

Periodic Safety Review of the BR2 Reactor

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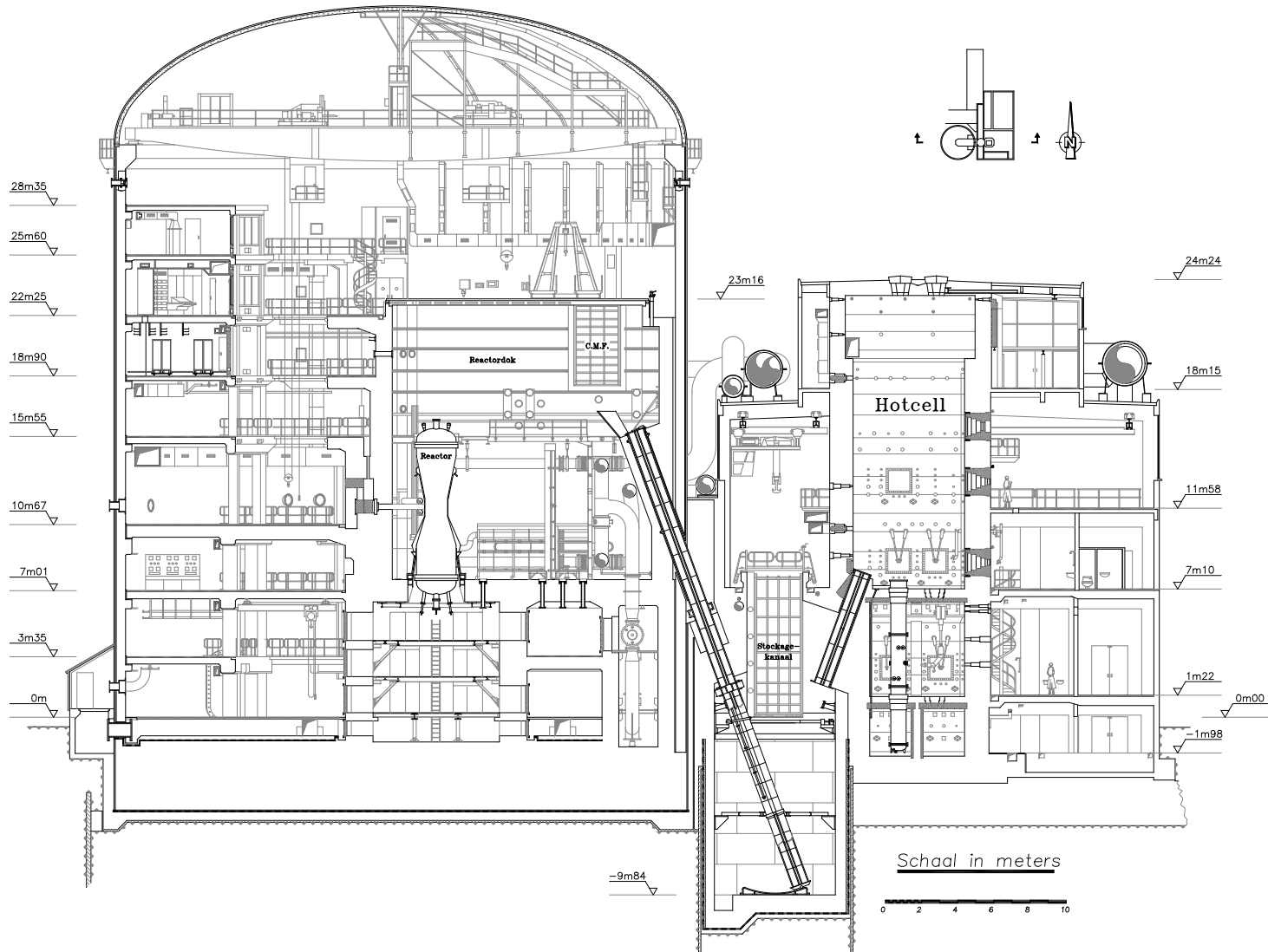
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Reactor Safety Section

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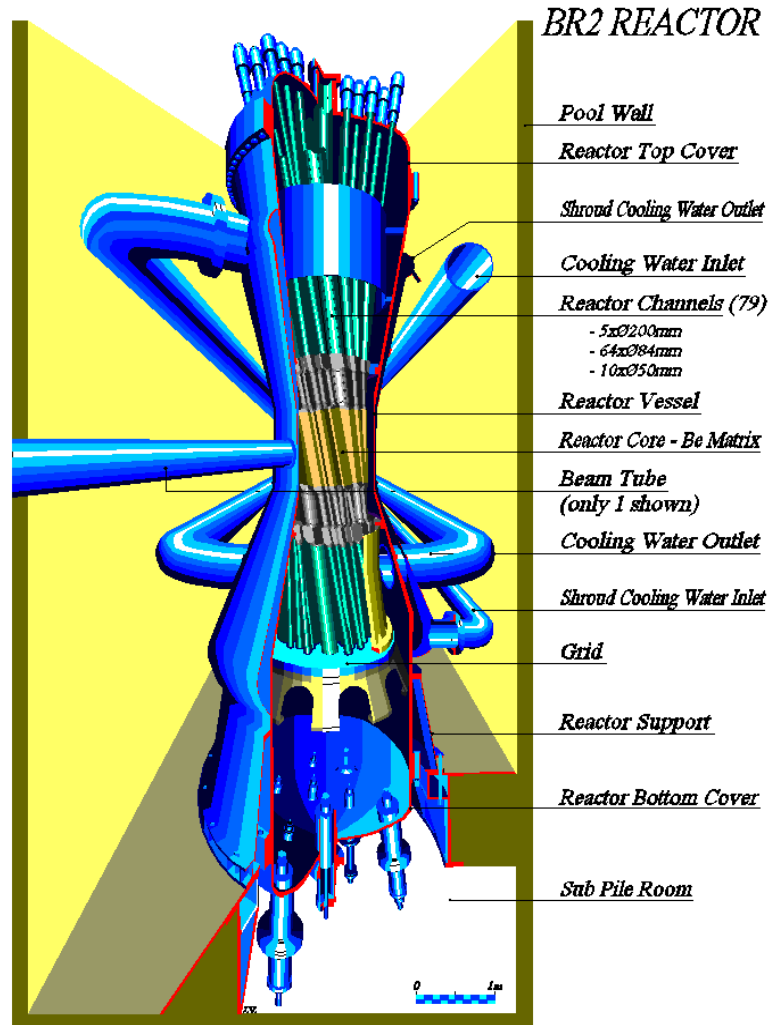
BR2: General description

- Material Test Reactor - tank in pool type
 - Maximal thermal power 125 MW (heat exchangers)
 - Licence limit: power density:
 - ♣ 470 W/cm² hot spot in routine operation
 - ♣ Up to 600 W/cm² hot spot special conditions
- Pressurized water (12 bar)
- Fuel:
 - HEU – UAlx plates
 - Conversion to LEU with UMo – min. 7.5 g/cm³
- Moderator: water and beryllium
- Containment building

BR2: General view



The BR2 reactor vessel



Utilization

- Originally designed as Material Test Reactor
 - Material irradiation
 - Fuel testing
 - Beam tubes foreseen – limited use
- Extensive program on fast reactors '70 and '80
 - Fuel failure tests
- Actual use
 - PWR fuel test – dedicated high pressure loop
 - Possibility for transients
 - Material irradiation (vessel steel, fusion, ADS)
 - Isotope production (Mo99, Ir192, ...)
 - Silicon doping (2 devices, up to 5" in the vessel and 8" blocks in the pool)

Requirements for Periodic Safety Review.

- Operating licence (Royal Decree of 29 June 1986) valid for undetermined period.
 - Licencing authority Federal Agency for Nuclear Control
- Requirement for Periodic Safety Review (article 2, §5.)
 - Up to 2008: every 5 year for reactors
 - Actually: every 10 year for all installations (practice for power reactors).
- Detailed followed by technical support organisation of FANC (BEL V).
- Final report (with action plan) to approved by BEL V.
- Summary published on website of FANC (in Dutch or French)
 - <http://www.fanc.fgov.be>

General list of topics

- Follow up material of structural components
- New safety practices
- Advanced safety analysis
- Organisation

Selection of subjects

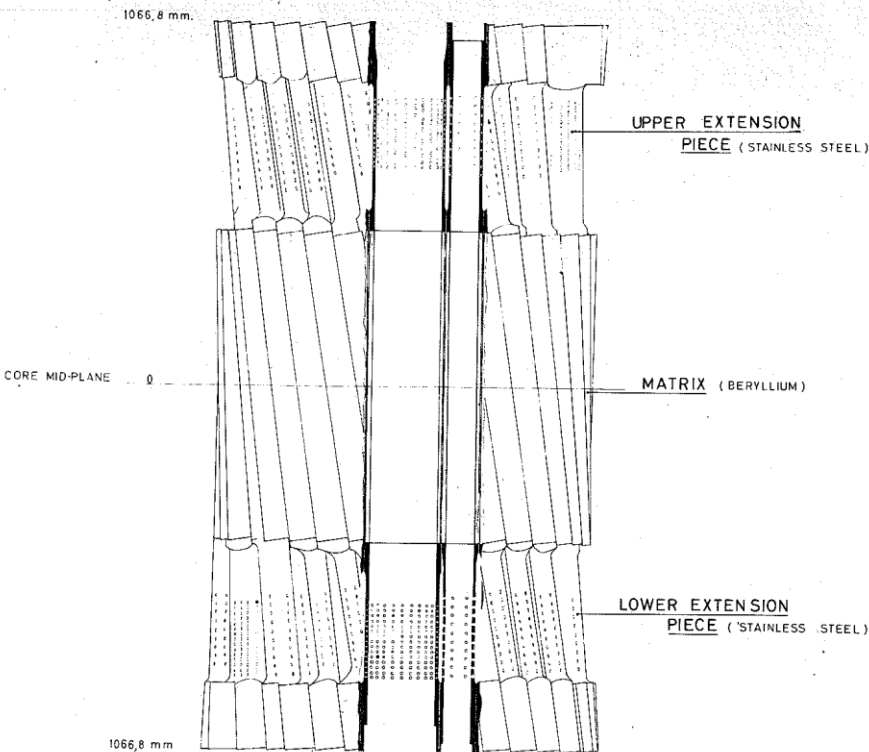
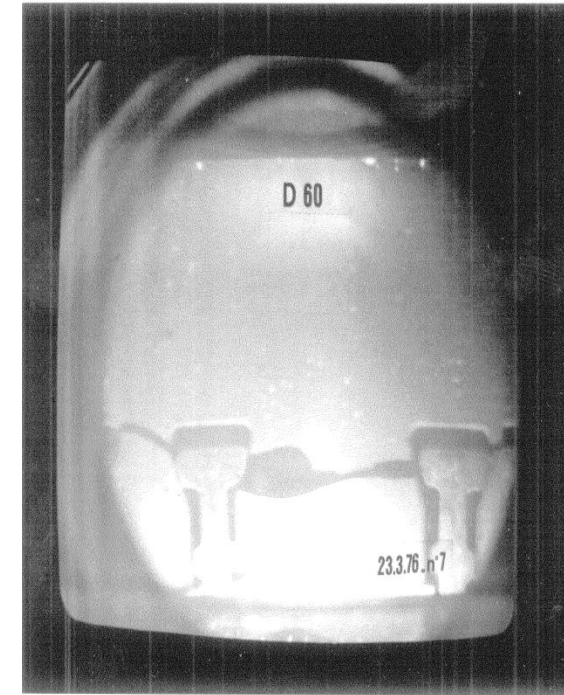
- “Brain storm” list proposed by operator (more than 70 potential subjects).
- Selection by safety department according to criteria for PSR
 - Maintain and improve safety
 - Application of new safety practices
 - Return of experience (own/other installations)
 - No short term “urgent” issues
- Final list in discussion between operator, department nuclear safety and BEL V.
 - 19 items in final selection

Conversion to LEU

- Feasibility selected as topic
 - Conclusion: LEU with density ~ 8 grU/cc
 - UMo dispersed – still to be qualified
- No change in fuel configuration
- Further project not under PSR (long term)
- Actual tasks:
 - Review of all safety analysis using up to date codes (MCNP, RELAP, PARET, PLTEMP)
 - Test irradiation of fuel elements with burnable poison in the stiffeners, in stead of in fuel meat.

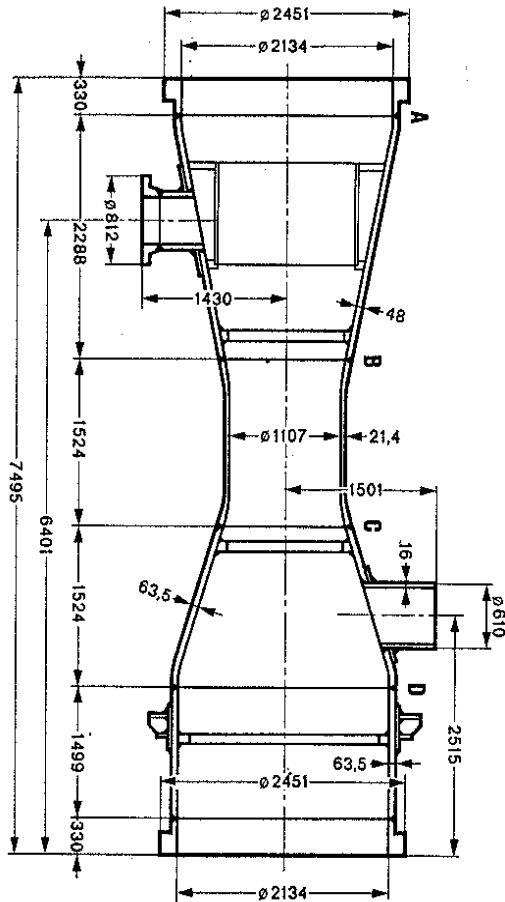
Ageing: The Beryllium Core

- Hexagonal beryllium blocks
- Ageing due to helium formation
 - Swelling, cracking
 - Poisoning due to helium 3

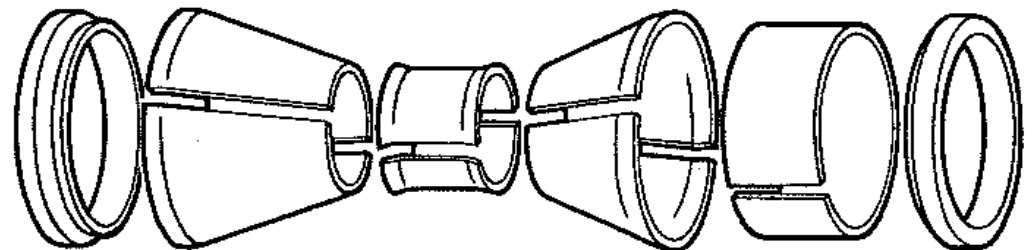


- Licence limit
 - Significant material loss
 - $6.4 \cdot 10^{22}$ fast neutrons per cm^2
- Replacement possible
 - Done twice: 1979 and 1996
 - Actual matrix up to

Ageing: The Reactor Vessel



- Material Al 5052-O
- Inspection required by licence in case of Be matrix replacement:
 - Ultrasonic and eddy current of irradiated part
 - Welds of other parts.
 - Low cycle fatigue analysis
- Material follow up program since 1997 (irradiation of samples from shroud)
 - Actual extrapolation up to 2016.



Ageing: Replacements

- Control rods:
 - Cadmium absorbers replaced by hafnium
 - Position indicators (redundant system with resolvers)
 - Drive mechanisms
- Instrumentation (flow, pressure, temperature)
 - Difficulties with maintenance and spare parts
- Radiation control equipment (activity of primary water)

Inspections

- **Primary circuit (non irradiated parts)**
 - Inspection program base on the ASME XI code
 - Problem: original design basis not known.
- **Devices for production (Mo99, Silicon, ...)**
 - Originally designed as experimental device (limited use)
 - Upgrade as reactor component.
- **High pressure water test loop (Callisto)**
 - Review of safety documentation (nearly 20 years of service)
 - Non destructive inspection of irradiated pressure tubes (ASME III class 1 components)
 - Inspection of rest of the loop (welds, pressure relieve valves)

Reglementation

- Check if modifications are necessary due to changes in reglementation.
- Two subjects identified:
 1. The protection against explosion risk (European ATEX directive).
 - Limited risk – no significant modification
 2. Single failure proof of hoisting cranes
 - Replacement of the trolleys (up to 25 tonne for loaded TN-MTR container)
 - Major investment

Competance Management

- BR2 more than 50 years in operation: all persons with the original design knowledge are no longer available
 - Collection of original documentation (up to now 90% recovered)
 - Formal training program for operators and other personnel
 - Learning from experience (own or foreign installations) – good practices included.
- Probabilistic safety assessment
 - Further interpretation of the result of the assessment

Resistance against severe external events

- Request of FANC to study the protection against severe external events
- Use of WENRA list + additional man made events
 - Seismicity (qualification in 1997)
 - Flooding (low risk in the region)
 - Heavy storm and whether conditions
 - External fire thread (forrest fire)
 - Terrorist attack using missile
 - Cyber attack
- Time schedule – after power plants
 - Subjects and work plans by mid december
 - Final report June 2010
- No international review foreseen

Conclusion

- Periodic Safety Review is a major tasks
- Main topics:
 - Ageing
 - Changing regulation
 - Knowledge management
- Important investment could be involved