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REPORT OF THE

INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (INSARR) MISSION

TO THE BR2 RESEARCH REACTOR

Belgian Nuclear Research Centre (SCK CEN)

Mol, Belgium
28 February – 8 March 2023

INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (INSARR)

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
Division of Nuclear Installation Safety

INTERNATIONAL ATOMIC ENERGY AGENCY

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INTERNATIONAL ATOMIC ENERGY AGENCY

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Mission Date:	28 Feb – 8 Mar 2023	
Location:	Mol, Belgium	
Facility:	BR2 Research Reactor	
Organized by:	IAEA at the request of the Federal Agency for Nuclear Control (FANC), the Belgian regulatory body	
Conducted by:	Mr A. Shokr	RRSS/NSNI – Team Leader
	Mr D. Sears	RRSS/NSNI – Deputy Team Leader
	Ms C. Pike	OSS/NSNI – Safety Culture Specialist
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	Mr K. Du Bruyn	SAFARI-1 Reactor, South Africa
	Mr N. De Lorenzo	INVAP, Argentina
	Mr C. Kaaijk	Delft Research Reactor, the Netherlands
	Mr D. Tucker	McMaster Nuclear Reactor, Canada

EXECUTIVE SUMMARY

In response to a request from the Federal Agency for Nuclear Control (FANC, regulatory body of Belgium), the IAEA conducted an Integrated Safety Assessment for Research Reactor (INSARR) mission to the BR2 research reactor in Mol, from 28 February to 7 March 2023. The reactor is owned and operated by the Belgian Nuclear Research Centre (SCK CEN). The BR2 is mainly used for research and development, radioisotope production, neutron transmutation doping of silicon, and fuel and materials testing. It is a tank-in-pool-type reactor, moderated by light water and metallic beryllium, fuelled with highly enriched uranium (HEU), and cooled by light water. The nominal power is 60-70 MW with a maximum thermal power of 125 MW.

The objective of the INSARR mission was to review the operational safety of the reactor, covering reactor management, safety committee, safety culture, management system, training and qualification of operating personnel, safety analysis, safety analysis report (SAR), operational limits and conditions (OLCs), conduct of operations, maintenance, safety of utilization and modifications, operational radiation protection and waste management programmes, emergency planning, and decommissioning plan. The review was performed following the methodology established by the IAEA Guidelines for Research Reactors Safety Review (INSARR Guidelines, 2013 Edition), which are based on the IAEA safety standards.

The mission team was composed of three IAEA staff members: Mr A. Shokr (Head, Research Reactor Safety Section (RRSS) - Team Leader), Mr D. Sears (Senior Safety Officer, RRSS, Deputy Team Leader), and Ms C. Pike (Safety Culture Specialist, Operational Safety Section); and five international experts: Mr N. De Lorenzo (INVAP, Argentina), Mr D. Tucker (McMaster University Nuclear Reactor, Canada), Mr K. Du Bruyn (SAFARI-1 Research Reactor, South Africa), Mr C. Kaaijk (Delft Research Reactor, the Netherlands), and Mr M. Balazik (Nuclear Regulatory Commission, the United States). The main counterparts of the mission were Mr S. Coenen (FANC), Mr S. Van Dyck (BR2 Reactor Manager) and Mr F. Joppen (Head of Asset Management). Senior managers and technical staff of SCK CEN and BR2 participated in the activities of the mission. Mr P. Baeten, SCK CEN Director General, and Mr S. Coenen and Mr R. Klein Meulekamp (FANC) and participated in the opening session and in the exit meeting of the mission. The summary report was provided in the exit meeting where the recommendations were discussed and agreed upon.

The IAEA team noted the competence of the BR2 staff and observed that effective administrative and technical measures are established by SCK CEN to ensure operational safety of the BR2. The IAEA team also noted the implementation of programmatic activities for developing a strong culture for safety. The team encouraged SCK CEN to sustain these efforts to ensure that safety is given the highest priority overriding demands of production and of reactor users.

The IAEA team also noted the effective formal and informal communications between SCK CEN and FANC and encouraged the continuation of this practice in planning and implementing activities of safety significance, including those related to conversion from use of HEU to LEU, and refurbishment and modernization of the structures, systems, and components (SSCs) important to reactor safety.

The IAEA team observed that the training and qualification of personnel, maintenance, ageing management and PSR are conducted in line with the IAEA safety standards. The team also identified areas needing improvement and provided recommendations and suggestions to address these areas for further safety improvements. These recommendations were mainly related to the need for:

- Strengthening the organizational structure for reactor operation by enhancing the coordination of the maintenance activities and the handling of radioisotope production and experimental devices;
- Ensuring that the planned restructuring of SCK CEN maintains a high level of safety of BR2, including with respect to availability of adequate human and financial resources, management system processes and documentation, and the support services necessary for safe operation of the reactor;
- Improving the work procedures of the SCK CEN reactor safety committee to include review of proposed tests, equipment, systems or procedures of safety significance, proposed modifications of items important to safety, proposed changes of experiments that have implications for safety, and regulatory inspection reports;
- Consolidating the information on safety analysis, that is currently scattered in other facility's documents, and reviewing and revising them, as needed, to ensure that the analysis adequately cover the identification and selection of all relevant postulated initiation events, description of event sequences and consequences, and comparison against acceptance criteria;
- Revising the SAR to include the missing information (or information that is presently scattered in other facility's documents) on the topics that are recommended by the IAEA safety standards, including reactor site, design safety requirements, engineered safety features, experimental facilities, environmental impact assessment, and decommissioning;
- Improving the OLCs to ensure that they are enveloping the safety parameter values and SSCs conditions, within which the reactor has been demonstrated to be safe, and by amending them to cover all operating states of the reactor, experiments, and periodic tests of SSCs that are subjected to safety system settings and limiting conditions for safe operation;
- Considering installation of manual scram capability at operational location(s) other than control rooms (e.g. reactor pool-top), and seismic detectors with emergency shutdown capability;
- Enhancing the effectiveness of the operation and maintenance activities through ensuring adequate quality checks and verifications of completed tasks;
- Enhancing the operational radiation protection programme, specifically with respect to justifying and revising, as needed, the established value of dose constraint of 10 mSv/year and by enhancing the operational performance of the radiation monitors at workplace; and
- Finalizing the development of the emergency response procedures and training programme for the personnel involved in the management of the SCK CEN's site emergency.

The IAEA team recommended that BR2 management should establish an action plan to implement the recommendations, which could be reviewed in a follow-up INSARR mission to be conducted in 2025.

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1. INTRODUCTION

1.1 BACKGROUND

Following a request from the Federal Agency for Nuclear Control (FANC), the regulatory body of Belgium, the IAEA conducted an Integrated Safety Assessment for Research Reactor (INSARR) mission to the BR2 research reactor, from 28 February to 7 March 2023.

The BR2 reactor is owned and operated by the Belgian Nuclear Research Centre (SCK CEN) and is located in Mol, Belgium. The BR2 is a tank-in-pool-type research reactor moderated by light water and metallic beryllium. The maximum thermal power of the reactor is 125 MW, with nominal power of 60-70 MW. The cylindrical fuel elements containing highly enriched uranium (HEU) UAlx can host irradiation rigs in the centre of the assembly. The BR2 is cooled by light water in a closed, pressurized loop operating at 1.2 MPa with an open secondary loop and modular cooling towers. The BR2 is mainly used for research and development, radioisotope production, neutron transmutation doping of silicon, and fuel and material testing. The reactor was previously used for neutron beam experiments, but the beam tubes were removed in 2016 and the associated penetrations have been sealed.

The BR2 achieved first criticality in 1961 and has undergone several modifications and upgrades during its lifetime, including a power upgrade from 75 to 125 MW (1971), replacement of the Beryllium matrix (1979 and 2016), refurbishment and reduction of operation (1997 and 2016), and enhancement of operational availability (2020). A “stress-test” has been performed following the accident at the Fukushima Daiichi nuclear power plants and most of the safety upgrades that were identified by the stress-test have been implemented.

The IAEA conducted a safety review mission on ageing management for continued safe operation of the BR2 research reactor in November 2017. This mission was performed based on the methodology of the IAEA mission on Safety Analysis for Long-Term Operation of Nuclear Power Plants (SALTO), adapted for research reactors. The mission provided recommendations and suggestions to improve the ageing management programme and to ensure continued safe operation of the facility.

The BR2 operation license is valid for the facility lifetime and licensing conditions are subjected to review based on the results of a periodic safety review (PSR). The last PSR was completed in 2016 and the next one is planned to be completed by July 2026. Several modifications and refurbishments have been implemented, are ongoing or planned, including an aging management programme and conversion of the reactor from the use of HEU to low enriched uranium (LEU) fuel. In this context, the INSARR mission was requested.

A pre-INSARR meeting was conducted virtually in June 2022. During this mission the technical and organizational arrangements for the INSARR mission were agreed between the IAEA representatives, BR2 management and FANC representatives.

1.2 OBJECTIVE AND SCOPE OF THE MISSION

The objective of the INSARR mission was to review the operational safety of the BR2 research reactor, and to provide recommendations and suggestions for safety improvements.

During the Pre-INSARR meeting, held in June 2022 (virtual), it was agreed that the scope of the INSARR mission would cover the following review areas, as listed in the IAEA Services Series No. 25:

- Operating organization and reactor management (RMG);
- Safety committee (SC);
- Safety culture (SCL);
- Management system for the reactor operation phase (IMS);
- Training and qualification of operating personnel (TRQ);
- Safety analysis (SA);
- Safety analysis report (SAR);
- Operational limits and conditions (OLCs);
- Conduct of operations (COP);
- Maintenance, periodic testing and inspection, including ageing management (MPTI);
- Safety of utilization and experiments (EXP);
- Safety of modifications (MOD);
- Operational radiation protection (ORP);
- Radioactive waste management (RWM);
- Emergency planning (EP);
- Decommissioning plan (DECOM).

1.3 BASIS FOR THE ASSESSMENT

The basis for the safety review of BR2 is the IAEA safety standards and guidelines. The following IAEA documents were used as the basis of this review

- IAEA Services Series No. 25: Guidelines for the Review of Research Reactor Safety (INSARR Guidelines), (2013);
- IAEA Safety Standards Series No. SSR-3, Safety of Research Reactors, (2016);
- IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety, (2016);
- IAEA Safety Standards Series No. GS-G-3.5, The Management System for Nuclear Installations, (2006);
- IAEA Safety Standards Series No. SSG-20 (Rev. 1), Safety Assessment and Preparation of the Safety Analysis Report for Research Reactors, (2022);
- IAEA Safety Standards Series No. SSG-24 (Rev. 1), Safety in the Utilization and Modification for Research Reactors, (2022);
- IAEA Safety Standards Series No. SSG-81 (Revision of NS-G-4.2), Maintenance, Periodic Testing and Inspection for Research Reactors, (Preprint 2022);
- IAEA Safety Standards Series No. SSG-83 (Revision of NS-G-4.4), Operational Limits and Conditions and Operating Procedures for Research Reactors, (Preprint 2022);
- IAEA Safety Standards Series No. SSG-84 (Revision of NS-G-4.5), The Operating Organization and Recruitment, Training and Qualification for Research Reactor Operating Personnel, (Preprint 2022);
- IAEA Safety Standards Series No. SSG-85 (Revision of NS-G-4.6), Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, (Preprint 2022);

- IAEA Safety Standards Series No. SSG-10 (Rev. 1), Ageing Management for Research Reactors, (Preprint 2022);
- IAEA Safety Standards Series No SSG-82 (Revision of NS-G-4.3): Core Management and Fuel Handling for Research Reactors, (Preprint 2022)
- IAEA Safety Standards Series No. GSR Part 6: Decommissioning of Nuclear Facilities, (2014);
- IAEA Safety Standards Series No. SSG-37 (Rev. 1), Instrumentation and Control Systems and Software Important to Safety of Research Reactors, (Preprint 2022);
- IAEA Safety Standards Series No. GS-G-3.1, Application of the Management System for Facilities and Activities, (2008).
- IAEA Safety Standards Series No. SSG-15: Storage of Spent Nuclear Fuel, (2012).

1.4 DOCUMENTS RECEIVED FROM THE COUNTERPARTS PRIOR TO AND DURING THE MISSION

ANNEX I includes the list of documents provided to the IAEA team by the counterparts. In addition to the reactor safety and operational documents, the SCK CEN and BR2 managers and technical staff made several presentations during the mission which covered all INSARR review areas. These presentations provided an overview of the status of the reactor facility and its associated documentation and were followed by detailed discussions within the framework of the mission activities. The list of these presentations is also provided in ANNEX I.

1.5 CONDUCT OF THE MISSION

The mission was conducted in accordance with the agenda provided in ANNEX II. The entry meeting started with a welcome address by the SCK CEN Director General and FANC representatives, which included the background of the request of the INSARR mission as well as a general description of the BR2, utilization and recent and planned improvements. This meeting also included a presentation from the BR2 reactor manager on the main safety features of the reactor and its safety status.

During the first day of the mission, the IAEA team and the technical counterparts made a walkthrough of the reactor facilities. The reactor was in operation at 52 MW for radioisotope production and material irradiation. The team visited the reactor containment building (the ground floor, reactor pool-top area, and operation control room) and the process building and the machine control room. During this walkthrough, the team observed very good housekeeping, including cleaning, minimal fire load, appropriate storage of operation tools and materials, and adequate tagging of systems and components. The team also noted adherence of the reactor operating personnel to the radiation protection procedures. The team also noted the adequacy of the practices of recording data in the operation logs.

The team also observed unloading irradiated Mo-99 targets as well as loading fresh targets in accordance with the established procedures, demonstrating effective coordination amongst the involved personnel and effective communication with the control room.

Five and one half out of seven days of the mission time were dedicated to a series of technical sessions and plenary discussions with the technical counterparts, walkthrough the facility, interviews for the review of the safety culture programme, drafting of the preliminary mission report, and final discussion with the technical counterparts about the findings and conclusions of the mission.

On Monday, 6 March, the IAEA team briefed FANC representatives (Mr S. Coenen and Mr R. Klein Meulekamp) and Mr N. Noterman, the representative of Bel V (the technical support organization of FANC) on the results of the mission.

The exit meeting was held on Tuesday, 7 March 2023, with the participation of the SCK CEN Director General, the representatives of FANC and Bel V, and SCK CEN and BR2 senior managers and technical staff. The mission conclusions and findings were discussed during this meeting, with general agreement from the counterparts on the mission recommendations.

1.5.1 INSARR Team and Counterparts

The mission team comprised three IAEA staff members: Mr A. Shokr (Head, Research Reactor Safety Section (RRSS) - Team Leader), Mr D. Sears (Senior Safety Officer, RRSS, Deputy Team Leader), and Ms C. Pike (Safety Culture Specialist, Operational Safety Section); and five international experts: Mr N. De Lorenzo (INVAP, Argentina), Mr D. Tucker (McMaster University Nuclear Reactor, Canada), Mr K. Du Bruyn (SAFARI-1 Research Reactor, South Africa), Mr C. Kaaijk (Delft Research Reactor, the Netherlands), and Mr M. Balazik (Nuclear Regulatory Commission, the United States).

The main counterparts of the mission were Mr C. Coenen and R. Klein Meulekamp (FANC), and Mr S. Van Dyck (BR2 Reactor Manager) and Mr F Joppen (Head of Asset Management). Senior managers and technical staff of SCK CEN and BR2 participated in the activities of the mission. Mr P. Baeten, SCK CEN Director General, and Mr R. Klein Meulekamp and Mr S. Coenen (FANC) participated in the opening session and in the exit meeting of the mission.

The list of mission participants is provided in ANNEX III.

1.5.2 Short description of the assessment method

The following procedures were used for the conduct of the safety review:

- Examination and assessment of BR2 reactor safety and operating documentation;
- Walkthrough of the BR2 and associated facilities;
- Discussions with the BR2 management, technical staff and operating personnel, and SCK CEN managers and technical staff;
- Interviews with SCK CEN and BR2 staff for review of the safety culture programme;
- Discussions among the IAEA team members;
- Preparation of the mission report.

The mission report is based on the Issue Pages (see APPENDIX I: ISSUE PAGES), a document which is developed during the mission by the IAEA team members and the technical counterparts.

1.5.3 Review criteria

The INSARR team reviewed the established organizational and technical measures, programmes, and procedures based on the IAEA Safety Standards and provided recommendations and suggestions to the operating organization, in accordance with the following definitions:

Recommendation: Recommendations are review team advice for improving safety based on IAEA Safety Standards. The recommendations focus on "what" is recommended to be done. The recommendations are designated with the letter "**R**" in the mission report.

Suggestion: Suggestions are review team proposals in conjunction with a recommendation, or they may stand on their own. They may indirectly contribute to improvements in safety, but they are primarily intended to enhance performance. They describe "how" to implement the recommendations. The suggestions are designated with the letter "**S**" in the mission report.

2. CONCLUSIONS AND RECOMMENDATIONS

The IAEA team appreciated the technical competence and the openness and transparency of the SCK CEN and BR2 technical staff and operating personnel and noted the management's commitment to safety and the implementation of an effective management system for the reactor operation phase.

The IAEA team also noted the effective formal and informal communications between SCK CEN and FANC and encouraged the continuation of this practice in planning and implementing activities of safety significance, including those related to conversion from use of HEU to LEU, and refurbishment and modernization of the structures, systems, and components (SSCs) important to reactor safety.

The IAEA team observed the implementation by SCK CEN of programmatic activities for developing a strong culture for safety. The team encouraged SCK CEN to sustain these efforts to ensure that safety is given the highest priority overriding demands of production and of reactor users.

The IAEA team also noted the good practice followed by SCK CEN on continuation of voluntary reporting to the review meetings of the Convention on Nuclear Safety on BR2 safety.

The IAEA team concluded that effective administrative and technical measures are established by SCK CEN to ensure operational safety of the BR2, and observed that the training and qualification of personnel, maintenance, ageing management, PSR, and conduct of experiments and modifications are being conducted in line with the IAEA safety standards.

The IAEA team identified areas needing improvement and provided recommendations and suggestions to address these areas. These covered organizational and management aspects, safety analysis and safety documents, and the operational safety programme and technical measures. These recommendations and suggestions are presented as follows.

Safety management and organizational aspects

- To strengthen the SCK CEN activities on safety culture, the leadership development training, that is presently considered as optional, should be mandatory for managers at all levels within the BR2 organizational structure.
- In view of the SCK CEN restructuring under consideration, adequate analysis should be performed, and measures taken accordingly, to ensure that a high level of safety is maintained for BR2, including with respect to availability of adequate human and financial resources, management system processes and documentation, and the support services necessary for safe operation of the reactor.
- It is suggested to consider reallocation of the function of handling of production and experimental devices and facilities within the BR2 operation expert group. It is also suggested to consider reallocation of the function of maintenance, periodic testing and inspection of SSCs important to safety in a single unit within this expert group. This will further clarify duties and responsibilities for safety, enhance the effectiveness of the operation and maintenance processes, and improve safety decision-making. This will also help address the feedback from the SCK CEN self-assessment of safety culture.

- The functioning of the SCK CEN safety committee should be improved, in accordance with the IAEA safety standards No SSR-3, by strengthening its membership and work procedures and revising the list of items to be reviewed by the committee to include proposed new tests, equipment, systems or procedures important to safety, proposed modifications of items important to safety and changes of experiments that have implications for safety, reports to be submitted to regulatory body and reports on regulatory inspections.

Safety analysis and safety documents

- In the frame of the ongoing PSR, the information on safety analysis that is currently scattered in several documents should be consolidated, reviewed for completeness, and revised as needed in accordance with the IAEA safety standards No. SSR-3 and SSG-20 (Rev. 1) to ensure that the analysis adequately cover the identification and selection of all relevant postulated initiation events, evaluation of the event sequence and consequences, and comparison against pre-established acceptance criteria.
- In the frame of the ongoing PSR, the contents of the SAR should be revised to include the missing information on the topics that are recommended by the IAEA safety standards No. SSG-20 (Rev.1), including reactor site, design safety requirements, engineered safety features, experimental facilities, environmental impact assessment, and decommissioning. It is also suggested to consider revising the format of the SAR to that established by the SSG-20 (Rev.1).

Operational safety programmes and technical measures

- The OLCs should be:
  - Reviewed to ensure that they are enveloping the safety parameter values and SSCs conditions, within which the reactor has been demonstrated to be safe;
  - Amended to cover all operational states of the reactor, including shutdown and "manipulation conditions" (refuelling), as well as experiments;
  - Reviewed with respect to the periodic tests, that are currently scattered in several documents, to ensure the establishment of surveillance requirements for all SSCs that are subjected to safety system settings and limiting conditions for safe operation;
  - Described in a single document (or a chapter of the SAR) in accordance with the IAEA safety standards No. SSR-3, including description of the specifications' objectives, applicability, statements (i.e. limiting values or conditions), and bases (justification) of their selection.
- Consideration should be given to the installation of manual scram capability at operational location(s) other than control rooms (e.g. reactor pool-top), and seismic detectors with emergency shutdown capability.
- It is suggested to review the operating procedures on core configuration change to consider the establishment of a requirement on full insertion of the reactor control rods as an initial condition for "core loading", including loading or shuffling fuel elements.
- To enhance the effectiveness of the operation and maintenance activities, measures should be established to ensure adequate quality checks and verifications of completed tasks.
- The operational radiation protection programme for BR2 should be further improved by:

- Reviewing, justifying, and revising, as needed, the established value of dose constraint of 10 mSv/year.
    - Improving the operational performance of the radiation monitors at the reactor stack, for personnel contamination, and at workplace (fixed area), particularly with respect to ageing degradation and the validity of their calibration. The suitability of the locations of the fixed area radiation monitors should also be reviewed and changed, as needed.
- To enhance the management of SCK CEN's site emergency, development of the emergency response procedures and training programme for involved personnel should be finalized in accordance with the IAEA safety standards No. SSR-3 and GSR Part 7.

The IAEA team also recommended that BR2 management develop an action plan to implement the recommendations of the mission. The implementation of the recommendations of the mission could be followed-up during regulatory inspections and reviewed in a follow-up INSARR mission that can be conducted in 2025.

APPENDIX I: ISSUE PAGES

ISSUE RMG 01: Need to improve the organization structure for the BR2 operation

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards No. SSG-84: The Operating Organization, and Recruitment, Training and Qualification of Research Reactor Operating Personnel, 2022
- IAEA Safety Standards Series No. SSG-85: Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, 2022
- The BR2 Reactor, PowerPoint Presentation to INSARR Mission, 2023
- The BR2 Reactor Organizational Structure, Documents to INSARR Mission, 2023

2. ISSUE CLARIFICATION AND OBSERVATIONS

The Belgian Nuclear Research Centre (SCK CEN) is the operating organization (the licensee) of the BR2. SCK CEN is structured in four institutes, one of them is the Nuclear Material Science (NMS), which is responsible for BR2 operation. The NMS consists of three expert groups. The organizational structure of the BR2 operation comprises expert groups and three SCK CEN internal safety departments:

- Reactor operation (Unit 4970, over 90 persons): The BR2 manager is the head of this group, and he has the direct responsibility for the reactor safety. This expert group includes units for reactor operation management (comprises the reactor operators and shift supervisors), reactor control and experiments (responsible for the BR2 core management, safety analysis, and maintenance of nuclear instrumentation of the reactor control system and the radiation detectors), and production management and material handling (includes operators of the production facilities and responsible for handling of production facilities, including targets for production of Mo-99, silicon doping, etc.). The heads of these groups report to the BR2 reactor manager.
- Infrastructure operation (Unit 4980, over 70 persons): This expert group includes units for infrastructure operational support, nuclear engineering (responsible for design, installation, and operation of experimental devises and facilities), material logistics, as well as mechanical and electric and electronic workshops, which are responsible for maintenance of SSCs other than nuclear instrumentation and radiation detectors, including those that are important to safety. The activities performed by this group is only dedicated for BR2. This group is also responsible for design and implementation of modification projects.
- Asset management: This expert group is responsible for the asset management programme, including ageing management of the BR2.

The IAEA team discussed the functions, duties, and responsibilities for safety of the groups and individuals included in the reactor organizational structure, including their line of communications and coordination of activities of safety significance in view of the established processes and procedures. The team clarified the impact on the effectiveness of planning and implementing procedures important to safety, such as maintenance and testing of SSCs important to safety and handling of nuclear materials and experimental devices, by individuals and units in multiple expert groups. Further analysis showed that similar feedback was obtained from the analysis of the safety culture self-assessment that was performed in 2022, where process inefficiency was identified as an area needing improvement, including complexity, unclarity (including interlinkage), duplication (different tools used to register same records), inconsistency of processes and procedures.

The SCK CEN organizational units include the Internal Prevention and Protection at Work (IDBPW), which functions independently from the BR2 reactor manager. The head of the IDBPW reports to the SCK CEN Director General. The IDBPW includes departments for environmental safety, health physics, nuclear safety, and fire safety. The health physics department carries out the function of radiation protection and has dedicated officers for the operational radiation protection programme of BR2. In accordance with the national law, the IDBPW also approves proposed experiments, clears the reactor operation start-up and the training programme for the BR2 operating personnel. (See also the Issue Page on Safety Committees for further discussion of the role of the IDBPW with respect to BR2 safety).

The responsibility of the BR2 reactor manager (the head of the BR2 operation expert group) is clearly defined by written procedures. The reactor manager has the necessary resources to carry out this responsibility. The reactor manager is appointed by the SCK CEN Director General and is approved by the FANC.

SCK CEN is at present considering restructuring the organization, aligning it with the recently established strategic plan. The proposed organizational structure was not shared with the IAEA team and was not discussed during the mission. However, the IAEA team highlighted the need for an adequate analysis (and measures taken accordingly) of this reorganization to ensure maintaining a high level of safety of BR2, including with respect to availability of adequate resources (human and financial), management system processes and documentation, and the support services necessary for safe operation of the reactor. The management of SCK CEN and BR2 are aware that proposals for restructuring of the organizational structure of the reactor operation have to be submitted to the regulatory body for review and assessment before its realization.

3. POSSIBLE SAFETY CONSEQUENCES

Planning and implementing processes and procedures important to safety (such as maintenance and testing of SSCs important to safety and handling of nuclear materials and experimental devices) by individuals and units in multiple expert groups within the NMS structure could reduce the efficiency and effectiveness of these processes and procedures and can have negative impact on safety.

The reactor operational safety can be jeopardized if restructuring of the operating organization has been made without ensuring the availability of human and financial resources required for safety to the new organizational structure as well as the appropriateness of the management system processes and procedures.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations and suggestions.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R1) In view of the SCK CEN restructuring under consideration, adequate analysis should be performed, and measures taken accordingly, to ensure that a high level of safety is maintained for BR2, including with respect to availability of adequate human and financial resources, management system processes and documentation, and the support services necessary for safe operation of the reactor.

S1) It is suggested to consider reallocation of the function of handling of production and experimental devices and facilities within the BR2 operation expert group. It is also suggested to consider reallocation of the function of maintenance, periodic testing and inspection of SSCs important to safety in a single unit within this expert group. This will further clarify duties and responsibilities for safety, enhance the effectiveness of the operation and maintenance processes and procedures, and improve safety decision-making. This will also help address the feedback from the SCK CEN self-assessment of safety culture.

ISSUE SC 01: Need to improve the effectiveness of the SCK CEN reactor safety committee

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards Series No SSG-84: The Operating Organization and the Recruitment, Training and Qualification of Research Reactor Operating Personnel, 2022
- IAEA Safety Standards Series No. SSG 24 (Rev.1), Safety in the Utilization and Modification of Research Reactors, 2022
- IAEA Safety Standards Series No. SSG 20 (Rev.1), Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, 2022

2. ISSUE CLARIFICATION AND OBSERVATIONS

The document SQ/O/131 describes the terms of reference (ToR) that SCK CEN has established for a Reactor Safety Committee (RSC), including the role, competence, composition and functioning of the RSC. The RSC also supports the IDBPW in performing their role as described in the Royal Decree of 20 July 2001, regarding the national regulation for the protection of the public, workers and the environment against the hazards of ionizing radiation.

The RSC advises the Director General of SCK CEN (who is also the president of the Committee). The members (up to five) of the committee are international experts external to SCK CEN. Members of the committee are invited to specific meetings according to their relevant experience on the topics of the meeting agenda. The BR2 Reactor Control and Experiments Unit acts as the secretariat of the RSC. Participants in RSC meetings include the managers of BR2, representatives of Bel V and FANC that are responsible for regulatory supervision at BR2, and members of other SCK CEN internal committees.

According to the ToR, the RSC meets once per year and reviews modifications made during the previous year, overviews of accidents or incidents and significant events, overviews of changes to the SAR and OLCs, gaseous releases and management of radioactive waste and radiation doses to the operating personnel. The RSC also provides recommendations to SCK CEN on possible safety improvements for the BR2 reactor and follows-up on the implementation of previous recommendations of the committee. The ToR includes provisions for on-demand requests for meeting of the RSC to address special topics such as investigations of significant incidents and modifications which may need licensing submission.

The last meeting of the committee was held in 2019. The IAEA team reviewed the minutes of this meeting, and found the minutes covered acceptance of the previous year's report, discussions of the reorganizations of the NMS institute, an update of the design and construction of the MINERVA LINAC, the status of operational issues at BR2, and a discussion of a new procedure of the Committee Evaluation Experiments (CEE) including a new experiment approval process incorporating lessons learned from the RECALL experiment and recommendations from Bel V.

The IAEA team observed that functioning of the RSC is not in line with the IAEA Safety Standards Series No. SSR-3. The RSC does not review proposal for experiments or modifications to the facility, proposals for changes to the SAR and OLCs, reports on regulatory inspection of the reactor, or reports to be submitted to the regulatory body. The topic covered by the committee are mainly items completed or projects implemented in the year preceding the meeting. The IAEA team discussed the need to improve the functioning of the RSC, including the list of items to be reviewed, taking into consideration that the scope of CEE is limited to experiments and that the scope of the nuclear installation modification committee (CWI) is limited to modifications (and is not independent from the BR2 management). Additionally, reports to be submitted to the regulatory body and reports on regulatory inspection are not reviewed by any of these committees.

3. POSSIBLE SAFETY CONSEQUENCES

Ineffective functioning of the RSC will negatively impact the capacity of SCK CEN for independent review and effective management and verification of the BR2 operational safety.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observation of the mission that the RSC does not function in line with the IAEA safety standards. However, at present, experiments are reviewed by a group (IDBPW) independent from the reactor management, and according to the Belgian regulations, Bel V reviews all items on a daily basis. SCK CEN will continue to identify and implement actions for further improvement of the RSC work procedures, including review of proposed modifications, changes to OLCs, and regulatory reports, in view of the practical difficulties of obtaining experts knowledgeable of BR2 from outside SCK CEN and the need for several committee meetings per year.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R2) The functioning of the SCK CEN safety committee should be improved, in accordance with the IAEA safety standards No SSR-3, by strengthening its membership and work procedures and revising the list of items to be reviewed by the committee to include proposed new tests, equipment, systems or procedures important to safety, proposed modifications of items important to safety, including OLCs, and changes of experiments that have implications for safety, reports to be submitted to regulatory body and reports on regulatory inspections.

ISSUE SCL 01: Leadership training for managers at all levels

1. BASIS AND REFERENCES

- IAEA Safety Service Series No 25 (INSARR Guidelines), 2013

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Requirement No. GSR Part 2: Leadership and Management for Safety, 2017
- IAEA Safety Guide No. GS-G-3.1: Application of the Management System for Facilities and Activities, 2006
- SCK CEN, PowerPoint Presentation to INSARR mission on Safety Culture, 2023
- SCK CEN presentations to INSARR mission on Organization Structure and Safety Committee, 2023
- BR2 document on training and qualification of BR2 operating staff

2. ISSUE CLARIFICATION AND OBSERVATIONS

The discussion in this mission was not an assessment of the safety culture. It focused on the aspects of the framework that should be in place to develop, maintain, and continue improve leadership and management for safety. Therefore, the observations and the associated recommendation that are provided by this mission address this framework and the activities that were implemented or planned to develop and sustain a strong culture for safety, specifically within BR2.

SCK CEN has established a policy on culture for safety, which emphasizes safety as the overriding priority. SCK CEN continued, during the past several years, to plan and implement programmatic activities to develop and maintain a culture for safety, security, health, environment, and quality. In this regard, an SCK CEN process is established. This programme covers management, operation and utilization of the BR2. The safety culture development process for 2020-2025 (which follows the "plan-do-check-act" – PDCA cycle) is under implementation. Development and implementation of the process is strongly supported by the SCK CEN senior management. The activities of this development phase include project planning, culture assessment, culture survey, trend analyses, focus group interviews, and action plans to continue to develop and sustain safety culture.

The IAEA team noted that the development of the safety culture self-assessment (SCSA) approach is technically sophisticated and well implemented. Considerable thought and efforts have been put into the survey design and data collection methods and analysis. There are additional opportunities for enhancing the engagement of all employees in the process, for example by encouraging higher participation levels in the survey and ensuring more frequent communications of the SCSA findings and associated actions. A shorter SCSA cycle could be considered, which would support further clarity of the link between the results of safety culture's self-assessment and the relevant corrective actions.

SCK CEN has established an integrated management system, which covers processes and procedures for the BR2 operation. These processes and procedures include training and qualification of personnel, operating procedures, maintenance, testing and inspections, radiation protection, radioactive waste management, utilization, modifications, emergency planning, and decommissioning. The management system has been developed and implemented in line with the IAEA safety standards, providing for the establishment of a strong culture for safety. (See also Issue Page IMS 01 on integrated management system).

SCK CEN has established a process for identification and treatment of non-conformances as well as mechanisms to facilitate learning from events. The process on non-conformances prioritizes safety and ensures appropriate follow-up on their resolution. The information on non-conformances, as registered in an internal tool, ProReAct, is discussed in the meetings of the safety culture steering committee, which are held twice per year. The identified non-conformances are also reviewed in the daily "10:00 O'clock meeting". The "Take 5 for the Team" initiative was launched to highlight personal accountability for safety and learning from events. As part of this initiative, reports from ProReAct are discussed in the monthly "S2HEQ" meetings and significant events are communicated to all staff in the "News Flash" and disseminated, annually, to all SCK CEN staff.

The IAEA team encouraged BR2 to continue identify opportunities for enhancing communications on safety culture, including use of multiple communication channels, and consider integrating "Take 5 for the Team" into the agenda of the team meetings and work procedures.

The team observed that the non-conformances are tracked and analysed at a granular level, and the corrective actions are identified on case-by-case basis. This may increase the perceptions of "administrative burden", which was highlighted in the SCSA survey result as the lowest ranking category. This granular approach can also limit opportunities for identification of trends and patterns that provide information about the underlying organizational or cultural contributors to events. The team was of the opinion that additional focus on human and organization contributors to events will enhance the organization learning and support the development of leading indicators for safety. The team noted some efforts are already underway to implement this approach.

The IAEA team also observed that the distinction between safety practices and safety culture may not be clear to all personnel within the organization, which could indicate lack of "shared understanding and values" of safety culture. Additionally, although human and organizational factors are recognized as important to safety, the focus of processes and documents are made on safety practices and resolution of non-conformances. For example, coding of non-conformances includes a classification for "safety culture", with sub-categories such as nuclear safety, industrial safety, and quality which focus more on safety practices rather than attitudes or communications. Posters labelled "safety culture" refer to safety procedures. While adhering to safety practices is an important aspect of safety culture, by its own can address the underlying attitudes such as questioning, trust, and comfort in raising concerns, which are important for a strong safety culture.

The management system documentation defines the functions, roles, and responsibilities for safety for the individuals and groups that are involved in BR2 management, operation and utilization. A training and qualification programme is established, based on the IAEA safety standards, for all personnel that have bearing on safety of BR2, including contractors (see also Issue Page TRQ 01 on training and qualification of personnel). The management system also defines processes for selection, onboarding, and individual performance review, all of which incorporate focus on safety as criterion.

The training and retraining programme covers management system and safety culture. An increased focus of SCK CEN on training on interpersonal skills, communications, and leadership skills is evident. All BR2 operators have attended a one-day workshop on communications with their teams, and plans in place for further training on cross-shift communication. A three-days training for supervisors, “Safety culture at SCK CEN”, is also available. The programme covers basics of culture, safety culture, human behaviour, conscious and unconscious process, and role of leaders in ensuring safety. About 60% of the “first line supervisors” participated in this training. In addition, all the directors of SCK CEN participated in a (non-mandatory) training course “Four essential roles of a leader”. The high levels of voluntary participation in training programmes indicates commitment to leadership for safety, but full participation by all managers and supervisors will build organization wide commitment and further strengthen safety culture. “Trust and leadership” was highlighted as a domain for improvement in the SCSA process, and full participation in leadership development is one means to address this.

The IAEA team observed the implementation by SCK CEN of programmatic activities for developing a strong culture for safety in line with the IAEA safety standards. The team encouraged SCK CEN to sustain these efforts to ensure that safety is given the highest priority overriding demands of production and of reactor users.

3. POSSIBLE SAFETY CONSEQUENCES

Managers at all levels must effectively communicate, model, and reinforce the attitudes, values and behavioural expectations for safety. Inadequate training of managers in these skills creates potential for declining safety culture, impacting many areas of safety performance.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendation.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R3) To strengthen the SCK CEN activities on safety culture, the leadership development training, that is presently considered as optional, should be mandatory for managers at all levels within the BR2 organizational structure.

ISSUE IMS 01: Need to ensure adequate quality checks and verification of completed operation and maintenance tasks

1. BASIS AND REFERENCES

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. GS-G-3.1: Application of the Management System for Facilities and Activities, 2006
- IAEA Safety Reports Series No. 75: Implementation of a Management System for Operating Organizations of Research Reactors, 2013
- SAR of BR2 Veiligheidsdossier-Volume 2: BR2 operation and organization (Chapter 2-03 Documents, recurring tests and inspections)

2. ISSUE CLARIFICATION AND OBSERVATIONS

SCK CEN has established an integrated management system (IMS) for the organization, called "Bluebook". This management system covers processes and procedures for the BR2. This integration ensured the consistency of BR2 processes with those for the organization, while preserving the specific requirements for BR2.

There are established processes (and sub-processes) for all activities in the reactor operation phase, including for organizational structure, training of personnel, operating procedures, maintenance, testing and inspections, radiation protection, waste management, utilization, emergency planning and decommissioning. Processes for reactor modifications and implementation of new experiments are also included. These non-routine works are new activities for which a work order is generated following a more complex approval process, accounting for the new risks that may be introduced for the facility and workers. All these processes are further supported by work instructions (procedures). Nuclear and radiation safety are integrated in these processes and the supporting procedures.

A process for identification, classification and treatment of non-conformities is established and effectively used. The process gives priority to those non-conformances with safety significance. The non-conformances are registered in the IMPACT and ProReAct platforms. Analysis on non-conformities (including trending) are performed every year by the "IMS Steering Committee", which provides recommendations for implementation by the IMS team at SCK CEN.

Process owners are identified, who are responsible for implementation of the process and its continued improvement.

Particular attention is given to the management of human resources. The information is preserved in the form of documents which were previously managed in an ACCESS database but are now completely migrated to the new platform ("ALEXANDRIA". The documents stored in this platform include manuals, operation and maintenance procedures, non-routine works, instructions, forms, reports, and minutes of meetings.

Internal audits of the IMS processes (including those related to BR2 operation) are performed by a team of fifteen SCK CEN employees with a frequency defined according to the process risk. The topics that are covered by internal audits are reviewed every three years. The IMS is certified ISO 9001 by Vincotte and a gap analysis for certifying to ISO 19443 is being undertaken. Certification to ISO 19443 is planned to be completed within 2024.

The team review of the IMS showed that the system has been developed and is being implemented in line with the IAEA safety standards, and that effective implementation of this system supports establishment of a strong culture for safety.

The quality checks and verification of implementation of operation and maintenance procedures are performed at the BR2 operational level. The activities performed during the mission showed the need to implement measures to ensure adequate quality checks and verifications of the completed operation and maintenance tasks. This would provide for ensuring effective use of these procedures, particularly those that are of safety significance. (See Issue Page MPTI 01 on maintenance, periodic testing and inspection for further discussions on inadequate quality checks and verifications of completed tasks).

3. POSSIBLE SAFETY CONSEQUENCES

Inadequate quality checks and verification of completed tasks negatively impact the effectiveness of operation and maintenance procedures and its quality. This has a potential of not ensuring that SSCs are inspected after maintenance before being declared functional and reinstated for normal operation, which could jeopardize operational safety.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendation.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R4) To enhance the effectiveness of the operation and maintenance activities, measures should be established to ensure adequate quality checks and verifications of completed tasks.

ISSUE TRQ 01: Training and qualification programme for BR2 operating personnel

1. BASIS AND REFERENCES

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSG-84: The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors, 2022
- SCK CEN/3487697 SOP - Training of staff - 2022-11-07
- SQ/B/044 Opleidingsdossier BR2 (Training file BR2) - 17/08/2022
- SR/O/001 Opleiding BR2-operatoren (Qualification Matrix for the BR2 operators) 2011-02-10
- SR/O/004 Opleiding personeelsleden expertisegroep BR2 met uitzondering van ROP (Training of staff members of BR2 Expertise Group BR2, except for Reactor Operators)

2. ISSUE CLARIFICATION AND OBSERVATIONS

A training and qualification programme is established for the BR2 operating personnel. The programme has been integrated with a recently established system on training accounting for the skills required within the for SCK CEN, which covers different roles within the organization as well as the staff competence development. This system is managed by the Learning and Development Department using a web-based platform called CONNECT, which was made available to the BR2 operating personnel in 2022. The original training and qualification programme for the BR2 operating personnel was managed by an MS ACCESS database and is still available while the staff is getting familiar with the CONNECT system.

When a new candidate is selected for filling a role within the SCK CEN, based on their previous qualification, the candidate is enrolled in the CONNECT system for two types of initial training: onboarding and role specific. The onboarding training has a duration of six months and uses the same syllabus for the whole SCK CEN staff, with additional training module on radiation protection for those who are developing activities in the controlled areas.

The training methods are a combination of classroom lectures, self-study, and on-the-job training. The training syllabus is specific to various roles within the reactor organizational structure, including operators of the reactor machine control room (at least one year duration), reactor control room operators (at least two years duration), shift supervisors, operation leaders, and reactor manager. The programme also covers maintenance personnel, and personnel handle production and experimental facilities. The training syllabus includes theoretical topics (such as reactor physics, reactor engineering, regulatory basis, nuclear safety, and radiation protection), and reactor specific training which includes reactor design, safety analysis, OLCs, operating procedures and maintenance programme. The reactor documents ae used as part of the training materials. Textbook information and dedicated PowerPoint slides are also prepared for some subjects. The trainers include senior and experienced staff from BR2 and SCK CEN.

A qualification process is established and personnel who function have bearing on safety (e.g. operators, operation leaders, deputy shift supervisor, shift supervisors) are required to pass an exam as part of the authorization process. The examination panel includes the reactor manager, the SCK CEN IDBPW unit and Bel V (the technical support organization for FANC).

A retraining programme is also established for the BR2 operating personnel. CONNECT system enables the operating personnel to participate in the retraining sessions (virtual, face to face and hands-on) that are required for the renewal of their authorization. A “training week” is organized three times per year providing for flexibility and avoiding impact on the reactor operation schedule. The topics that are included in these “training weeks” are defined considering the particular needs (e.g. recent modifications, new procedures, operating experience feedback and selected theoretical subjects). Some topics include an assessment test.

As the training programme for the BR2 staff has been recently transferred to the CONNECT, the suitability of the system was evaluated by verification and validation of the system through enrolling a group of the already authorized operators as newcomers.

The documentation management system (ALEXANDRIA) is being linked with the CONNECT system, for ensuring that the latest revision of the reactor safety and operation documents are always available for training.

3. POSSIBLE SAFETY CONSEQUENCES

The training and qualification programme for the BR2 operating personnel (including syllabus, schedule, training material, and assessment) is developed and implemented in line with the IAEA safety standards.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

No recommendations or suggestions are provided by the IAEA team in this area.

ISSUE SA 01: Need to ensure the completeness and clarity of the safety analysis

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards Series No. SSG 20 (Rev.1): Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, 2022
- SCK CEN Periodic Safety Review 2016, BR2-VF5-1.3.4
- SCK CEN Periodic Safety Review 2016, BR2-VF5-1.1
- SCK CEN Stress Test, 2012
- SCK CEN Safety Analyses Report of the BR2, 2021
- SCK CEN Presentation, "BR2 LEU Conversion Safety Analyses"
- SCK CEN Presentation, "INSARR – BR2 Safety Analyses"

2. ISSUE CLARIFICATION AND OBSERVATIONS

In the frame of the PSR performed in 2016, SCK CEN re-evaluated some of the design bases accidents using modern simulations to confirm the results of the original testing that was performed on the BR2 in 1963. The simulation results were comparable to the original test measurements. During the INSARR mission, SCK CEN presented preliminary information to support the safety analysis for the future conversion from the use of HEU to LEU fuel. SCK CEN is preparing for the next PSR (to be completed in 2026) and plans to include information on the conversion from the use of HEU to LEU, update the evaluation of radiological consequences, and review the relevant postulated initiating events (PIEs) that are established by the IAEA safety standards No. SSR-3.

Following the accident at the Fukushima Daiichi nuclear power plant, SCK CEN performed an analysis ("stress test") of the BR2 response to both internal and extreme external PIEs. This covered earthquakes, flooding, other external events (e.g. extreme weather, fire, and airplane crash), loss of the offsite power supply, and loss of the ultimate heat sink.

The IAEA team reviewed the information on the safety analysis that are currently scattered in several facility's documents to ensure that the safety of the BR2 was adequately analysed and evaluated to demonstrate safety. The SAR identifies two events that bounds all credible events. The bounding events are identified as a reactivity excursion in the BR2 core and a criticality accident in the spent fuel storage pool. The SAR references a separate document describing the radiological consequences of these events. Analysis of some other events (such as dropping of heavy loads) is available in another document. Analysis of some PIEs is available in the stress-test documents while others are in the PSR 2016 documents, posing unclarity and challenges to evaluate the completeness of the safety analysis.

3. POSSIBLE SAFETY CONSEQUENCES

Inadequate clarity of the information of safety analysis, including its complete and comprehensive nature, can negatively affect demonstration of fulfilling the basic safety functions and the validity of the OLCs.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendation.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R5) In the frame of the ongoing PSR, the information on safety analysis that is currently scattered in several documents should be consolidated, reviewed for completeness, and revised as needed in accordance with the IAEA safety standards No. SSR-3 and SSG-20 (Rev. 1) to ensure that the analysis adequately cover the identification and selection of all relevant postulated initiating events, evaluation of the event sequence and consequences, and comparison against pre-established acceptance criteria.

ISSUE SAR 01: Need to revise the SAR to ensure fulfilment of its purpose

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards Series No. SSG 20 (Rev.1): Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, 2022
- SCK CEN Periodic Safety Review 2016, BR2-VF5-1.3.4
- SCK CEN Periodic Safety Review 2016, BR2-VF5-1.1
- SCK CEN Stress Test, 2012
- SCK CEN Safety Analyses Report of the BR2, 2021

2. ISSUE CLARIFICATION AND OBSERVATIONS

The SAR of BR2 was used as a source of information for review of all areas during this INSARR mission. The latest version of the SAR was issued in 2021.

The review of this mission showed that significant amount of information that is important to safety is not included in the SAR, inconsistently with its nature as the main document for the licensing process of the facility, and for demonstration safety of site, design, operation, modification, utilization and eventual decommissioning of the facility.

In comparison with the IAEA safety standards No. SSG-20 (Rev.1), examples of the topics that are not covered (or not referred to) in the SAR, include reactor site characteristics, design safety requirements, engineered safety features, environmental impact assessment, experimental facilities, electrical systems, auxiliary systems, instrumentation and control, and decommissioning. The information on other several topics is not adequate for evaluation of relevant areas. Information on these topics could be found in other facilities' documents, but references to this information or description of its summary is missing from the SAR, posing significant challenges to evaluate the completeness and the adequacy of the document to demonstrate safety.

The IAEA team discussed the above-mentioned facts with the BR2 technical staff and operating personnel, who were aware of the issue, including the possibility of use of the ongoing PSR to consolidate this information that are scattered in several facility's documents, and complete them in accordance with the IAEA safety standards.

3. POSSIBLE SAFETY CONSEQUENCES

Incomplete information in the SAR hinders its purpose as the basis for the interaction between the operating organization and the regulatory body in the licensing process and as the main document that provides the basis for the safe operation, modification, and utilization of the reactor and demonstrates the adequacy of safety analysis. This will also affect the effectiveness of the training programme of the reactor operating personnel.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendation.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R6) In the frame of the ongoing PSR, the contents of the SAR should be revised to include the missing information on the topics that are recommended by the IAEA safety standards No. SSG-20 (Rev.1), including reactor site, design safety requirements, engineered safety features, experimental facilities, environmental impact assessment, and decommissioning. It is also suggested to consider revising the format of the SAR to that established by the SSG-20 (Rev.1).

ISSUE OLC 01: Need to improve the OLCs

1. BASIS AND REFERENCES

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Guide No. SSG-83: Operational Limits and Conditions and Operating Procedures for Research Reactors, 2022
- SCK CEN/22532263 - SOP - Management of Nuclear OLCs - 2021-02-16
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-01 - Spécifications techniques nucléaires et thermo-hydrauliques –
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-02 - Controle van de radioactiviteit-
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-02 – Disponibilités
- Presentation: BR2 OLCs (for INSARR) - Frank Wols, Geert Van den Branden, Steven Verlinden -17/02/2023

2. ISSUE CLARIFICATION AND OBSERVATIONS

The OLCs for the BR2 (also referred to in BR2 documents as "technical specifications") are developed in accordance with procedures SCK CEN/22532263. The OLCs are described in Chapter 3 of the SAR. The review of the IAEA team showed that the OLCs are not developed in accordance with the IAEA safety standards. Several deficiencies were identified as follows:

- The current set of OLCs do not ensure that they envelop the safety parameter values and SSCs conditions, within which the reactor has been demonstrated to be safe (e.g. no limits are established on maximum fuel burnup);
- Experiments are not part of the OLCs (despite some limiting conditions can be found in other facility's documents);
- There are no established OLCs for some operational states of the reactor, including shutdown and "manipulation conditions" (refuelling);
- Surveillance requirements are not part of the OLCs (although periodic tests for several SSCs are currently scattered in various documents);
- The description of the OLCs lacks clarity on their objectives, applicability, specification statements or values, and bases of their selection (justification). Additionally, some OLCs are described in English, and some others in Dutch or in French, negatively impacting their clarity.
- Proposed changes of OLCs are not subjected to a review by the reactor safety committee before their establishment (see the Issue Page SC 01 – Reactor Safety Committee).

The IAEA team also noted the lack of an emergency shutdown capability from operation location(s) outside of the control rooms and that there is no reactor automatic protective action in seismic events. (See also Issue Page COP 01 for further discussions on this item).

During the mission, the BR2 technical staff and operating personnel were aware of some of these deficiencies. At the time of the mission, BR2 has initiated an action to define the reactor operational states. OLCs for shutdown and manipulation conditions are planned to be established accordingly.

3. POSSIBLE SAFETY CONSEQUENCES

Lack of OLCs for some operational states of the reactor and for experiments, lack of a consolidated set of surveillance requirements for all SSCs that are subjected to safety system settings and limiting conditions for safe operation, and ambiguity of description of these OLCs do not ensure that these OLCs are enveloping the reactor safety parameter values and the SSCs conditions within which the reactor has been demonstrated to be safe, which negatively impact safety.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendation.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R7) The OLCs should be:

- Reviewed to ensure that they are enveloping the safety parameter values and SSCs conditions within which the reactor has been demonstrated to be safe;
- Amended to cover all operational states of the reactor, including shutdown and "manipulation conditions" (refuelling), as well as experiments;
- Reviewed with respect to the periodic tests, that are currently scattered in several documents, to ensure the establishment of surveillance requirements for all SSCs that are subjected to safety system settings and limiting conditions for safe operation;
- Described in a single document (or a chapter of the SAR) in accordance with the IAEA safety standards No. SSR-3, including description of the specifications' objectives, applicability, statements (i.e. limiting values or conditions), and bases (justification) of their selection.

ISSUE COP 01: Considerations for strengthening reactor emergency shutdown capabilities

1. BASIS AND REFERENCES

- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards Series No. SSG-83: Operational Limits and Conditions and Operating Procedures for Research Reactors, 2022
- ST/W/100: Emergency Diagnostic Procedure
- SR/W/105: Mobilization of the Emergency Services Organization

2. ISSUE CLARIFICATION AND OBSERVATION

The reactor operation is managed by the BR2 Operation Expert Group. The reactor operation shifts are well managed; responsibilities of the personnel within the shift are clear; and there is an OLC on minimum staffing during an operational shift. Further information on staffing arrangements and duties and responsibilities can be found on Issue Page RMG 01 on operating organization and reactor management.

The BR2 has two control rooms. The reactor operation and monitoring of nuclear parameters are performed from the first control room, which is located within the containment building of the reactor. The second control room ("machine control room") is located outside the containment building and equipped with the process instrumentation. Every control room is equipped with a manual scram pushbutton. The IAEA team discussed the possibility of installation of an emergency shutdown capability (e.g. a manual scram pushbutton) at location(s) outside of the control rooms (e.g. at the reactor operational areas such as reactor pool-top). The team also highlighted that installation of such an emergency shutdown capability is to be managed as a project of a modification important to safety, which has to be justified and be subjected to requirements for review and assessment, quality, and procedures for design, installation, testing, and operation.

The team also noted that there is no seismic instrumentation within the reactor building and there is no reactor protective action established in case of earthquakes.

Operating procedures are established for the BR2. These procedures cover reactor core configuration management, thermal balance, and reactor start-up, power operation, and shutting down. These procedures also cover operational and maintenance activities that are important to safety. The reactor operating personnel are trained on the use of procedures, as part of their initial training programme as well as retraining. Up to date procedures are available in the reactor control room. Procedures for operator's response to the anticipated operational occurrences and incident conditions are also available, including events such as loss of electrical power supply, primary pipe break and loss of coolant, and fire. The discussions with the operating personnel showed their familiarity with the operating procedures. The IAEA team also noted the adequacy of the procedures and the practices of recording reactor operational data in the control room logs.

The IAEA team also noted that the core configuration management procedures are effectively performed. Procedures are also available for verification of core safety parameters after core configuration change, including approach to criticality, calibration of control rods, and evaluation of the reactivity shutdown margins and excess reactivity. The team discussed with BR2 staff the procedures of approach to criticality by mass, which at present involve insertion of positive reactivity while the control rods are partially withdrawn from the reactor core. The team suggested the consideration of establishment of a requirement on full insertion of the reactor control rods as an initial condition for "core loading", including loading or shuffling fuel elements. This will ensure the highest possible reactivity shutdown margin while inserting significant amount of reactivity (e.g. by loading new, or shuffling, fuel elements) and eliminates the risk of failure of insertion of the control rods in case they are needed.

The procedures for safety performance indicators are effectively used in continuous enhancement of the operational safety performance of the reactor. The IAEA team also reviewed some of the operational records, including the measurement of the control rod drop time, which confirm operation within the OLCs.

During the reactor walkthrough, the IAEA team observed very good housekeeping, including cleaning, minimal fire load, appropriate storage of tools and materials, and adequate tagging of systems and components. The team noted the adequacy of water leakage detection from various areas within the reactor building including the beam tubes and sub-pile room. The team also noted adherence of the reactor operating personnel to the radiation protection rules. The team also observed handling of irradiated Mo-99 targets as well as loading of fresh ones in accordance with the established procedures demonstrating effective coordination amongst involved personnel as well as communication with control rooms.

A fire hazard assessment is performed and updated regularly. The fire detection and extinguishing system is upgraded accordingly. The functionality of the system is checked annually. The IAEA team also noted, during the walkthrough, that sufficient measures are established to ensure fire safety.

The IAEA team also noted the continuation of the good practice followed by SCK CEN on voluntary reporting to the meetings Convention on Nuclear Safety on the BR2 safety.

3. POSSIBLE SAFETY CONSEQUENCES

Lack of an emergency shutdown capability (e.g. a manual scram pushbutton) from operational area(s) such as the reactor pool-top as well as lack of seismic detectors may jeopardize safety of personnel and of the reactor.

Keeping the control rods partially extracted from the reactor core while inserting a significant amount of reactivity during refuelling process does not provide for availability of a maximum possible reactivity shutdown margin and increases the risk of failure of control rod insertion in case that they are needed, which could affect safety.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the IAEA team observations, recommendation, and suggestion.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R8) Consideration should be given for the installation of a manual shutdown capability (e.g. scram pushbutton) from operational location(s) other than control rooms (e.g. reactor pol-top), and seismic detectors with a reactor emergency shutdown capability.

S2) It is suggested to review the operating procedures on core configuration change to consider the establishment of a requirement on full insertion of the reactor control rods as an initial condition for “core loading”, including loading or shuffling fuel elements.

ISSUE MPT 01: Maintenance, periodic testing and inspection programme of BR2

1. BASIS AND REFERENCES

- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards Series No. SSG-81: Maintenance, Periodic Testing and Inspection of Research Reactors, 2022
- Work Order Reports: ST/V110-C114a (Primary Flow), ST/V110-C111 (Delta P over vessel), and ST/V110-C107b (Inlet Pressure to vessel).

2. ISSUE CLARIFICATION AND OBSERVATION

A maintenance process is established for the BR2 reactor, and the maintenance programme and procedures are developed, generally, in line with the IAEA safety standards. The programme includes preventive maintenance for all SSCs that are important to safety. The type and frequency of maintenance activities are established in accordance with the design requirements and the recommendations of the SSC's manufacturers. The asset management programme also provides input to the preventive maintenance.

The maintenance, periodic testing and inspection activities are performed by personnel of two Expert Groups of the NMS institute (see the Issue Page RMG 01 on operating organization and reactor management).

The planned maintenance, periodic testing and inspection activities are registered in a database (CON 30), which also contains the frequency of maintenance and periodic testing of individual SSCs. Bel V has a remote access to this database. The majority of these activities are performed during the scheduled reactor shutdown. A work process and procedures are in place for urgent corrective maintenance tasks. An on-call system of qualified staff are available for performing these urgent, and for the relevant discussion during the following 10 O'clock meeting. The routine maintenance, and inspection activities (for a specific reactor shutdown) are scheduled using a Microsoft scheduler plan in a dedicated shutdown meeting (with participation of all relevant groups and individuals). This meeting is held two weeks and, again, three days before the reactor shutdown.

There are written procedures for all maintenance, periodic testing and inspection activities. These procedures are reviewed and updated, every three years, when SSCs are replaced or modified, based on feedback from maintenance personnel performing the work, or based on the outcome of the risk assessment of the asset management programme.

A work permit system is established, and is in line with the IAEA safety standards, and the relevant form includes information on procedures to be used, reference to relevant drawings and supporting documents, equipment be used, precautions to be considered and radiological protection aspects, and required approvals and notifications. The work permits are discussed in the daily "10 O'clock meeting", where work permits are approved, and maintenance work orders are issued.

The IAEA team reviewed samples of the records of completed maintenance tasks, including the ST/V110-C114a (primary coolant flow), ST/V110-C111 (Pressure difference over the reactor vessel), and ST/V110-C107b (inlet pressure to vessel)- which are important to safety. The IAEA team found that there was a lack of evidence of performing quality checks and verifications of the completed tasks, which negatively impacts the quality of the procedures and their effectiveness. (See Issue Page IMS 01 on quality checks and verifications of completed operation and maintenance tasks).

The IAEA team also found that there was no traceability of the calibration equipment used for maintenance and testing of some SSCs important to safety such as those mentioned above.

A systematic ageing management programme have been initiated in 2011 and was subjected to an IAEA peer review mission in 2018. The INSARR team noted that the recommendations of the 2018 peer review remain valid, including with respect to the need for considering all relevant ageing degradation mechanisms, establishing procedures for managing spar parts of SSCs important to safety, and establishing a process for obsolescence management.

3. POSSIBLE SAFETY CONSEQUENCES

Inadequate quality checks and verification of completed tasks negatively impact the effectiveness of operation and maintenance procedures and its quality and could jeopardize operational safety.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the IAEA team observations.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

The maintenance programme of BR2 is developed and implemented in line with the IAEA safety standards. No recommendations or suggestions are provided in this area. See Issue Page IMS 01, on quality checks and verifications of completed operation and maintenance tasks, which is also applicable to maintenance, periodic testing and inspection.

ISSUE EXP 01: Safety of utilization and experiments in BR2

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards Series No. SSG-24 (Rev.1): Safety in the Utilization and Modification of Research Reactors, 2022
- 354-INS-01 Safety-evaluation experiments BR2 (CEE)
- 354-SUP-02 CEE – Dossier requirements
- 354-SUP-16 Legal Framework, Scope and organizational aspects for the CEE
- 124-SOP-01 Modification nuclear facilities Class I
- SCK CEN Presentation: INSARR –Neutron irradiation experiments at BR2, Philippe GOUAT & Miquel Torres -2023-02-17
- SCK CEN Presentation: BR2 LEU Conversion Safety Analyses, G. Van der Branden (Frank Wols and Jared Wight), 2023-03-02
- SCK CEN Presentation: Production and Material Handling, K. Sebrechts, 2023-03-02

2. ISSUE CLARIFICATION AND OBSERVATIONS

SCK CEN has a detailed procedure in place for evaluating neutron irradiation experiments in BR2. It is documented in the Integrated Management System of SCK CEN: 354-INS-01, Safety Evaluation of Experiments - BR2 (CEE).

The purpose of the procedure is to verify that each new neutron irradiation experiment is reviewed for its safety significance. These procedures define an experiment as “a trial or test that is: within the limits of the licence; does not influence OLCs; can be operated without a modification to the characteristics of the installation; and is temporary and can be removed easily”. An experiment can be proposed as a repetition of a previously evaluated project or as new proposal.

Each proposed irradiation experiment is evaluated by the Committee for the Evaluation of Experiments (CEE). This advisory committee is independent of the BR2 organization and provides recommendations to the SCK CEN Director General through the Internal Service for Prevention at Work (IDBPW). The terms of reference (ToR) of the CEE are established by document 354-SUP-16, Legal Framework, Scope and Organizational Aspects for the CEE, which describes the committee’ s scope, composition, competence and membership, as well as those personnel that should attend the committee meetings as observers.

If the experiment is new, the CEE evaluation is performed in four phases with a detailed review in each:

1. Preliminary design;
2. Detailed design;
3. “Assembly & commissioning” (manufacturing, installation and commissioning);
4. “Return of experience” (Evaluation of experience feedback).

If the safety and operational aspects of the proposed experiment are enveloped by those of an existing experimental facility, Phases 1 and 2 are skipped and Phases 3 and 4 executed. If not, the experiment is considered as a new one.

The content of the safety analyses and required documents for a new experiment is established by document 354-SUP-02 CEE – Dossier Requirements. This includes: a check on conformity with BR2 technical specifications, reactivity assessment, heat flux and removal, decommissioning and processing of radioactive materials, “ALARA report”, update of documents, commissioning, operating manuals, handling, alarm handling, inspection and operating limiting and conditions. All information is combined in an experiment specific Descriptive Report or a Safety Assessment Report, which is not included in the reactor SAR.

The route of approval of an experiment modification depends on its stage of implementation. If the experiment is in the engineering phase, the proposal is reviewed by the CEE. If a repetitive experiment has already been already approved by the CEE and it constitutes a part of the BR2, proposed modification is managed in accordance with procedures 124-SOP-01, Modification of Nuclear Facilities Class I. In this case, the safety review is performed by the Comité Wijziging Installatie (CWI) (see also Issue Page MOD 01).

The IAEA team reviewed the minutes of CEE meetings from 4th quarter of 2022 and found them to be complete and in accordance with the ToR. The team also discussed with the BR2 staff the CEE report on the COBRA LEU LTAs CEE phase II and noted that the irradiation was designed to qualification conditions for BR2, with a max surface heat flux of 470W/cm2 and peak fuel burnup of ~ 60%.

The IAEA team also clarified that careful consideration should be given to safety categorization of new experiments due to the fact that “experiments” presently is not part of the OLCs and that new experiments could entail hazards that were not previously assessed.

The IAEA team was informed that some irradiation experiments are connected to the reactor protection system of the reactor as their operation may require protection actions (scram). These experiments are considered as a “non-standard operation” according to form SO/040, which is reviewed and approved by Nuclear Safety BR2 (NS2) and the BR2 Reactor Manager. The form includes a risk analysis and a stepwise plan for implementation. The IAEA team reviewed these forms for experiment PWC-CD (Forms 20220361 and 20220334) and found them to be complete.

The BR2 is also extensively utilized for isotope production and silicon doping. The reactor includes seven rigs for irradiation of HEU and LEU Mo-99 targets, nine rigs for irradiation of industrial isotopes in sealed capsules at reactor pool pressure, and one rig for irradiation of materials under primary coolant pressure. Irradiations for production purposes are managed by the Production and Material Handling unit and proposals for new irradiation are managed by the commercial production manager. The Sidonie (in core) and Poseidon (pool side) facilities are used for irradiation of silicon ingots. The IAEA team discussed with the counterparts the observation that the highest individual and collective dose values are associated with silicon doping work. The team highlighted the need for further optimization of safety and protection for this operation (see Issue Page OPR 01 on operational radiological protection programme).

3. POSSIBLE SAFETY CONSEQUENCES

(See Issue Page OLC 01 for possible consequences if “experiments” is not part of the OLCs.)

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

The measures established by the BR2 for the safety of experiments are generally in line with the IAEA safety standards, and there are no recommendations in this review area.

ISSUE MOD 01: Safety of modifications of BR2

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards Series No. SSG-24 (Rev.1): Safety in the Utilization and Modification of Research Reactors, 2022
- SCK CEN Document: 124-SOP-01 Modification nuclear facilities Class I
- SCK CEN Document: BR2-SUP-SQ/O/132
- SCK CEN Document: BR2-SUP-SQ/O/101
- SCK CEN List of modifications since 2016
- SCK CEN Presentation INSARR BR2 Major Modifications, Brigitte Gomand, 02/03/2023

2. ISSUE CLARIFICATION AND OBSERVATIONS

SCK CEN has established procedures for modifications of BR2 (SCK CEN 124-SOP-01 Modification Nuclear Facilities Class I). The procedures apply to all temporary or permanent modifications that have a potential impact on safety. The procedures describe the steps for evaluation and approval of a proposed modification, including submission of information to SCK CEN safety committees. The procedures also describe the process of submission of proposed projects to FANC and its technical support organization (Bel V) in accordance with national regulations.

BR2 modifications are reviewed by the Committee on Change of Installations (CWI). In cases where the collective dose may exceed 5 man.mSv, the "ALARA committee" is also involved in the review. The CWI reports to the BR2 reactor manager, Head of Nuclear Safety (NS2) and Bel V. The safety analysis of a proposed modification project is reviewed by BR2 management, operations, maintenance, reactor physics and safety experts.

The categorization of modifications and their routes of approval are defined by FANC: "small modification" (no potential impact on radiation protection or nuclear safety), "non-important modification" (potential impact on radiation protection or nuclear safety but not subjected to a request for licence), and "important modification" (modification that constitutes a deviation from the operation license conditions). The operation license conditions require that no modification that has a negative impact on safety is allowed.

The categorization of the modification is discussed at the CWI meeting. The categorization is approved by Nuclear Safety BR2 (NS2), the Reactor Manger, and Bel V. The CWI committee meetings are held monthly and cover the following topics: Classification of SSCs, risk analysis, test and commissioning (including operator training), and documentation (e.g. SAR update, as-build drawings, procedures, training, technical specifications). The modifications are recorded in two databases; one for modification requests (SF/O/08) and one for notifications that modification has been completed (SF/O/013).

A sample modification project on the implementation of an "electronic scram" was reviewed during the mission. The review covered all steps from the initial request (SF/O/08-1019) through to the notification of completion (SF/O/013-1554). Although the team review showed that the implementation of the project was performed in accordance with the established procedures, it was noted that this modification was classified as a "non-important modification" while it should have been subjected to an independent review before its implementation as it involves an SSC that is important to safety. This reinforces the INSARR mission recommendation on the functioning of the reactor safety committee (see Issue Page SC 01 on reactor safety committee).

The modification procedure also includes a section for modifications that are defined as "urgent". This applies to modifications that are categorized as "small" and are managed through non-conformance reports (NCRs), which need to be approved by the NS2 "site-inspector". The "urgent" modifications are coordinated by the "plant responsible" person, who is responsible for ensuring that the categorization and supporting analyses are documented and completed as soon as possible after completion of the modification. The purpose of this "urgent" modification procedure is to facilitate, in the event of a non-safe situation, urgent actions to quickly restore the equipment or system to a safe state. The counterparts mentioned that there was no situation that required the implementation of this procedure during the past six years. The IAEA team observed unclarity of the situations or conditions where an "urgent" procedure would be needed, and suggested reconsideration of this category of modification.

The IAEA team also reviewed a modification to replace a pump in the secondary cooling system (SO/040-20180294) and found that it was implemented in accordance with the established procedures, including the assessment of CWI. The replacement pump was selected based on an assessment of the equivalence of flow rate and pressure characteristics. Several years later, during a routine inspection, high temperature was detected at the pump fuse and connecting cables. The subsequent analysis concluded that the replacement pump's motor had a higher electrical power rating than that of the replaced one. The error was attributed to invisible power engineering units at the old pump's label (where the power rating was given in HP but was mistakenly assumed to be kW). The power rating of the replacement pump (kW) was expected to be lower than the old pump, but it was higher resulting in over heating of the fuse and cables. Inspections with a thermal camera, as part of the recently introduced ageing management measures for electrical systems, revealed this fault. The IAEA team stressed the need for careful attention to modifications of SSCs important to safety, particularly when replacing obsolete components of unknown or undefined specifications.

3. POSSIBLE SAFETY CONSEQUENCES

Deficiencies in safety categorization of modifications, including lack of clarity regarding the criteria of modification categories, or inadequate independent review of proposed modifications could jeopardize safety.

Replacement of obsolete components of undefined specifications could entail risk that was not previously assessed and can lead to loss of the intended function of the replacement component.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the mission observations.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

No new recommendation or suggestion is provided in this area. However, the above-mentioned observations could be addressed through the implementation of the recommendation on the functioning of the safety committee (Issue Page SC 01 on Reactor Safety Committee), and the recommendations of the IAEA mission on ageing management and continued safe operation of BR2 (2017) with respect to obsolescence management.

ISSUE ORP 01: Need to improve the operational radiation protection programme of BR2

1. BASIS AND REFERENCES

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSG-85: Radiation protection and Radioactive Waste Management in the Design and Operation of Research Reactors, 2022
- Memorandum SCK CEN/52357808: Radiation Protection program SCK CEN, Fernand Vermeersch, 2022 December 20
- BPR-NRS_Process-Model_Nuclear-and-radiological-safety.pdf
- BR2_RadiationProtection.pdf
- Radiation protection program 2.pdf

2. ISSUE CLARIFICATION AND OBSERVATIONS

The operational radiation protection programme for BR2 is managed by the SCK CEN integrated management system in accordance with the process SCK CEN/21032135 MOD – Nuclear and radiological safety (the latest version issued in 2023).

The SCK CEN organizational structure ensures the independence of the radiation protection function from the BR2 management. The radiation protection personnel (which located in the IDBPW department) has appropriate authorities to carry out their responsibility. Nevertheless, there are evidence of effective communication between the BR2 management and operating personnel with the radiation protection group. The reactor operation shifts include a radiation protection officer. The radiation protection officers are trained on the operational radiation protection programme of BR2.

Dose limits are established by the national regulations and are in accordance with the IAEA safety standards and international practices. There are adequate operational radiation protection procedures, including for decontamination of personnel, areas and objects, and for operation and maintenance tasks that involve radiation exposure. These procedures are effectively used by the facility personnel. The maintenance work permit (order) incorporates radiation protection aspects and are cleared by the radiation protection officers. Proposals of new experiments and modifications of BR2 are reviewed by the radiation protection staff and approval from radiation protection experts is required prior to their implementation.

Personnel doses are monitored and controlled through an electronic personnel dosimetry system and database. These doses are monitored against limits established for tasks, daily and weekly dose and are monitored and trended for work groups, tasks and individuals. Personnel doses for operating personnel are monitored through an appropriate system that is operated by accredited dosimetry services. Records on personnel doses are analysed and feedback is incorporated, including in operating procedures or training of personnel. Records are kept in accordance with the national requirements, and they are in line with the international practices.

A dose constraints value of 10 mSv per year has been adopted and applies to all personnel at the facility and the SCK CEN site. Dose planning and optimization of protection and safety follows an established process, in line with the IAEA safety standards, with pre-determined thresholds for approvals and reference to review by radiation protection officers and the SCK CEN “ALARA committee”. This committee meets nominally 10 times per year and dose records are reviewed. Goals are not formally established for optimization of safety and protection. The IAEA team noted that the established value of 10 mSv/year is not justified and is relatively higher than those that are established by similar research reactors worldwide. The team also clarified that, while there is evidence of appropriate monitoring of personnel exposures against expectations, it is not clear that a dose constraints value of 10 mSv per year fulfils the objective of the radiation protection programme. The need for review, and revise as needed, of this value was discussed with the reactor operating personnel.

The non-conformity system is effectively used to track tasks that were not performed in accordance with work plan or that that have resulted in pre-determined criteria such as personnel contamination, exceedance of task dose limit, etcetera.

A system for workplace radiological classification and zoning is implemented. Controlled areas are identified and delineated. Supervised areas are defined at BR2 as areas where personnel may receive up to one tenth of the annual dose limit and only use of sealed sources and contained radioactive material are permitted in these areas. Hand and foot and whole-body surface contamination monitors are installed at the boundaries of the designated contamination areas ("Red Zones") and at the exit of the controlled area. The validity of calibration of these monitors is not ensured.

A programme for radiation monitoring at workplace is established in accordance with the IAEA safety standards and international practices. Monitoring of workplace is performed at appropriate frequency at various status of reactor operation (i.e. reactor start-up, power operation, handling of material, shutdown), and records are well-documented, and analysed.

An extensive system of workplace within BR2 monitoring for area dose rate and airborne contamination (area fixed radiation monitors) is in place. Some monitors (e.g. at the shielded bunkers) are more aligned with process monitoring than area radiological monitoring. These monitors undergo ageing degradation, and the validity of their calibration is not ensured. Air effluents are monitored by an installed reactor stack monitor.

Continuous improvement of the radiation protection program of the facility is driven through:

- The formal management review of nuclear safety and radiation protection, conducted once per two years.
- Routine scheduled review and reissue of related procedures on a two-year frequency.
- Tracking of incident related corrective actions, inspection actions and improvement opportunities (in the Pro-React system), with annual review of the open actions and root causes.
- PSR of the facility every ten years.

3. POSSIBLE SAFETY CONSEQUENCES

Unjustified values of dose constraints can have negative impacts on the appropriate application of the radiation protection principle of optimization of safety and protection.

Invalid calibration, inappropriate locations of fixed area monitors, and obsolescence of radiation monitors have negative impacts on personnel doses and the effectiveness of the operational radiation protection programme, and can jeopardize operational safety of the reactor.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendation.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R9) The operational radiation protection programme for BR2 should be further improved by:

- Reviewing, justifying, and revise as needed, the established value of dose constraints of 10 mSv/year.
- Improving the operational performance of the radiation monitors at the reactor stack, personnel contamination, and workplace (fixed area), particularly with respect to ageing degradation and the validity of their calibration. The suitability of the locations of the area fixed radiation monitors should also be reviewed and changed, as needed.

ISSUE RWM 01: Operational radioactive waste management programme

1. BASIS AND REFERENCES

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No SSG-85: Radiation Protection and Radioactive Waste Management in Design and Operation of Research Reactors, 2022
- SCK CEN/4701308 - SOP - Evacuation of radioactive waste (2021-12-02)
- Internal note: Summary waste management programme for INSARR 2023

2. ISSUE CLARIFICATION AND OBSERVATIONS

The operational radioactive waste management programme for BR2 is established by the procedure SCK CEN/4701308. This document covers the relevant activities up to the transfer to the radioactive waste processing organization Belgoprocess, which is located nearby the SCK CEN site.

The management of the solid and liquid radioactive waste that are generated by the operation and utilization of the BR2 is performed in a coordinated manner by the BR2 operation team (performs handling of radioactive waste within the BR2), the radiation protection group (performs radioactive waste characterization activities) and the SCK CEN's Management of Radioactive Waste and Liabilities - EHS- (ensures compliance with regulations) following the requirements and guidelines that are established by the Belgian Agency for Radioactive Waste and Enriched Fissile Material (NIRAS).

The IAEA team review during this mission showed that the activities of operational radioactive waste management programme of BR2 are performed in line with the IAEA safety standards. The main outcome of the review is as follows.

- Minimization of generation of radioactive waste: It is one of the criteria for design of experiments and modifications. The staff members of EHS are involved in the review of design and operating procedures of experiments and modifications. They are also involved in the development of the BR2 decommissioning plan. The BR2 operating procedures takes minimization of generation of radioactive waste into consideration. Trends show a significant reduction in the amount and volume of the generated radioactive waste form operation and utilization of BR2, notably during the past ten years.
- Classification of radioactive waste: The classification of radioactive waste is established by NIRAS and is in line with the IAEA safety standards and international practices. This classification ensures compatibility with the capacity of Belgoprocess of waste management.
- Segregation of radioactive waste: Design features and operational practices are established for collection and segregation of radioactive waste.
- Radiochemical characterization of the segregated radioactive waste is performed in accordance with written procedure and are subjected to independent evaluation by specialized laboratories.
- Tracking: The generated radioactive waste is recorded in a database providing detailed information on its characteristics, including the updated location, and providing for trending analysis of the amounts and volume of the generated radioactive waste.

- Conditioning for transportation: Liquid radioactive waste is transferred to Belgoprocess via four pipelines according to their radioactive waste class. Low and medium activity radioactive solid waste are conditioned and packaged in accordance with the requirement of the waste management facility.

The high level radioactive waste is stored in the BR2 reactor (wet storage in the reactor transfer canal), waiting for the availability of the hot cell (currently allocated to radioisotope production) for processing (cutting of non-activated portions, volume reduction, passivation of components, etc). Two radioactive beryllium blocks (that were replaced since the beginning of the reactor operation) are stored in the transfer canal, and processing of them is waiting the approval of the relevant regulatory requirements. The type, volume, and amounts of the high-level radioactive waste are appropriately identified and recorded in the abovementioned database. The stored radioactive waste does not negatively impact the operational safety of the reactor.

The spent fuel is dispatched to the reprocessing facility in La Hague and the resulting radioactive waste is returned to Belgoprocess.

The operational radioactive waste management programme is subjected to internal audits every six months. Meetings are held every three weeks between the EHS and BR2 operation manager for review and update of the status of relevant activities. NIRAS and Belgoprocess also have periodic inspections to the SCK CEN facilities.

In relation with the gaseous releases at the BR2, there is an online monitoring of the releases at the reactor stack and protective measures may be taken in case that limits are exceeded (e.g. isolation of the reactor containment).

3. POSSIBLE SAFETY CONSEQUENCES

The operational radioactive waste management for BR2 is developed and implemented in line with the IAEA safety standards.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendations.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

The operational radioactive waste management for BR2 is developed and implemented in line with the IAEA safety standards, and no recommendation or suggestion is provided by the IAEA team in this area.

ISSUE EP 01: Need for improvement of procedures and training programme for the site emergency plan

1. BASIS AND REFERENCES

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. GSR - Part 7: Preparedness and Response for a Nuclear or Radiological Emergency, 2017
- IAEA Safety Standards Series No. GSG-2: Criteria for Use in Preparedness and Response to a Nuclear or Radiological Emergency, 2011.
- SCK CEN PowerPoint Presentation: "Emergency Planning", provided to INSARR mission, 2023.

2. ISSUE CLARIFICATION AND OBSERVATIONS

The "site emergency plan" for BR2 is managed through the SCK CEN management system. The Emergency Plan is documented in KB 22/05/2019 Emergency Plans and management of a site emergency. The emergency plan for the site is submitted to the Regulator (FANC) and to the TSO (Bel V). It was reported to the IAEA team that the current structure for the site emergency plan has been in place for approximately five years. There is no history of activation of the plan for an actual site emergency. Set of procedures exists for managing emergencies and incidents within the BR2 building (building emergency class).

The BR2 building emergency and the site emergency plan are parts of general emergency plan at the region and at the national level. The BR2 emergency plan covers the anticipated operational occurrences and design basis accidents that are considered in the BR2 safety analysis. Analysis of bounding cases for radiological consequences for BR2 accidents have been assessed and are used as a basis for emergency planning.

There is evidence that an organizational framework for the management of emergencies exists and includes clearly defined responsibilities for emergency preparedness and response. Emergency response procedures are in various stages of preparation. Efforts are still required to complete the development of a full set of these procedures.

Drills and exercises are occurring, including drills with external response organizations. The IAEA team reviewed drill and exercise schedules coving an appropriate range of activities planned for 2023. There is evidence that lessons learned from exercises are identified and used to improve training of personnel and emergency procedures. A site emergency exercise is required by Belgian law every two years, although the initiating event for this exercise is not necessarily associated with BR2. SCK CEN technical staff mentioned that a site evacuation exercise has not been conducted.

A duty roster of on call personnel adequate to implement the emergency plan is maintained. Response times for activation were reported to be one to two hours.

Training for personnel with responsibilities under the site emergency plan is occurring and training material exist. A systematic assessment and documentation of roles and responsibilities under the emergency plan and associated training needs has been initiated but not completed at the time of the mission. The IAEA team discussed the status of the site emergency training programme with SCK CEN technical staff, and identified that such a programme needs to be fully developed.

A team of technical staff meets nominally once per month to plan emergence preparedness activities. The team includes the emergency planning coordinator, and representatives from the health physics, fire, security and medical services.

Continuous improvement of emergency planning is driven through management reviews under the management system, internal audits, with the most recent completed audit in 2022 September, PSR, and lessons learned from emergency drills and exercises.

3. POSSIBLE SAFETY CONSEQUENCES

Inadequate assessment and documenting training needs for personnel with duties in the site emergency plan or incomplete emergency response written procedures for implementation of the site plan could potentially result in gaps in capability to effectively implement the plan.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendation.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

R10) To enhance the management of SCK CEN's site emergency, development of the emergency response procedures and training programme for involved personnel should be finalized in accordance with the IAEA safety standards No. SSR-3 and GSR Part 7.

ISSUE DECOM 01: Decommissioning plan for BR2

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards Series No. SSG-85: Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, 2022
- IAEA Safety Standards Series No. GSR Part 6: Decommissioning of Facilities, 2014
- Presentation BR2 Planning for decommissioning, Decommissioning plan, Patrick Maris - 03/03/2023

2. ISSUE CLARIFICATION AND OBSERVATIONS

SCK CEN has developed initial decommissioning plans for all nuclear facilities, including BR2. The BR2 decommissioning plan covers a description of the reactor facilities, breakdown of work packages, physical and radiological inventory, decommissioning strategy (including outline of the decommissioning phases; decommissioning techniques and radioactive waste management, cost estimation, and mechanism of funding decommissioning work. SCK CEN is responsible for decommissioning of the reactor. Immediate dismantling was established as a decommissioning strategy.

The initial decommissioning plan is updated every five years, and is submitted to FANC and the National Institution for Radioactive Waste and Enriched Fissile Materials (NIRAS) for review and assessment. The latest approved initial decommissioning plan (Revision 4) was issued in 2017. Drafting revision 5 of the plan is ongoing for issuance in 2023.

According to the regulatory requirements, the final decommissioning plan shall be approved at least three years before the final shutdown of the reactor. At present, the dismantling period is scheduled for the period 2037 to 2048, achieving a decommissioning goal (green field) and final release of the site from regulatory control by 2049.

The management of the radioactive waste resulting from decommissioning of nuclear installations in Belgium, including conditioning, transport, storage, and disposal is the responsibility of NIRAS. SCK CEN has gained extensive experience in decommissioning during the past years, mainly through decommissioning of the BR3 reactor. This experience was transferred to the organization for “Dismantling, Decontamination and Waste” (DDW), Which was assigned the responsibility for decommissioning operations of BR2.

Additionally, the established operation practices at BR2 consider ultimate decommissioning, including with respect to reactor drawings and operation records, training of personnel, installation of new experiments, and in the modification and refurbishment work. DDW is consulted in the evaluation of the appropriateness of proposed modifications and experiments to the capabilities of NIRAS as well as the decommissioning cost and the relevant funding mechanism.

3. POSSIBLE SAFETY CONSEQUENCES

Not applicable.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the mission observations.

5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES

The practices of the BR2 on decommissioning planning are in line with the IAEA safety standards, and there is no recommendation in this review area.

ANNEX I: DOCUMENTS FROM THE COUNTERPARTS

Documents provided during the mission

Document	Title	Remarks
354-SUP-02	CEE-Dossier Requirements	
124-SUP-001	20220110-Publicatie- Art.11 en Art 12	Belgisch Staatsblad
-	Explanation of Dutch→ English translation on Classification for modification of installation	
SF/O/08 nr 1019	Aanvraag tot wijziging BR volgnummer 1019	
-	Verslag van CWI 23/2016	Report CWI
SCK CEN/IDPBW/2016/F-0054	Assessment Note 2016/F-0054 (site inspector)	
R-br2-SI-16-004-0-n	Verslag van Systematische Inspectie Opvolging van de uitbating	
SCK CEN/IDPW/2016/F-0197	BR-2 Indienstelling van de nieuwe actie ES bij hoge primaire druk (>15 bar)	
	2023_03_02 09_46 BR2 Emergency Procedures	
	2023_03_02 Example of Non-Standard Work Permit	
	2023_03_02 non standard work procedure	
SO/040 nr 20220334	Niet standaard Operatie Fomulier	
SO/040 nr 20220361	Niet standaard Operatie Fomulier	
SF/B 941, date 20-02-2023, cycle 01 /2023	Waardentabel Valtijden en afvalstromen controlestaven	
SO/040 nr 20230122	Niet standaard operatie Formulier	
	Siemens Onderhoudsverslag Beveiligingsinstallatie 15/07/2022	
SCK CEN/51680263	Calculation of criticality for storing COBRA-LEU in the BR2 storage pool	
BR2-VF5-1.1	Periodieke Veiligheidsrevaluatie 2016	
BR2-VF5-1.3.4 Ed.1	Periodieke veiligheidsrevaluatie 2016	
	CEE615 20 September 2022 Meeting Report	
	CEE616 15 November 2022 Meeting Report	
	CEE617 6 December 2022 Meeting Report	
	CEE618 14 February 2023 Meeting Report	
	20221219_Incident_report_NCR_20220676	
	202303030844 - contamination map red zone CB6 + canal zone	
	202303030846-1 - excerpt log book RPO	
	NCR20220677 - contamination staff PWC	

Advance Information Package (Electronic Version)

PowerPoint Presentations:

- BR2 experiments 2023 03 02 AM - Presentation MTorres-PGouat.pdf
- BR2 LEU Conversion Safety Analyses Status for INSARR - Presentation - GVdBranden (FWols).pdf
- BR2_OLCs_for_INSARR - presentation FWols-GVdBranden-SVerlinden.pdf
- Conduct of Operations - sup doc presentation - HOoms.pdf
- DDW_potentials_presentation - JDadoumont.pdf
- Decommssioning sup doc presentation - HOoms.pdf
- Emergency plan 2023 03 03 - presentation BMartens.pdf
- Info training and qualification general - presentation SVDun-AVansant.pdf
- INSARR BR2 General Session - presentation SVerlinden.pdf
- INSARR BR2 Major Modifications - presentation BGomand.pdf
- INSARR explanation training role examples - roles PMH - IVDun-AVansant (training).pdf
- INSARR explanation training role examples - roles reactorpilot - IVDun-AVansant (training).pdf
- Maintenance 2023 03 01 - presentation IN PREP MDausi.pdf
- Planning Decommissioning - presentation - PMaris.pdf
- Plant Asset Management at BR2 - presentation FVEndert.pdf
- PMH Production and Material Handling - presentation KSebrechts.pdf
- Radiation protection measurement system BR2 - presentation JMermans.pdf
- Radiation Protection Programme - presentation JJanssens.pdf
- RadWaste - sup doc presentation - HOoms.pdf
- Safety culture - corporate 2023 03 01 AM - presentation IKnoops.pdf
- Safety culture - Human factors 2023 03 03 - presentation APaesmans-IKnoops.pdf
- Safety culture - ProReAct 2022 03 02 nm - FINAL - presentation IKnoops-BGomand.pdf
- Safety culture - ProReAct 2022 03 02 PM - presentation IN PREP IKnoops-BGomand.pdf
- Safety Culture level Institute BR2 new - presentation BGomand.pdf
- The BR2 reactor - presentation - SVDyck.pdf
- Training and qualification general - presentation FJoppen.pdf

Procedures Nuclear:

- JMermans - Afregeling_meetketens_reactorcontrole_-_hoogspanningswaarden.pdf
- JMermans - Grenswaarden_van_de_lineaire_meetketens_L1-L2-L3 (zie_procedure_st_b_1025).pdf
- JMermans - Kalibratie_van_de_gelijkstroomversterkers_H&B_TKE_130_van_de_veiligheidsmeetketens.pdf
- JMermans - Meetresultaten_op_de_ionisatiekamer_detectors_BR2.pdf
- JMermans - Nazicht_van_de_CS103A.pdf
- JMermans - Nazicht_van_de_nieuwe_L-ketens_L1-L2-L3._(Volgens_procedure_ST_B1025).pdf
- JMermans - Systematisch_nazicht_v_CS_103A_formulier_SF_B_466.pdf
- Test_der_alarmen_en_akties_v_d_lineaire_ketens_Test_des_alarms_et_actions_des_chaines_lin,aires.pdf
- Veranderingen_van_het_fluxniveau_van_de_reactor_bij_de_start._Changement_de_niveau_de_flux_du_react._au_d,marrag

Procedures Non-Nuclear:

- Afregelprocedure meetketen instrumentatie - C111 (DPRCA 4-1301) - Drukverschil over reactor - MDausi.pdf:

Work documents:

- BeMatrix_Inspectie2022.pdf
- BR2_Vessel_Part3_NDT _Inspections.pdf
- ControlRodSleeves.pdf
- dir.txt
- Documentbeheersing BR2 - IMS.pdf
- MOD+-+Maintenance+BR2.pdf
- NCRMS SQ-O-081.pdf
- Opleiding - Opleiding BR2 uitgezonderd ROP.pdf
- Opleiding - Opleiding BR2-operatoren.pdf
- Opleiding-opleidingsmatrix continue 3 jaar ROP.pdf
- Opleidingsdossier BR2 ROM - Reactor Operational Management.pdf
- Periodieke_inspecties SQ-O-065.pdf
- procedures – non-nuclear
- procedures - nuclear
- Report RSC 2018.pdf
- Report RSC 2019.pdf
- SOP - Exploitation BR2.pdf
- SOP - Maintenance BR2.pdf
- SOP - Production.pdf
- Stress test SCK_CEN.pdf
- Table of contents BR2 SAR.pdf
- toolbox items.pdf
- Wijzigingen_aan_de_installaties_BR2 SQ-O-101.pdf

Ageing management programme:

- Ageing management igorr2020_BR2.pdf
- BR2_AIP_AMP ageing management.pdf

Self-assessment:

- BR2 Self Assessment_Summary.pdf

Fuel conversion project:

- CEE_-_COBRA_LEU_LTAs_Phase_II - R2.pdf
- Methodology Report for Reactor Load and Core Physics Management of the BR2 Reactor_Ed.02.pdf
- RELAP5_Safety_Analyses_in_Support_of_the_BR2_COBRA_Lead_Test_Assembly_Irradiation_final_with_LTA_pic.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.2-05.pdf

Operation procedures:

- Planning reactor BR2 in 2021_v8.pdf
- Planning reactor BR2 in 2022_v3.pdf
- ROM procedures in ALEXANDRIA on 2022 12 21.pdf

Maintenance Programme:

- Maintenance executed from 01 01 2021 with execution time of more 2months.pdf

Major Modifications:

- INSARR BR2 Modifications FVE SVLi BGo.pdf

Management Systems:

- SAR-Reactor BR2 Veiligheidsdossier-Vol.2-03 (in dutch).pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.2-03 table of contents - summary.pdf

OLCs:

- 300-SOP-01_EnglishSummary.pdf
- 300-SOP-01_Management-of-nuclear-OLCs.pdf
- BR2_OLC_AlarmAction_Tables.pdf

Preparation PSR 2016:

- BR2_Werkdocument_per_installatie_PVR2026 (in dutch).pdf
- BR2_Werkdocument_per_installatie_PVR2026 table of contents - summary.pdf

Radiation protection programme:

- BPR-NRS_Process-Model_Nuclear-and-radiological-safety.pdf
- BR2_RadiationProtection.pdf
- Radiation protection program 2.pdf

Reactor description:

- Organization chart BR2 202301_Eng.pdf
- SAR - Reactor BR2 Veiligheidsdossier-Vol.0-00.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.1-01.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.1-02.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.1-05.pdf

Reactor Safety Committee:

- 124-SOP-01_EnglishSummary.pdf
- 124-SOP-01_Modification-nuclear-facilities-Class-1.pdf
- 354-INS-01_Safety-evaluation-experiments-BR2-(CEE).pdf
- Comit,_voor_maandelijkse_opvolging_van_de_exploitatie_met_de_Erkende_Instelling_(CEI).pdf
- Reactor_safety_committee_(RSC).pdf
- SOP+-+Modification+nuclear+facilities+Class+I.pdf

Safety Performance Indicators:

- resultaat KPI en SPI 2021.pdf
- resultaat ncr KPI en SPI 2019 2020.pdf
- Voorstel KPI en SPI 2022 v1.pdf

SAR:

- SAR-Reactor BR2 Veiligheidsdossier-Vol.2-04.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-01 techn. specs draft table of contents.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-01 techn. specs draft.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-02 techn. specs radiation protection table of contents.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-02 techn. specs radiation protection.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-03 Availabilities table of contents.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.3-03 Availabilities.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.4-01.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.4-02.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.4-03.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.4-05.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.4-10.pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.4-12.pdf

Summary recent refurbishment:

- Refurbishment programme.pdf
- tblBericht van wijziging sinds 2016.xlsx

Training records:

- SAR-Reactor BR2 Veiligheidsdossier-Vol.2-01 (in dutch).pdf
- SAR-Reactor BR2 Veiligheidsdossier-Vol.2-01 - table of contents - summary.pdf
- SOP+-+Training+of+staff.pdf

Radioactive waste management programme:

- INSARR - summary of waste management.pdf
- SOP+-+Evacuation+of+radioactive+waste.pdf

ANNEX II: AGENDA

MONDAY 27 February 2023 – IAEA Team (at the hotel)	
18:00-18:30	INSARR Methodology: Structure, Reporting, General Guidance on the conduct of the mission (A. Shokr)
18:30-19:30	Preliminary comments on available documents from AIP (10 minutes for each review team member)

TUESDAY 28 February 2023	
09:00-09:30	**Location**: Lake House – Salon 2 **Entry meeting**, Opening address: SCK CEN/BR2, IAEA and FANC **IAEA:** A. Shokr, D. Sears, C. Pike, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN:** P. Baeten, F. Vermeersch , S. Verlinden, J. Janssens, M. Dausi, S. Van Dyck, G. Van den Branden, F. Wols, K. Sebrechts, H. Ooms, F. Joppen **FANC:** S. Coenen, R. Klein Meulekamp
09:30-10:30	**Location:** Lake House – Salon 2 **Presentation by FANC –** R. Klein Meulekamp **General description of the BR2 Reactor and its Safety Status** – S. Van Dyck **IAEA:** A. Shokr, D. Sears, C. Pike, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN:** S. Van Dyck, G. Van den Branden, F. Wols, F. Joppen, S. Verlinden **FANC:** S. Coenen, R. Klein Meulekamp
10:30-10:45	Coffee break

10:45-13:00	**Location**: Lake House – Salon 2 **Operating organization and reactor management** – S. Van Dyck **IAEA:** A. Shokr, D. Sears, C. Pike, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **Safety committee** – S. Verlinden **IAEA:** D. Sears, A. Shokr, C. Pike, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **Training and qualification** – F. Joppen **IAEA:** N. De Lorenzo, A. Shokr, D. Sears, C. Pike, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN/BR2:** S. Van Dyck, G. Van den Branden, F. Wols, F. Joppen, S. Verlinden **FANC:** S. Coenen, R. Klein Meulekamp
13:00-14:00	Lunch break
14:00-16:30	**BR2 Reactor walkdown** **IAEA:** D. Sears, A. Shokr, C. Pike, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN/BR2:** F. Joppen, G. Van den Branden, F. Wols, F. Van Endert
16:30 – 17:00	**Location**: BR2 – Demo meeting room IAEA Team meeting (on-site)
17:15	Transfer to the Hotel

WEDNESDAY 1 March 2023	
09:00-09:30	**Location**: BR2 – Demo meeting room **Briefing the main counterpart**: A. Shokr

09:00-12:30	**Location**: BR2 – Demo meeting room **Maintenance, periodic testing and inspection, including ageing management activities (1)** **IAEA:** K. Du Bruyn, D. Sears, C. Kaaijk, M. Balazik **SCK CEN/BR2:** M. Dausi, F. Van Endert, D. Seghers	**Location:** BR2 – Office 1 **Radiation protection programme** **IAEA:** D. Tucker, N. De Lorenzo, A. Shokr **SCK CEN/BR2:** J. Janssens, F. Wols, B. Thijs	**Location:** BR2 – Office 2 **General overview of the safety culture work at SCK-CEN (1)** **IAEA:** C. Pike **SCK CEN/BR2:** F. Vermeersch, C. Turcanu, I. Knoops
12:30-13:30	Lunch break		
13:30-16:00	**Location**: BR2 – Demo meeting room **Maintenance, periodic testing and inspection, including ageing management activities (2)** **IAEA:** K. Du Bruyn, D. Sears, C. Kaaijk, M. Balazik **SCK CEN/BR2:** M. Dausi, F. Van Endert, D. Seghers	**Location:** BR2 – Office 1 **Radioactive waste management** **IAEA:** D. Tucker, N. De Lorenzo, A. Shokr **SCK-CEN/BR2:** P. Maris, F. Slachmuylders, H. Ooms	**Location:** BR2 – Office 2 **Safety culture (2): Institute level** **IAEA:** C. Pike **SCK CEN/BR2:** F. Vermeersch, I. Knoops
16:00-17:00	**Location**: BR2 – Demo meeting room IAEA Team meeting (on-site)		
17:15	Transfer to the Hotel		
THURSDAY 2 March 2023			
09:00-09:30	**Location**: BR2 – Demo meeting room **Briefing the main counterpart**: A. Shokr		
09:00-10:15	**Location**: BR2 – Demo meeting room	**Location:** BR2 – Office 1	**Location:** BR2 – Office 2

<table>
<tr><td></td><td>Utilization and experiments
IAEA: C. Kaaijk, D. Sears, M. Balazik
SCK CEN/BR2:
M. Torres, K. Sebrechts, Ph. Gouat
(P. Jacquet)</td><td>Conduct of Operations
IAEA: K. Du Bruyn, D. Tucker, N. De Lorenzo, A. Shokr
SCK CEN/BR2:
H. Ooms, D. Meynen</td><td>Safety culture (3) – Training
IAEA: C. Pike

SCK CEN/BR2:
S. Van Dun, J. Janssens, B. Smolders</td></tr>
<tr><td>10:15-10:30</td><td colspan="3">Coffee break</td></tr>
<tr><td>10:30-13:00</td><td>Location: BR2 – Demo meeting room

Major modifications

IAEA: C. Kaaijk, D. Sears, M. Balazik

SCK CEN/BR2:
F. Van Endert, B. Gomand, S. Verlinden</td><td>Location: BR2 – Office 1

Conduct of Operations (cont.)

IAEA: K. Du Bruyn, D. Tucker, N. De Lorenzo, A. Shokr
SCK CEN/BR2:
H. Ooms, D. Meynen</td><td>Location: BR2 – Office 2

Safety culture (3) – Training (cont.)

IAEA: C. Pike

SCK CEN/BR2:
S. Van Dun, J. Janssens, B. Smolders</td></tr>
<tr><td>13:00-14:00</td><td colspan="3">Lunch break</td></tr>
<tr><td></td><td colspan="2">Location: BR2 – Demo meeting room

Safety analysis
IAEA: M. Balazik, A. Shokr, D. Sears, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker
SCK CEN/BR2:
G. Van den Branden, F. Wols, S. Verlinden</td><td>Location: BR2 – Office 2

Safety culture (4)- Corrective Action System
IAEA: C. Pike
SCK CEN/BR2
I. Knoops, B. Gomand</td></tr>
<tr><td>17:15</td><td colspan="3">Transfer to the Hotel</td></tr>
<tr><td>18:00</td><td colspan="3">IAEA Team Meeting: Hotel Conference Room</td></tr>
<tr><td colspan="4" align="center">FRIDAY 3 March 2023</td></tr>
<tr><td>09:00-09:30</td><td colspan="3">Location: BR2 – Demo meeting room

Briefing the main counterpart: A. Shokr</td></tr>
</table>

09:00-12:30	**Location**: BR2 – Demo meeting room **Operational Limits and Conditions (1)** **IAEA:** N. De Lorenzo A. Shokr, D. Sears, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN/BR2** G. Van den Branden, F. Wols, S. Verlinden		**Location:** BR2 – Office 2 **Safety Culture (5): Human factors management** **IAEA:** C. Pike **SCK CEN/BR2** A. Paesmans, I. Knoops
12:30-13:30	Lunch break		
13:30-16:30	**Location:** BR2 – Office 1 **Emergency Planning** **IAEA:** D. Tucker + K. Du Bruyn **SCK CEN/BR2** B. Martens, J. Janssens	**Location**: BR2 – Demo meeting room **Planning for Decommissioning** **IAEA:** C. Kaaijk, N. De Lorenzo **SCK CEN/BR2** J. Dadoumont, H. Ooms, X. Bairiot	**Location:** BR2 – Office 2 **Utilization and experiments (cont'd)** **IAEA:** D. Sears, M. Balazik **SCK CEN/BR2** (B. Ponsard)
16:45	Transfer to the Hotel		
18:00	IAEA Team Meeting: Hotel Conference Room		

SATURDAY 4 March 2023 IAEA Team at the Hotel	
09:30-12:30	Development of issue pages (Team members)
12:30-14:00	Lunch break
14:00-16:00	Discussion on issue pages (Team members)
SUNDAY 5 March 2023	
Free day	

MONDAY 6 March 2023	
09:30-11:00	**Location:** BR2 – Large meeting room **Management system for the operation phase** **IAEA:** N. De Lorenzo, D. Sears, A. Shokr, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN/BR2:** F. Joppen, F. Wols, S. Verlinden, F. Vermeersch, I. Knoops
11:00-12:30	**Location:** BR2 – Large meeting room **Briefing to FANC** **FANC/BEL V:** S. Coenen, R. Klein Meulekamp, N. Noterman **IAEA:** A. Shokr, D. Sears, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN/BR2:** F. Joppen,
12:30-13:30	Lunch break

13:30-15:00	**Location:** BR2 – Large meeting room **General comments on the safety analysis report** **IAEA:** D. Sears, A. Shokr, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN/BR2:** F. Joppen, F. Wols, S. Verlinden, J. Janssens
15:00-17:00	**Location:** BR2 – Large meeting room **Drafting of the mission summary report:** IAEA Team
17:15	Transfer to the Hotel
TUESDAY 7 March 2023	
09:00- 11:00	**Location:** Lake House – Salon 2 **Finalization of the mission summary report:** IAEA Team
11:00- 13:00	**Location:** Lake House – Salon 2 **Exit Meeting: Mission conclusions and main recommendations (All)** **IAEA:** A. Shokr, D. Sears, N. De Lorenzo, K. Du Bruyn, C. Kaaijk, D. Tucker, M. Balazik **SCK CEN/BR2:** P. Baeten, F. Vermeersch, S. Verlinden, J. Janssens, M. Dausi, S. Van Dyck, G. Van den Branden, F. Wols, K. Sebrechts, H. Ooms, F. Joppen **FANC/BEL V:** R. Klein Meulekamp, N. Noterman

ANNEX III: LIST OF PARTICIPANTS

SCK CEN Participants

Mr Peter Baeten,	SCK CEN Director General
Mr Steven Van Dyck	BR2 Reactor Manager
Mr Frank Joppen	BR2 Plant Asset Management
Mr Hans Ooms	Head of Operations BR2
Mr Dirk Meynen	BR2 Operations
Mr Geert Van den Branden	Head of BR2 Reactor Control and Experiment Section
Ms Brigitte Gomand	Technical Secretariat
Mr Karel Sebrechts	Head of Production Management and Material Handling
Ms Bertina Smolders	Secretariat – Coordination BR2 Training Programme
Mr Bernard Ponsard	Isotope production manager BR2
Mr Mik Dausi	Head of Infrastructure Operational Support
Mr Patrice Jacquet	Head of Nuclear Engineering Office
Miquel Torres	BR2 Contact Officer
Mr Philippe Gouat	Project Engineer
Mr Frank Van Endert	Mechanical Systems
Mr Danny Seghers	Electrical and Instrumentation Systems
Mr Fernand Vermeersch	Head of Radiation Protection and Safety Department
Mr Steven Verlinden	Head of Nuclear Safety BR2
Mr Job Janssens	Nuclear Safety BR2
Mr Bart Thijs	Team Leader BR2 Radiation Protection Services
Ms Inge Knoops	Integrated Management Systems
Mr Bededikt Martens	Reactor Safety
Mr Catrinel Turcano	Head of Nuclear Science and Technology Studies Section
Ms An Paesmans	Head of Human Resource Department
Ms Suzy Van Dun	Training Coordinator
Mr Ans Van Sant	Training Coordinator
Mr Xavier Bairiot	Head of Dismantling, Decontamination and Waste
Mr Jerome Dadoumont	Head of Dismantling and Decontamination Section
Mr Patrick Maris	Head of Management of Waste and Liabilities Section
Mr Frederik Slachmuylders	Waste and Liabilities Section (BR2 contact person)

Federal Agency for Nuclear Control and BEL V (Observers)

Mr Robin Klein Meulekamp	FANC
Mr Simon Coenen	FANC
Mr Nicolas Noterman	BEL V

IAEA Team

Mr A. Shokr	RRSS/NSNI – Team Leader
Mr D. Sears	RRSS/NSNI – Deputy Team Leader
Ms C. Pike	OSS/NSNI – Safety Culture Specialist
Mr M. Balazik	US Nuclear Regulatory Commission, USA
Mr K. Du Bruyn	SAFARI-I Reactor, South Africa
Mr N. De Lorenzo	INVAP, Argentina
Mr C. Kaaijk	Delft Research Reactor, the Netherlands
Mr D. Tucker	McMaster Nuclear Reactor, Canada