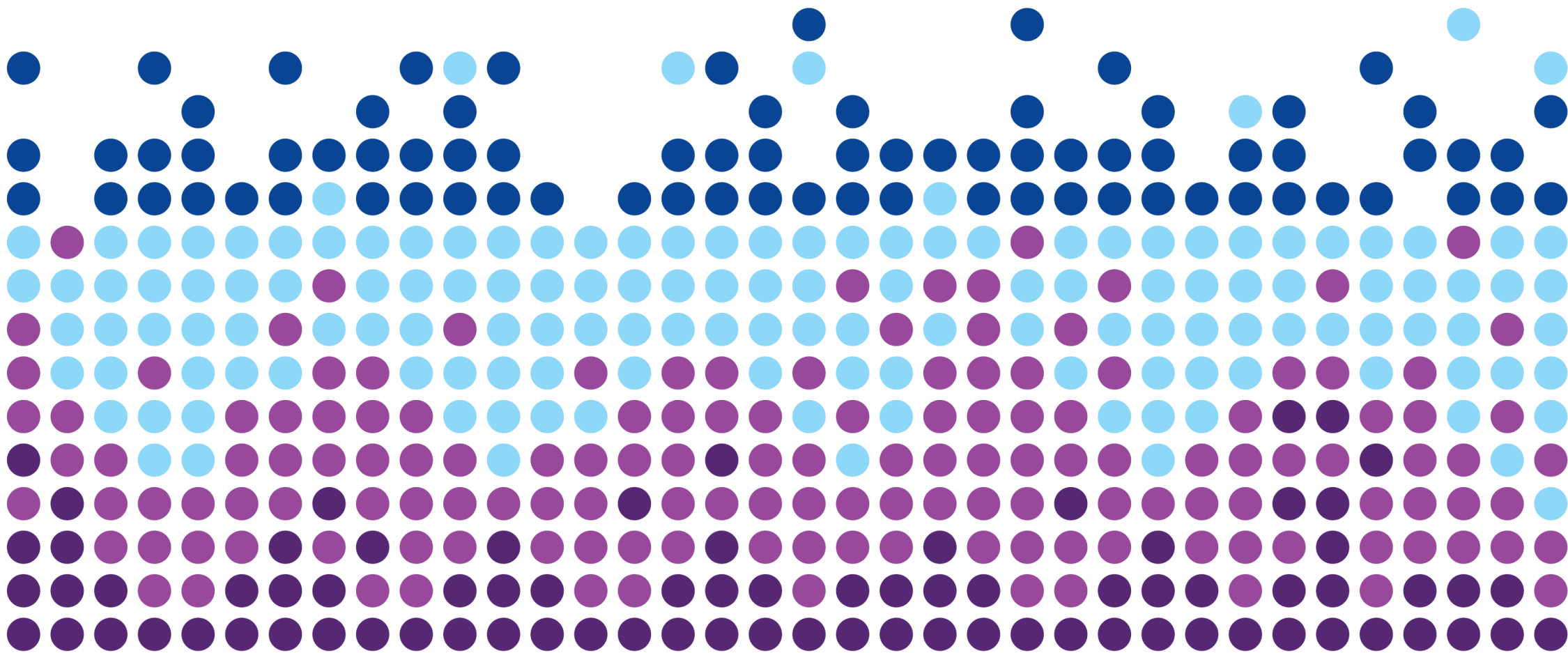




The BR2 is considered having the best Overall ageing management program and is the only research reactor to not have any challenges and AFI in the draft report. BR2 received several Good Performance and one Good Practice. So, in consequence, the current Action Plan is enough and does not need to be update/upgrade following the TPR workshop.”

ENSREG Topical Peer Review on Ageing Management, May
2018





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Ageing management case 1

The BR2 Beryllium matrix



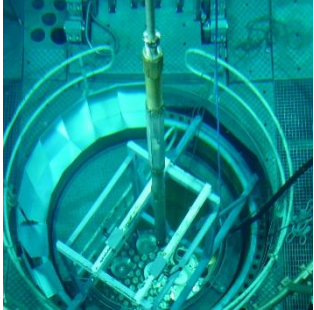


**Replacement of
internals as
preventive measure**

Performed in 1979,
1996 and 2016



Ageing management of the Be matrix



Ageing issues

- Transmutation
- Radiation induced swelling
- Cracking of matrix blocks



Countermeasures

- Restrict shut down with age of matrix
- Inspect channels periodically
- Replace matrix at end of life (fluence $< 6,4 \cdot 10^{22} \text{ n/cm}^2$)

Review design, qualify components and revisit construction and operation procedures for matrix replacement





The primary cooling loop

Ageing management case 2

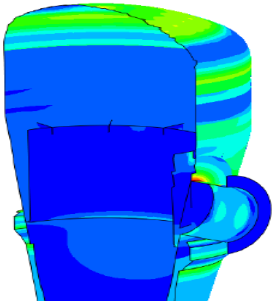




**Periodic inspections and
integrity assessment**
Integrity assessment
Design base and modern
standards



Ageing management of the primary system



Ageing issues

- Irradiation embrittlement
- Fatigue
- Standard evolution

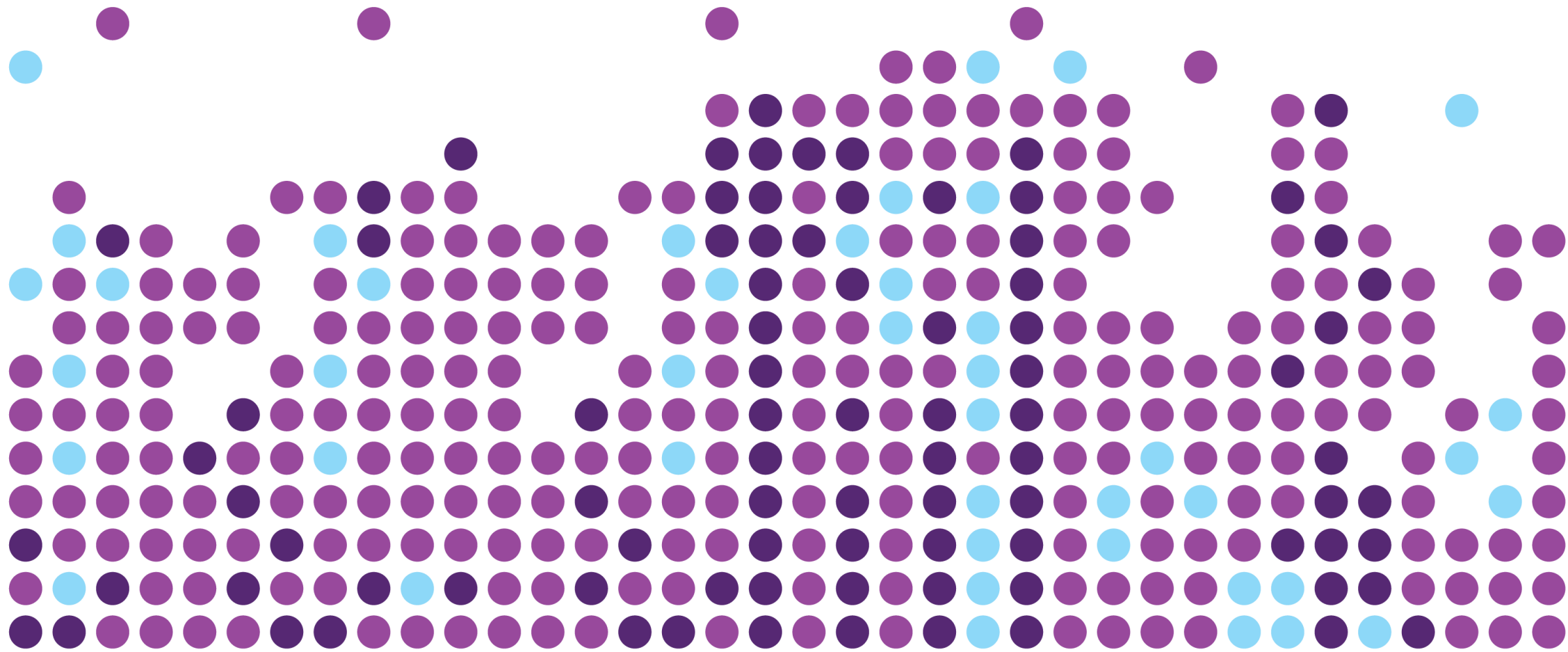


Countermeasures

- Material irradiation program with lead factor
- Record on transients and structural integrity assessment
- Periodic inspection for construction defect and evolution

Review design and original construction file, assess defects according to modern standard, use calibrated inspection techniques to ensure integrity of primary loop and vessel – perform qualified repair






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Ageing management case 3

The emergency electric feed system





**Modernisation of
the electric system**
Comply to modern
safety requirements



Ageing management of the electric emergency feed



Ageing issues

- Safety requirement evolution
- Reliability degradation with age
- Increase defense in depth against internal & external hazards

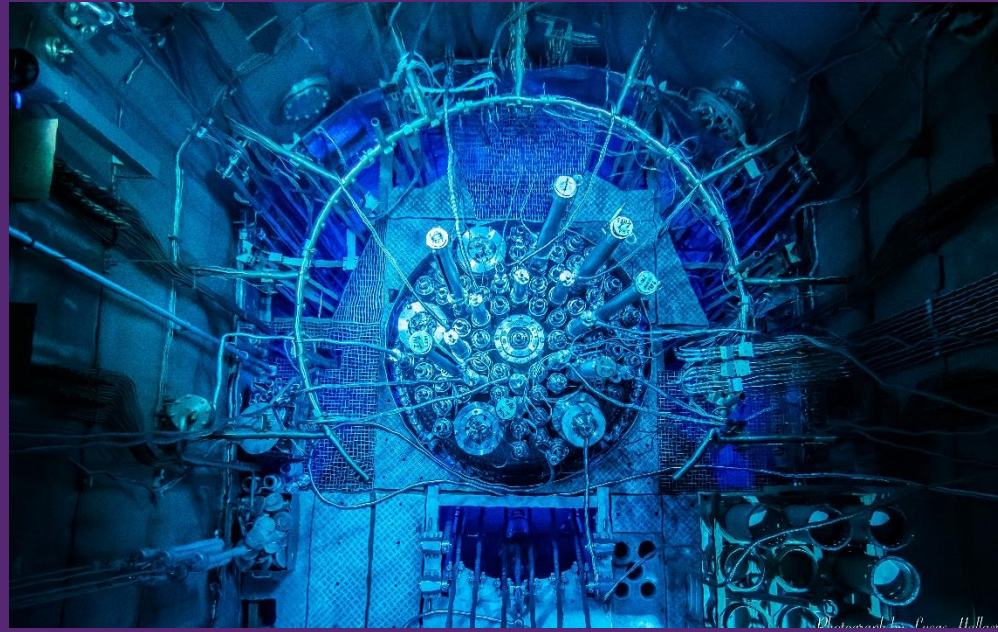


Countermeasures

- Review design base
- Replace obsolete components with modern technology
- Separate support systems for redundant components and design for enhanced fire safety and seismic resistance

New state of art system in new building with separation of components from generator and UPS up to user





Outlook



Successful ageing management of the BR2

- Relies on a continuous integration of plant observation, evolving knowledge and pro-active replacement
- Enhances reliability and economy of the operation
- Allows for an increased availability of the reactor: > 200 days per year as of 2020
- Paves the road to the next periodic safety reassessment, covering the 2026-2036 period