BR2: the first year of operation after refurbishment

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The BR2 reactor has resumed operation in April '97 after an extensive refurbishment shutdown, which lasted for nearly two years.
The yearly operation is presently limited to 5 major cycles of 21 efpd, plus some short cycles for special programmes.

The reactor is mainly used for irradiations in the framework of the following programs: qualification of MOX fuel at high burn-up, the PWR vessel surveillance program and associated modelling activities, the IASCC program focused on PWR vessel internals.
The major irradiation device is the CALLISTO loop, simulating PWR conditions and comprising three in-pile sections.
Additionally production activities are carried out: radio-isotopes and silicon doping. Irradiations for the surveillance programmes of beryllium and aluminum are underway; they concerns unirradiated and preirradiated samples, with various lead factors.

Several refurbishment actions are still continuing, mainly:
- continuation of the renewal of the process instrumentation,
- extension of the BR2 DAS,
- follow-up of the seismic qualification study,
- follow-up of the PSA study: some detailed studies on supporting systems .

A formalised training programme for the reactor operators has been launched. Special attention is given to the new reactor control desk and the emergency control panel outside of the containment building.
A solution for the evacuation of the spent fuel has been adopted and is being implemented: reprocessing in La Hague.

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BR2
The first year of operation after refurbishment

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BR2 is back in operation

- Operation resumed in April '97 after a ~ 2 year refurbishment shutdown
- Decision to continue operation based on recognition that BR2 is an essential research tool for SCK·CEN
  - Engineering R&D in relation to Belgian PWR
  - Support of internal fuel and materials research
- Objective of refurbishment was PLEX

  BR2 design = optimized design for MTR-use and safety experiments

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Refurbishment Motivation & Execution

- Motivation: - Be-matrix replacement
  - relicensing
- Total duration: 1991- 1998
- 5 distinct phases:
  - 1991-92: overall survey and identification of work items
  - 1992-94: detailed studies and design work
  - 1994-95: procurement, work procedures and preparation
  - mid '95-april '97: refurbishment shutdown
  - 1997-98: remainder of work (non-critical activities),

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Major Refurbishment Issues

Modifications

- Be-matrix replacement
- Upgrading safety systems: Scram and isolation systems
- Instrumentation: Control desk, ECP, process instrumentation
- Support systems: Electrical supplies, compressed air
- Industrial safety: Fire protection, Pressurizor, ...

Inspections Al pressure vessel

Maintenance (extensive overhaul)

- Hydraulic Circuitry, Cooling towers, Emergency power Units, Cranes, Ventilation, Sub-pile room, ...

Major Refurbishment Studies

Safety assessments

- Vessel integrity
- PSA -> LOCA assessments
- Thermo-hydraulic analysis (RELAP model)
- Seismic qualification

Operational safety improvements

- Ergonomic study
- Update of documentation and procedures
- Operator training programme

Refurbishment project structure

Internal project structure

- Refurbishment committee:
  general planning, resource allocation, budgetary follow-up
- Safety committee:
  examination of major modifications (3 stages procedure)
- BR2 QA-system:
  initiation, follow-up and notification of all modifications.
  updating of related documentation, procedures and drawings
- Periodic meetings with the regulatory body
  represented in Safety committee
  one assigned "site inspector"

Operation licence

- needs only to be prolonged, not renewed
- procedure : decennial safety reassessment
  (same procedure as Power Stations)
- basic documents :
  updated SAR, including results from studies, inspections, improvements and upgradings of refurbishment programme
- follow-up through periodic meetings with the regulatory body

Present utilization of BR2

Basis: **internal R&D programmes related to needs of Belgian PWR's**

- MOX fuel: properties at high burn-up
  (thermal conductivity, fission gas release, PCMI)
- Structural materials: experimental and modelling work
  - Pressure Vessel Steels: Embrittlement, RPV surveillance
  - IASCC: mainly Vessel Internals
- In-core instrumentation: development of on-line detectors
- Geological waste disposal: long-term behaviour

BR2 utilisation: irradiation devices

- PWR-loop **CALLISTO**
  - ► steady state irradiations under realistic PWR conditions
  - ► 3 IPS with capacity for 9 fuel rods (fresh and pre-irradiated) in each of them
  - ► used for MOX, RPV steel and corrosion programs
- **PWC** capsules associated with ^{3}He-screens
  single-rod transient tests on pre-irradiated MOX fuel rods
- Reflector rigs : steel and structural materials
- Gamma irradiation facilities :
  long-term waste behaviour, remote handling

New irradiation devices for BR2

- Pool Side Facility : **MERLIN**
  - large irradiation space for vessel-steel & remote handling programs
  - includes a n-flux converter outside of the vessel
- PWR-type integrated loop : **DESTIN**
  - steady-state and transient tests in central 200 mm flux trap
  - up to 25 fuel rods (fresh or pre-irradiated)
- Dedicated corrosion loop : **ECLIPS**
  - controlled and adaptable chemical conditions
  - in-core and out-core positions
- Instrumentation test rig : **DOLMEN**

BR2 surveillance programs

- **Be matrix surveillance:**
  - ► samples from the 2 previous matrixes
  - ► fast fluence > 6e22 n(>1 MeV)/cm², Fth/Ff ~ 1
  - ► irradiation in central position of fuel elements
  - ► PIE: swelling, gas content, ^{3}H release
- **Al vessel surveillance:**
  - ► base metal and weld samples from vessel shroud
  - ► thermal fluence ~ 3e22 n/cm², Fth/Ff ~ 8 - 20
  - ► irradiation in various reflector positions
  - ► PIE: fracture toughness, microstructure

Continuing refurbishment actions

- DAS extension, integrating operation and experiments
- continued upgrading of process instrumentation
- follow-up PSA:
  - detailed analysis of support system failures especially electrical supplies
  - fault-tree linking and PSA updating
- actions following the seismic qualification study

Fuel cycle management

- Definite solution for back-end has been adopted:
  - reprocessing in La Hague
  - dilution of recovered uranium
- A previous urgent relieve reprocessing campaign in Dounreay (shortage of on-site storage capacity) allowed to demonstrate that the fuel cycle can be closed. However a mixed core strategy has to be adopted in order to maintain the BR2 characteristics

Operator training program

- Regulatory requirement -> formal training program
- regular in-house training (theoretical and experimental)
  +
  periodic outside training (simulator, training reactor)
- official periodic operator relicensing
- special attention for: - new control desk
  - emergency control desk

BR2: the present status

- Reliable operation since restart in April '97
- Present operation regime:
  5 standard cycles (21 efpd)
  + some dedicated short cycles
- Present utilisation: - Belgian programmes
  - Production activities
  - Programs for third parties
- BR2 available for: - scientific collaborations
  - irradiations on request