# SAFETY REVIEW MISSION ON AGEING MANAGEMENT FOR BR2 RESEARCH REACTOR

## REPORT TO

## THE GOVERNMENT OF BELGIUM

**Mission date:** 6-14 November 2017

**Location:** Mol, Belgium

**Installation:** BR2 Research Reactor

**Organized by:** International Atomic Energy Agency (IAEA)
SCK•CEN

*'Findings, conclusions and recommendations resulting from the IAEA Programme are intended only to assist national decision makers who have the sole responsibility for the regulation and the safe operation of their nuclear facilities. Moreover, they do not replace a comprehensive safety assessment which needs to be performed in the framework of the national licensing process.'*



Issue date: 2017-12-21

## EXECUTIVE SUMMARY

At the invitation of Federal Agency for Nuclear Control (FANC), a safety review mission on ageing management for Belgium Research Reactor 2 (BR2) for continued safe operation (further also referred to as 'mission') was conducted at the SCK•CEN Nuclear Research Centre located near Mol in Belgium from 6 to 14 November 2017.

The BR2 research reactor (further also referred to as "BR2") is owned and operated by SCK•CEN, Studiecentrum voor Kernenergie/Centre d'Etude de l'Energie Nucléaire, Stichting van Openbaar Nut – Fondation d'Utilité Publique - Foundation of Public Utility. The reactor achieved its first criticality in 1961 and full power operation started in 1963. There is no time limited operating licence for BR2, however, since the licence renewal of 1986, BR2 has to conduct a Periodic Safety Review (PSR) every 10 years and the last PSR for BR2 was conducted in 2016 and reviewed by Federal Agency for Nuclear Control (FANC), the Belgian nuclear regulator.

The IAEA team consisted of three IAEA staff members and three external experts covering all areas of the mission agreed during a preparatory meeting in July 2016. The mission team reviewed the completed, in-progress and planned BR2 activities related to ageing management of structures, systems and components (SSCs) important to safety and revalidation of time limited ageing analyses (TLAAs) for continued safe operation.

Through the review of documents, presentations and discussions with the technical counterparts and members of the facility staff, the IAEA team concluded that the BR2 facility has made significant progress in the implementation of an effective ageing management programme and in preparation for continued safe operation. The team also noted that the BR2 approach in planning and implementing the ageing management programme and in preparation for continued safe operation generally follows the IAEA safety standards.

The IAEA team noted the professionalism and openness of the BR2 staff and appreciated the commitment of SCK.CEN senior management for safety improvements. The walk-downs of the reactor facilities showed that the SSCs are in good physical conditions. The IAEA team also noted the following good performances:

- Conducting periodic safety reviews (PSR) and use of its results in ageing management;
- Reporting, on voluntary basis, to the meetings of Convention on Nuclear Safety on continued safe operation of BR2;
- Implementing an effective chemistry control of secondary cooling water to minimize ageing degradation of related SSCs.

The team also identified several issues that need to be addressed for further safety improvement. These are as follows:

- Bases for developing and implementing effective ageing management are not fully established;
- Deficiencies exist in scope setting and screening of SSCs for ageing management; and all radioisotope production facilities and experimental devices are not covered by ageing management;
- Lack of maintenance, including monitoring of SSCs important to safety, in storage (spare parts);

- Inadequate assurance that all ageing effects are considered by the approach currently used for ageing management review;
- Feedback from maintenance, inspection and surveillance programmes is not systematically taken into account for ageing management;
- Equipment qualification programme is not established;
- Ageing management of electrical and I&C systems and components important to safety is not adequate;
- A comprehensive ageing management review for civil structures and components has not yet been performed;
- Review and update of the ageing management programme for civil structures and components, including those for radioisotope production has not yet been completed.

A summary of the results was presented to BR2 management during the exit meeting held on 14 November 2017. The BR2 management expressed a determination to address the areas identified for improvement, and indicated the intention to invite a follow-up mission in about two years-time to review the progress in resolving the issues.

**CONTENTS**

# 1. INTRODUCTION

## 1.1. SUMMARY OF THE SAFETY REVIEW MISSION

The peer review approach has proven to be an effective tool for performing the safety review of complex issues, and the evaluation of the safety performance of an entire facility organization. This is confirmed by recurring positive experiences with Safety Aspects of Long Term Operation (SALTO) Reviews for nuclear power plants. The SALTO peer review is a comprehensive operational safety review service addressing strategy and key elements for safe LTO of NPPs.

IAEA Member States give a high priority to continued safe operation of research reactors (e.g. beyond 30 or 40 years) as an alternative to decommissioning. SALTO methodology is adapted for research reactors to review key elements of ageing management that considers life-limiting processes and features for SSCs.

## 1.2.SUMMARY INFORMATION ON THE FACILITY

### 1.2.1. General information

The BR2 research reactor (further also referred to as "BR2") in Mol, Belgium is owned and operated by SCK•CEN, Studiecentrum voor Kernenergie/Centre d'Etude de l'Energie Nucléaire, Stichting van Openbaar Nut – Fondation d'Utilité Publique - Foundation of Public Utility. The reactor achieved its first criticality in 1961 and full power operation started in 1963. The reactor is a material test reactor with a unique design. The reactor uses high enriched uranium (enrichment in U-235) and is cooled by light water. The moderator is a mixture of light water and beryllium. The reactor pressure vessel is located in a pool of water.

BR2 has the following characteristics:

Reactor type: Material Test Reactor
Thermal power: 125 MW
Licence limit power: maximum heat flux on fuel plates - 470 W/cm$^2$
Pressure in the primary circuit: 1.2 MPa
Average water temperature: inlet less than 40 °C, outlet less than 60 °C
Reactor vessel diameter at the core: 1.1 m
Height of the core: 0.76 m; diameter variable, depending on the number of loaded fuel elements
Nominal enrichment of the fuel: about 91 %
Fuel quantity (U mass only) variable (typical 14 kg U-235), metallic fuel plates ($UAl_x$)
Secondary cooling loop open with cooling towers with forced convection.

### 1.2.2. Regulatory framework

BR2 was commissioned to start power operation in 1963 without a predefined life time. There is no time limited operating licence for BR2, however, since the licence renewal of 1986, BR2 has to conduct a Periodic Safety Review (PSR) every 10 years and the next PSR for BR2 is due in June 2026. This PSR must include the framework for continued safe operation for BR2.

According to the Royal Decree of November 2011 (article 10) an ageing management program is required for nuclear reactors. The BR2 licence (Royal Decree N.0024 of June, 30, 1986) limits the life time of the beryllium reflectors. These reflectors have been replaced 3 times (1980, 1996 and 2016). Depending on the utilization, the beryllium matrix can be used

for a period between 15 and 25 years. Inspection of the reactor vessel is required when the beryllium matrix is unloaded for replacement.

### 1.2.3. Facility's ageing management policy

The BR2 ageing management programme was initiated in 2013, in order to comply with the new Belgian regulations on the safety of nuclear installations. The programme was developed in the framework of the periodic safety review of 2016. A dedicated group (Plant Assessment Management - PAM) of, at that moment, 5 persons was engaged for starting the project, working under the final responsibility of the reactor manager. The first tasks of the PAM group were the execution of a number of important design upgrades and to start the classification of systems, structures and components. The mandatory reactor vessel inspection was also executed by the PAM group.

The methodology for PAM is defined in internal BR2 note BR2/SVD/NBR2-2020-2012-03 (August 29, 2013). Application is further defined in PSR2016 document BR2-VF1-1.2. More detailed information on the classification and the follow up of different SSC's is given in the PAM documents (published as part of the PSR 2016):

- BR2-VF4-1.1: Plant Asset Management – Asset Concept Management (ACM)-phase;
- BR2-VF4-1.2: Plant Asset Management – Installation Concept Management (ICM)-phase;
- BR2-VF4-1.3: Plant Asset Management – Work Concept Management (WCM)-phase.

Methods to assess whether SSCs need a design upgrade in order to make continued safe operation possible is given in an additional document:

- PAM: Identification of design upgrades.

In order to get the system for PAM into operation as quick as possible, choice has been made to start from the basic information. However, an Integrated Management System (IMS) for the whole SCK•CEN is under development. The BR2 PAM will be taken up in this IMS.

## 1.3.OBJECTIVES

The objective of this mission was to review the current status and future plans of the ageing management for the continued safe operation of the BR2 and associated activities performed at the facility against the IAEA safety standards.

SCOPE

In accordance with section 3 of draft IAEA Ageing Management for Continued Safe Operation Guidelines [18], the scope of this mission as agreed during the preparatory meeting [20] was as follows:

- Area A - Organizational aspects for ageing management and continued safe operation;
- Area B - Scoping and screening of SSCs relevant to ageing management;
- Area C - Ageing management and time limited ageing analyses of mechanical components;
- Area D - Ageing management and time limited ageing analyses of electrical, and instruments and control components;
- Area E - Ageing management and time limited ageing analyses of civil structures.

## 1.4.CONDUCT OF THE MISSION

### 1.4.1. Basis for the review and review methodology

The review was performed following the methodology similar to that for IAEA Safety Aspects for Long Term Operation (SALTO) mission for nuclear power plants but based on the IAEA safety standards for research reactors.

The following documents and information were used as the basis for the review:

- IAEA Safety Standards;
- IAEA Review Guidelines;
- Advance Information Package [21];
- Documents provided during the mission;
- Discussion with the BR2 reactor management and operating personnel, and SCK.CEN technical staff;
- Discussion among the IAEA team members.

The IAEA Safety Standards Series No SSR-3 [1], Safety Guide SSG-10 [5], Safety Guide NS-G-4.2 [6], and SSG-37 [15] are the basic references for the peer review, supported by other Safety Guides as listed in the section 4 of this report.

### 1.4.2. Conduct of the mission

The list of participants in the mission is given in Appendix I, while the mission programme is presented in Appendix II.

The mission was conducted through review of facility documentation, meetings and discussions between the IAEA team and counterpart specialists and other staff from the facility. Facility walk-downs were also arranged as part of the mission.

Plenary sessions and parallel discussions were organized as needed. The discussions were conducted in parallel for all the areas assigned to the experts. Each expert was assigned a facility counterpart, responsible for the area under review.

The counterparts and facility management were informed on a daily basis of the IAEA team's preliminary findings. Each reviewer and counterpart reached agreement on the observed facts. The host facility peer attended the daily team meetings. The day before the exit meeting, the reviewers delivered to the team leader their parts of the mission report as was already discussed and agreed with counterparts from the facility.

The mission report was produced to present the findings within the review scope, The text reflects only those areas in which the team considers that a recommendation, a suggestion, an encouragement, a good practice or a good performance is appropriate.

At the exit meeting of the mission, the IAEA team members provided the conclusions of the team review together with the statements of recommendations, suggestions, encouragements, and good performances.

A summary report containing the mission conclusion as well as recommendations, suggestions, encouragements, and good performances was handed to the main counterparts during the exit meeting.

## 2. MISSION RESULTS

### 2.1.GENERAL CONCLUSIONS

Through the review of facility safety and technical documents, presentations and discussions with counterparts and members of the facility staff, the IAEA team concluded that the facility has made significant progress in the field of ageing management and in preparation for continued safe operation. The BR2 activities address most of the topics as recommended by the IAEA safety standards.

The team noted the following good performances:

- Conducting periodic safety reviews and use of its results in ageing management;
- Reporting, on voluntary basis, to the meetings of Convention on Nuclear Safety on the safety of BR2, including continued safe operation;
- Implementing an effective chemistry control of secondary cooling water to minimize ageing degradation of related SSCs.

The IAEA team noted the professionalism and openness of the BR2 staff and appreciated the commitment of SCK•CEN senior management for safety improvements. The walk-downs of the reactor facilities showed that the SSCs are in good physical conditions. The team also identified several issues that need to be addressed for further safety improvement. The team's findings that led to the recommendations and suggestions for improvement were:

- Bases for developing and implementing effective ageing management are not fully established;
- Deficiencies exist in scope setting and screening of SSCs for ageing management; and all radioisotope production facilities and experimental devices are not covered by ageing management;
- Lack of maintenance, including monitoring of SSCs important to safety, in storage (spare parts);
- Inadequate assurance that all ageing effects are considered by the approach currently used for ageing management review;
- Feedback from maintenance, inspection and surveillance programmes is not systematically taken into account for ageing management;
- Equipment qualification programme is not established;
- Ageing management of electrical and I&C systems and components important to safety is not adequate;
- A comprehensive ageing management review for civil structures and components has not yet been performed;
- Review and update of the ageing management programme for civil structures and components, including those for radioisotope production has not yet been completed.

An evaluation of each review area is contained within the following relevant subsections of section 2.2. Recommendations and suggestions are stated in section 2.2 and described in detail in individual issue sheets in Appendix III.

The BR2 management expressed a determination to address the areas identified for improvement, and indicated the intention to invite a 'follow-up mission' for BR2 in about two years-time to review the progress in resolving the issues.

## 2.2. DETAILED CONCLUSIONS

### 2.2.1. Organizational aspects for ageing management and continued safe operation

#### Related regulatory requirements, codes and standards

Bases for developing and implementing effective ageing management are not fully established e. g. regulatory requirements, design documentation, quality assurance programme. The team **recommends** that the facility should fully establish bases for developing and implementing effective ageing management. (Issue A-1).

#### Organizational structure for ageing management

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

#### Facility policy for ageing management

Reporting by the national authorities, on voluntary basis, to the meetings of Convention on Nuclear Safety on the safety of BR2, including continued safe operation is considered to be a **good performance**.

#### Ageing management implementation programme

Ageing management programme is in the implementation phase and is intended for implementation taking into account experience feedback from BR2 and other sources. The team was informed that the ageing management programme will be reviewed periodically. The team **encourages** the facility to pursue the ageing management programme with feedback from the facility and other similar facilities worldwide.

#### Current safety analyses report and other current licensing basis documents

One of the licensing conditions of BR2 is that the periodic safety review should be carried out every ten years and it should demonstrate safe operation for next ten years. A periodic safety review is carried out by the facility and results are also used as input to ageing management programme. The team considers conducting periodic safety review and use of its results for ageing management and continued safe operation as a **good performance**.

#### Configuration/ modification management including design basis documentation

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

### 2.2.2. Scoping and screening of SSCs relevant to ageing management

#### Methodology and criteria for scoping and screening of SSCs for ageing management

The methodology for scoping and screening of SSCs for ageing management mixes important to safety and not important to safety SSCs in grouping and hence does not ensure that SSCs

important to safety get priority for ageing management. Some of the radioisotope production facilities and experimental devices are not included in the ageing management programme. The team **recommends** the facility to improve scope setting and screening of SSCs for ageing management, and expand ageing management programme to cover radioisotope production facilities and experimental devices (Issue B-1).

### 2.2.3. Ageing management and time limited ageing analyses of mechanical components

**Area specific scoping and screening of SSCs for ageing management**

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

**Ageing management review**

The ageing assessment of SSCs important to safety has not been systematically based on an overall set of identified ageing effects and degradation mechanisms. In addition, a systematic approach to identify the applicable Time Limited Ageing Analyses (TLAAs) and their validity for all SSCs important to safety is not included in the ageing management programme under development. The IAEA team **suggests** that the facility consider ensuring that all ageing effects in accordance with the IAEA Safety Standards SSG-10 are taken into account in ageing management review (Issue C-2).

**Review of ageing management programmes**

There is no programme identified to maintain and monitor SSCs in storage (spare parts) that is important to safety. The IAEA team **recommends** that the facility implement maintenance programme, including monitoring of SSCs important to safety in storage (spare parts) (Issue C-1).

Feedback from maintenance, inspection and surveillance programmes is not fully taken into account for ageing management. The IAEA team **suggests** that the facility consider systematically incorporating feedback from maintenance, inspection and surveillance programmes for continuous improvement of ageing management (Issue C-3).

In the secondary cooling system, ageing issues both with the heat exchangers and the cooling tower concrete structures led to converting the system to demineralised water in 1995. Water chemistry is similar to the primary systems: pH ~5.5-6.0 and conductivity 1.0-5.0 µs/cm. Although this solution is potentially costly from an operational viewpoint, it has eliminated several ageing and other issues common to secondary cooling systems: e.g. scale build-up, clogging and corrosion in the heat exchanger tubes, disposal of waste water from blow-downs, algae growth, legionnaire's bacteria, etc., all of which offset the cost to some extent. The IAEA team considers this to be a **good performance.**

**Obsolescence management programme**

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

**Existing time limited ageing analyses**

No recommendations, suggestions, encouragements, good practices or good performances were identified in this area (see Issue C-2).

**Revalidation of time limited ageing analyses**

No recommendations, suggestions, encouragements, good practices or good performances were identified in this area (see Issue C-2).

**Data collection and record keeping**

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

### 2.2.4. Ageing management and time limited ageing analyses of electrical and I&C components

**Area specific scoping and screening of SSCs for ageing management**

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

**Ageing management review**

The assessment of the current physical status of the electrical and I&C components relies on visual inspections and, the recorded experience through maintenance activities, calibration, data collection through the monitoring of electrical, and I&C systems and components important to safety and, to a large extent, from the records of the Non-conformance Reports (NCRs) stored in the NCR database. Few examples are: battery operational conditions, cable insulation, the use of thermography of Class A electrical, and I&C systems and components important to safety, where Class A refers to the class emerging from the PAM. A significant amount of data on the performance of electrical, and I&C components is collected and stored in Bidasse system. The IAEA team **encourages** the facility to consider use of existing large amount of historical data collected in the "Bidasse" system to perform a more comprehensive trend analyses for improvement of ageing management.

**Review of ageing management programmes**

The review of ageing management programme showed that a fully developed equipment qualification programme is not in place. Seismic qualification of electrical and I&C SSCs was not performed. An analysis to verify if there is a need to qualify SSCs that are required to function during and after accident conditions is not available. The IAEA team noted that instruments for primary coolant flow and core differential pressure were qualified including for accident conditions at the time of procurement. The IAEA team **recommends** that the facility should establish equipment qualification programme. (This applies to all SSCs important to safety) (Issue D-1).

The current ageing management for electrical, and I&C systems and components important to safety is conducted within the frame of the maintenance and inspection activities, and through monitoring programmes. Ageing analysis to identify ageing effects on electrical, and I&C systems and components important to safety is not performed. There exists valuable data

from operation and maintenance history but it has not been taken into account to enhance trend analysis. The IAEA team **recommends** that the facility should develop and establish adequate ageing management of electrical and I&C systems and components important to safety (Issue D-2).

**Obsolescence management programme**

The obsolescence management programme is in development and the IAEA team observed that, within the framework of obsolescence, some appropriate actions have been taken by the facility, to counteract its negative effects. Given that the I&C components are subject to rapid technological changes, the IAEA team **encourages** the facility to consider the aspects of the early obsolescence of I&C components during the development process of the obsolescence management programme.

**Existing time limited ageing analyses**

No recommendations, suggestions, encouragements, good practices or good performances were identified in this area (see Issue C-2).

**Revalidation of time limited ageing analyses**

No recommendations, suggestions, encouragements, good practices or good performances were identified in this area (see Issue C-2).

**Data collection and record keeping**

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

### 2.2.5. Ageing management and time limited ageing analyses of civil structures

**Area specific scoping and screening of SSCs for ageing management**

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

**Ageing management review**

The facility has not performed a comprehensive ageing management review for civil structures and components such as including all components of building structures, taking into account all possible ageing mechanisms, and condition assessment. The IAEA team **recommends** the facility to perform a comprehensive ageing management review for civil structures and components (Issue E-1).

The facility has started to update the inspection procedure for the management of the ageing effect of the asbestos in the ceiling of the containment building. The team **encourages** the facility to complete the update of the inspection procedure in a timely manner.

**Review of ageing management programmes**

The facility has not completed the review and update of the ageing management programme for civil structures and components, including those for radioisotope production. The IAEA team **recommends** the facility to complete the review and update of the ageing management

programme for civil structures and components, including those for radioisotope production (Issue E-2).

The facility performs leak tests for the containment building, airlocks and penetrations as well as the sub-pile room. Test results are evaluated and some trending analyses were performed. The IAEA team **encourages** the facility to continue to provide evaluation and trending analysis of the test results.

The facility's programme for managing the pool liner leaks of the canal includes the periodic painting of the pool liner, visual inspection of concrete from the external sides and leak detection at the bottom of the pool. However leaks from the pool liner that cannot be visually detected may lead to degradation of the concrete under the existing programme. The IAEA team **encourages** the facility to establish a procedure to monitor unaccounted loss of water from all pools, including the reactor pool.

**Obsolescence management programme**

The facility plans to perform obsolescence management review for the civil structures and components in phase three of the PAM Project. The IAEA team **encourages** the facility to complete the obsolescence management review for the civil structures and components.

**Existing time limited ageing analyses**

No recommendations, suggestions, encouragements, good practices or good performances were identified in this area (see Issue C-2).

**Revalidation of time limited ageing analyses**

No recommendations, suggestions, encouragements, good practices or good performances were identified in this area (see Issue C-2).

**Data collection and record keeping**

The approach followed by the facility is generally in line with the IAEA safety standards and no recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

## 3. ISSUE SHEETS

### 3.1. PRESENTATION AND PROCESSING OF THE SAFETY ISSUES

In Appendix III of the report, the issues raised by the review performed by the IAEA team are presented in detail, following a standard format. Each 'issue sheet' consists of the sections described below.

For the limited scope or full scope mission on the subject:

(1) Issue identification;

(2) Issue clarification;

(3) Assessment by the IAEA team.

In the issue clarification, section 2, of the issue sheet, a fundamental overall problem (FOP) is defined and a clear reference to the IAEA safety standards or other reference documents used for the review is indicated.

The purpose of section 3 of the issue sheet is to reflect the discussions with the counterpart's experts, to record the facts, discuss safety consequences, issue possible recommendations and suggestions, and record documents reviewed.

For follow-up missions on the same subject, information is added pertaining to:

(4) Counterpart actions;

(5) Follow-up assessment by the IAEA team.

The purpose of section 4 of the issue sheet is to reflect the views of and the measures taken by the counterpart for the issue resolution, including the self-assessment.

The purpose of section 5 of the issue sheet is to reflect the discussions with the counterpart's experts, to record the facts, to record documents reviewed, and decide on the degree of resolution at the time of the follow-up mission. The status of the issue is assessed, and the respective 'resolution degree' is assigned to reflect the assessment of the IAEA team. The degree is scaled from 1 to 3 as follows.

1. Insufficient progress to date: Actions taken, or planned, do not lead to the conclusion that the issue will be resolved within a reasonable time frame. This category applies to recommendations on which no action or inadequate action has been taken.
2. Satisfactory progress to date: The implemented actions partially meet the intent of the recommendation or suggestion of the mission and actions are continuing.
3. Issue resolved: The intent of the recommendation or suggestion of the mission is fully met. Issue closed.

If, as an outcome of a follow-up mission, a new safety issue appears with respect to the previous ones, a new issue should be generated. Issue sheets are numbered in sequential order for further reference.

### 3.2. OVERVIEW OF THE REVIEWED ISSUES

The issues identified and grouped in the five review areas during this IAEA mission are the following:

| Issue No. | Fundamental Overall Problem | Rec. | Sugg. |
|---|---|---|---|
| **Review Area A:** Organizational aspects for ageing management and continued safe operation | | | |
| **A-1** | Bases for developing and implementing effective ageing management are not fully established. | 1 | - |
| **Review Area B:** Scoping and screening of SSCs relevant to ageing management | | | |
| **B-1** | Deficiencies exist in scope setting and screening of SSCs for ageing management and all radioisotope production facilities and experimental devices are not covered by ageing management. | 1 | - |
| **Review Area C:** Ageing management and time limited ageing analyses of mechanical components | | | |
| **C-1** | There is a lack of maintenance including monitoring of SSCs important to safety in storage (spare parts). | 1 | - |
| **C-2** | The approach used for ageing management review does not ensure that all ageing effects are considered. | - | 1 |
| **C-3** | Feedback from maintenance, inspection and surveillance programmes is not systematically taken into account for ageing management. | - | 1 |
| **Review Area D:** Ageing management and time limited ageing analyses of electrical, and instruments and control components | | | |
| **D-1** | Equipment qualification programme is not established. | 1 | - |
| **D-2** | Ageing management of electrical and I&C systems and components important to safety is not adequate. | 1 | - |
| **Review Area E:** Ageing management and time limited ageing analyses of civil structures | | | |
| **E-1** | The facility has not performed a comprehensive ageing management review for civil structures and components. | 1 | - |
| **E-2** | The facility has not completed the review and update of the ageing management programme for civil structures and components, including those for radioisotope production. | 1 | - |

The complete set of issue sheets is presented in Appendix III of this report.

## 4. REFERENCES


[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, IAEA Safety Standards Series No. SSR-3, IAEA, 2016.

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[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4 (Rev. 1), IAEA, 2016.

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, IAEA Safety Standards Series No. GSR Part 2, IAEA, 2016.

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Research Reactors, IAEA Safety Standards Series No. SSG-10, IAEA, 2010.

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[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Operational Limits and Conditions and Operating Procedures for Research Reactors, IAEA Safety Standards Series No. NS-G-4.4, IAEA, 2008.

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors, IAEA Safety Standards Series No. NS-G-4.5, IAEA, 2008.

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, IAEA Safety Standards Series No. NS-G-4.6, IAEA, 2009.

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, IAEA Safety Standards Series No. SSG-20, IAEA, 2012.

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[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Nuclear Power Plants, Safety Standards Series No. SSG-25, IAEA, Vienna (2013).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Instrumentation and Control Systems and Software Important to Safety for Research Reactors, IAEA Safety Standards Series No. SSG-37, IAEA, 2015.

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Nuclear Installations, IAEA Safety Standards Series No. GS-G-3.5, IAEA, 2009.

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidelines for the Review of Research Reactor Safety, IAEA Services Series 25, IAEA, 2014.

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidelines for Peer Review of "Ageing Management of Research Reactors for Continued Safe Operation", IAEA Services Series, IAEA (Draft).

[19] INTERNATIONAL ATOMIC ENERGY AGENCY, SALTO Peer Review Guidelines, IAEA Services Series 26, IAEA, 2014.

[20] Report on Preparatory Meeting for Ageing Management Review for Continued Safe Operation to the BR2 Research Reactor, Mol, Belgium, July 2016.

[21] Advance Information Package, Mol AGEING MANAGEMENT FOR CONTINUED SAFE OPERATION Advance Information Package (AIP), October 2017.

## 5. GLOSSARY FOR THE MISSION

### Ageing

General process in which characteristics of a structure, system or component gradually change with time or use. We distinguish between:

1. **Physical ageing** is a general process in which characteristics of SSCs gradually change with time or use. It occurs due to physical or material degradation processes (i.e. chemical and/ or biological).
2. **Non-physical ageing** is the process of becoming out of date (i.e. obsolete) owing to the availability, evolution of knowledge and technology, and associated changes in requirements, codes and standards.

Physical ageing is referred as ageing while non-physical ageing is referred as obsolescence. Types of **obsolescence** are:

1. Obsolescence of technology (**technological obsolescence**) - lack of spare parts and technical support, lack of suppliers, lack of industrial capabilities;
2. Obsolescence of regulations, codes and standards - deviations from current regulations, codes and standards, both hardware and software, design weaknesses (e.g. in equipment qualification, separation, diversity or severe accident management capabilities);
3. Obsolescence of knowledge - knowledge of current regulations, codes and standards and technology relevant to SSCs not updated.

### Ageing Management

Engineering, operations and maintenance actions to control ageing degradation and wear of structures, systems or components, within acceptable limits. Examples of engineering actions include design, qualification, and failure analysis. Examples of operational activities include surveillance, carrying out of operational procedures within specified limits, and performance of environmental measurements.

### Ageing management programmes (AMPs)

Programmes developed using a structured methodology, to ensure a consistent approach for defining and implementing ageing management. AMPs should be developed specific to ageing effects/ degradation mechanisms or specific to a structure or component and should be consistent with the generic attributes of an effective AMP. Each AMP should identify specific actions relating to the prevention, detection, monitoring and mitigation of the ageing effects. Such specific actions may include plant programmes for maintenance, equipment qualification, in-service inspection, testing and surveillance, as well as controlling operational conditions. Each AMP includes a mechanism that ensures timely feedback of operating experience as well as research and development results (if applicable).

### Ageing management review

Systematic assessment of ageing effects and their related degradation mechanisms that have been experienced or are anticipated. The assessment should include an evaluation of the impact of the ageing effect on the ability of the in-scope structures or components to perform their intended function(s), including consideration of the current condition of the structure or component.

**Continued Safe Operation**

See section 7.12, IAEA Safety Standards Series No. SSG-10, Ageing Management for Research Reactors.

**Design Basis**

The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, so that the facility can withstand them without exceeding authorised limits by the planned operation of safety systems.

**Design life**

The period of time during which a facility or component is expected to perform according to the technical specifications to which it was produced.

**Licensing Basis**

A set of regulatory requirements applicable to a nuclear installation.

**Periodic Safety Review**

A systematic reassessment of the safety of an existing facility (or activity) carried out at regular intervals to deal with the cumulative effects of ageing, modifications, operating experience, technical developments and siting aspects, and aimed at ensuring a high level of safety throughout the service life of the facility (or activity).

**Time limited ageing analyses (TLAA)**

Plant specific calculations and safety analyses (time limited ageing analyses or residual life assessments) using time limited assumptions that are based on an explicitly assumed time of plant operation or design life. The licensee calculations and analyses:

- Involve systems, structures, and components within the scope of licence renewal or life extension;
- Consider the effects of ageing;
- Involve time-limited assumptions defined by the current operating term, for example, 40 years;
- Were determined to be relevant by the licensee in making a safety determination;
- Involve conclusions or provide the basis for conclusions related to the capability of the system, structure, and component to perform its intended functions; and
- Are contained or incorporated by reference in the Current Licensing Basis.

TLAAs are generally applied to demonstrate that the analysed ageing effects will not adversely affect the ability of the structure or component to perform its intended function throughout an assumed period of operation.

## I.2. THE RESEARCH REACTOR AND OTHER ORGANIZATIONS

## APPENDIX I - LIST OF PARTICIPANTS

### I.1. IAEA REVIEW TEAM

## APPENDIX II - MISSION PROGRAMME

| | | | | |
|---|---|---|---|---|
| **MONDAY, 6 November 2017 – Team at the Hotel** | | | | |
| **15:00-18:30** | Mission Methodology: Structure, Reporting, General Guidance on the conduct of the mission (IAEA Team leader)<br>Preliminary comments from available documents (10 minutes for each review team member) | | | |
| **TUESDAY, 7 November 2017** | | | | |
| **09:30-11:00** | Opening remarks – SCK-CEN, IAEA, FANC<br>Introduction of participants – Both sides<br>Review of the mission objective, agenda, and review methodology (IAEA Team leader)<br>Presentation – General description and Ageing Management Programme – BR2 | | | |
| ***11:30-12:00*** | ***Lunch*** | | | |
| **12:00-15:00** | Walkthrough of BR-2<br>IAEA team with counterparts (4 groups - each reviewer with counterpart – TL and DTL will join some group) | | | |
| **15:00-16:00** | **Review area A**<br>**Presentation of the area status (max. 45. min)**<br>Interview, documents review and discussion | **Review area C**<br>**Presentation of the area status (max. 45. min)**<br>Interview, documents review and discussion | **Review area D**<br>**Presentation of the area status (max. 45. min)**<br>Interview, documents review and discussion | **Review area E**<br>**Presentation of the area status (max. 45. min)**<br>Interview, documents review and discussion |
| **16:00-16:30** | Debriefing the counterpart | | | |
| **16:30–16:55** | Daily report preparation | | | |
| **17:00-17:30** | IAEA Team meeting | | | |
| **WEDNESDAY, 8 November 2017** | | | | |
| **08:00-12:30** | **Review area A and B** | **Review area C** | **Review area D** | **Review area E** |
| **11:00–11:30** | Meeting of TL and RR manager | | | |
| ***12:30-13:30*** | *Lunch break* | | | |
| **13:30-16:00** | **Review area A and B** | **Review area C** | **Review area D** | **Review area E** |
| **16:00-16:30** | Debriefing the counterpart | | | |
| **16:30–16:55** | Daily report preparation | | | |
| **17:00-17:30** | IAEA Team meeting | | | |

| THURSDAY, 9 November 2017 | | | | |
|---|---|---|---|---|
| **08:00-12:30** | **Review area A and B** | **Review area C** | **Review area D** | **Review area E** |
| **11:00-11:30** | Meeting of TL and RR manager | | | |
| ***12:30-13:30*** | *Lunch break* | | | |
| **13:30-16:00** | **Review area A and B** | **Review area C** | **Review area D** | **Review area E** |
| **16:00-16:30** | Debriefing the counterpart | | | |
| **16:30–16:55** | Daily report preparation | | | |
| **17:00-17:30** | IAEA Team meeting | | | |
| **FRIDAY, 10 November 2017** | | | | |
| **08:00-12:30** | **Review area A and B** | **Review area C** | **Review area D** | **Review area E** |
| **11:00 11:30** | Meeting of TL and RR manager | | | |
| ***12:30-13:30*** | *Lunch break* | | | |
| **13:30-16:00** | **Review area A and B** | **Review area C** | **Review area D** | **Review area E** |
| **16:00-16:30** | Debriefing the counterpart | | | |
| **16:30–16:55** | Daily report preparation | | | |
| **17:00-17:30** | IAEA Team meeting | | | |
| **SATURDAY, 11 November 2017** | | | | |
| **08:00-10:00** | Team meeting - discussion of potential issues and good practices | | | |
| **10:00-10:30** | Team training– development of evaluative section of report and exit speeches | | | |
| **10:30-12:30** | Drafting of issues, good practices and evaluative section of report – bilateral discussions with TL | | | |
| ***12:30-13:30*** | *Lunch break* | | | |
| **13:30-18:00** | Drafting of issues, good practices and evaluative section of report – bilateral discussions with TL | | | |
| **SUNDAY, 12 November 2017 – Free day** | | | | |

| MONDAY, 13 November 2017 | |
|---|---|
| **08:00-09:30** | Team meeting with host plant peer – issues, good practices - presentation, discussion and agreement by team |
| **09:30-11:00** | Team meeting with host plant peer – evaluative section of report - presentation, discussion and agreement by team (counterparts review the issues and good practices simultaneously) |
| **11:00-12:30** | Finalizing of draft issues, preparation of evaluative part of report |
| ***12:30-13:30*** | *Lunch break* |
| **13:30-15:00** | Discussion of issues, good practices and evaluative part of report with counterparts |
| **13:45-14:30** | TL debriefing with RR manager |
| **14:30-15:15** | TL debriefing with regulatory authority |
| **15:00-16:00** | Revision of the draft issues based on counterpart's comments |
| **16:00-17:00** | Agree the issues, good practices and evaluative section of report with counterparts |
| **17:00-18:00** | Preparation of exit meeting speeches |
| **TUESDAY, 14 November 2017** | |
| **08:00-10:00** | Rehearsal of exit speeches |
| **10:00-11:00** | **Exit meeting** - (including BR2 management)<br>Opening by the main counterpart<br>Description of mission scope - deputy team leader<br>Main finding and conclusions - team leader and reviewers<br>Main counterpart's remark (comparison against initial expectation)<br>Remarks by Regulatory authority<br>Remarks by IAEA management<br>Remarks by Reactor manager<br>Closing by the SCK.CEN management |

Facility walk-down will be organized as optional for reviewers based on their requests.

## APPENDIX III - ISSUE SHEETS

| **1. ISSUE IDENTIFICATION** | **Issue Number: A – 1** |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Organisation and functions, current licensing basis, configuration/ modification management** | |
| **Issue Title:** Incomplete bases for establishment of ageing management | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>Bases for developing and implementing effective ageing management are not fully established. | |
| **2.2 – IAEA BASIS:**<br>SSR-3 Requirement 86<br>The operating organization for a research reactor facility shall ensure that an effective ageing management programme is implemented to manage the ageing of items important to safety so that the required safety functions of structures, systems and components are fulfilled over the entire operating lifetime of the research reactor.<br>SSG-10<br>2.8 Successful implementation of the ageing management programme requires:<br>(b) addressing all relevant regulatory requirements, codes and standards;<br>7.10 The ageing management programme should be used to demonstrate that, in spite of ageing degradation, the design basis for SSCs important to safety remains valid.<br>GS-G-3.1<br>2.4. Organizations should integrate all their components into an integrated management system.<br>2.5 In an integrated management system, all goals, strategies, plans and objectives of an organization should be considered in a coherent manner. | |
| **3. ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** 14/11/2017 |
| **3.1 – FACTS:**<br>**F1)** Ageing management programme is in implementation stage.<br>**F2)** A complete and consistent set of regulatory requirements, codes and standards related to ageing management has not been identified by the facility.<br>**F3)** The design basis documentation is not available for all SSCs important to safety. For example, there is a lack of design basis and design requirements of some SSCs for electrical and I&C components. | |

**F4)** Integrated management system (IMS) is in implementation stage. Quality assurance programme related to ageing management is under development and will be a part of IMS.

**3.2 – SAFETY CONSEQUENCE:**

Without fully established bases for developing and implementing ageing management, ageing management will not be effective.

**3.3 – RECOMMENDATION/SUGGESTION:**

**R)** The facility should fully establish bases for developing and implementing effective ageing management.

**3.4 – DOCUMENTS REVIEWED:**

- Royal Decree on safety of nuclear installations published on 21.12.2011;
- BR-2 72S7680 all volumes, Safety Analysis Report;
- BR-2 72S7680 Vol 3: Technical Specifications;
- R-SER-16-046-0-n_BR-2: Safety Evaluation Report by BEL V;
- 20022438 PAM, Methodology Asset Configuration Management, 8.04.2014;
- 2001799 PAM, Methodology Installation Concept Management, 8.04.2014;
- 2012411 Plant Asset Management, Work order Management and Skills;
- Integrated Management System Portal;
- Database SFO/008 and 013;
- GEC ALSTHOM NT 0000 0001, 17.11.1994;
- Database Document Management System Alexandria Dagverslag-2017;
- BR-2 – NBR2-2020-00;
- SAR Vol 4 CH 7, The Reactor Vessel References 1- 24;
- Meeting Report: BR-2 Co-ordination meeting;
- 169-INS-1530: INS- Work Instruction;
- SFH/606 and SFB/941 equipment test reports;
- BR2/SVD/NBR2-2020-2012-03;
- BR2-VF1-1.2;
- BR-2-VF4-1.1 rev 2;
- BR-2-VF4-1.2;
- Electrical and I&C database.

| 4. COUNTERPART ACTIONS | | Date: D2/M2/ YYY2 |
|---|---|---|
| n.a. | | |
| 5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM | | Date: D3/M3/ YYY3 |
| **5.1 – FACTS:**<br>**F1)** n.a. | | |
| **5.2 – DOCUMENTS REVIEWED:**<br>n.a. | | |
| **5.3 – RESOLUTION DEGREE:** | | |
| **1.** | **Insufficient progress to date** | n.a. |
| **2.** | **Satisfactory progress to date** | n.a. |
| **3.** | **Issue resolved** | n.a. |

n.a.: not applicable for the present mission.

| 1. ISSUE IDENTIFICATION | Issue Number: B - 1 |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Scoping and screening for ageing management** | |
| **Issue Title:** Deficiencies in scope setting and screening of SSCs for ageing management | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>Deficiencies exist in scope setting and screening of SSCs for ageing management and all radioisotope production facilities and experimental devices are not covered by ageing management. | |
| **2.2 – IAEA BASIS:**<br>SSR-3 Requirement 86<br>The operating organization for a research reactor facility shall ensure that an effective ageing management programme is implemented to manage the ageing of items important to safety so that the required safety functions of structures, systems and components are fulfilled over the entire operating lifetime of the research reactor."<br>SSG-10<br>5.2 A systematic ageing management programme for the research reactor should be applied, comprising the following elements:<br>– Screening of SSCs for ageing management review;<br>5.4 A systematic approach should therefore be applied to focus resources on those SSCs, including experimental devices, that can have a negative impact on the safe operation of a reactor and that are susceptible to ageing degradation.<br>Annex II TABLE II–1. TYPICAL RESEARCH REACTOR SSCs Hot cells Communications Fuel assemblies and storage. | |
| **3. ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** 14/11/2017 |
| **3.1 – FACTS:**<br>**F1)** A methodology for scope setting and screening of SSCs for ageing management does not ensure that SSCs important to safety are separated from SSCs not important to safety.<br>**F2)** A hot cell that is located inside the machine hall which is used for radioisotope production and experimental devices are not included in the scope for ageing management.<br>**F3)** Communication system (including paging system) and spent fuel storage system are not included in the scope of SSCs for ageing management. | |

**3.2 – SAFETY CONSEQUENCE:**

Without comprehensive scope setting and screening of SSCs for ageing management, ageing effects of all SSCs important to safety will not be properly managed.

**3.3 – RECOMMENDATION/SUGGESTION:**

**R)** The facility should improve scope setting and screening of SSCs for ageing management, and expand ageing management programme to cover radioisotope production facilities and experimental devices.

**3.4 – DOCUMENTS REVIEWED:**

- Royal Decree on safety of nuclear installations published on 21.12.2011;
- BR-2 72S7680 all volumes, Safety Analysis Report;
- BR-2 72S7680 Vol 3: Technical Specifications;
- R-SER-16-046-0-n_BR-2: Safety Evaluation Report by BEL V;
- 20022438 PAM, Methodology Asset Configuration Management, 8.04.2014;
- 2001799 PAM, Methodology Installation Concept Management, 8.04.2014;
- 2012411 Plant Asset Management, Work order Management and Skills;
- Integrated Management System Portal;
- Database SFO/008 and 013;
- GEC ALSTHOM NT 0000 0001, 17.11.1994;
- Database Document Management System Alexandria Dagverslag-2017;
- BR-2 – NBR2-2020-00;
- SAR Vol 4 CH 7, The Reactor Vessel References 1- 24;
- Meeting Report: BR-2 Co-ordination meeting;
- 169-INS-1530: INS- Work Instruction;
- SFH/606 and SFB/941 equipment test reports;
- BR2/SVD/NBR2-2020-2012-03;
- BR2-VF1-1.2;
- BR-2-VF4-1.1 rev 2;
- BR-2-VF4-1.2;
- BR2-V4-1.1.pdf.

| **4. COUNTERPART ACTIONS** | **Date:** D2/M2/ YYY2 |
|---|---|
| n.a. | |

| 5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM | | Date: D3/M3/ YYY3 |
|---|---|---|
| **5.1 – FACTS:**<br>**F1)** n.a. | | |
| **5.2 – DOCUMENTS REVIEWED:**<br>n.a. | | |
| **5.3 – RESOLUTION DEGREE:** | | |
| **1.** | **Insufficient progress to date** | n.a. |
| **2.** | **Satisfactory progress to date** | n.a. |
| **3.** | **Issue resolved** | n.a. |

n.a.: not applicable for the present mission.

| 1. ISSUE IDENTIFICATION | Issue Number: C - 1 |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Ageing management review, review of ageing management programmes and revalidation of time limited ageing analyses for mechanical components** | |
| **Issue Title:** Lack of maintenance and monitoring of SSCs important to safety in storage (spare parts) | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>There is a lack of maintenance including monitoring of SSCs important to safety in storage (spare parts). | |
| **2.2 – IAEA BASIS:**<br>SSR-3 Requirement 67: Responsibilities of the operating organization<br>7.7. The operating organization shall prepare and issue specifications and procedures in accordance with the classification of structures, systems and components and the management system, in particular for the procurement, manufacturing, loading, utilization, unloading, storage, movement and testing of items important to safety …<br>SSG-10<br>4.15. The following issues should be taken into account in implementing a systematic ageing management programme:<br>(h) Appropriate storage of spare parts and consumables susceptible to ageing, to minimize degradation while in storage and to control their shelf life properly;<br>NS-G-4.2<br>Procurement and storage of spare parts<br>5.24. The programme should describe the procurement process and should identify the items and quantities of spare parts and materials to be held at all times. Storage conditions and storage time limits should also be specified in the programme. | |
| **3. ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** 14/11/2017 |
| **3.1 – FACTS:**<br>**F1)** There is no programme identified to maintain and monitor SSCs important to safety in storage.<br>**F2)** As an example, a spare new primary pump in storage is not subject to any maintenance or monitoring programme.<br>**F3)** In general, it was confirmed that maintenance and monitoring of spares in storage at the facility is not implemented. | |

| | |
|---|---|
| **3.2 – SAFETY CONSEQUENCE:**<br>Without maintenance including monitoring of SSCs important to safety in storage, unanticipated early failure of a SSC important to safety can occur. | |
| **3.3 – RECOMMENDATION/SUGGESTION:**<br>**R)** The facility should implement maintenance including monitoring of SSCs important to safety in storage (spare parts). | |
| **3.4 – DOCUMENTS REVIEWED:**<br>None | |
| **4. COUNTERPART ACTIONS** | **Date:** D2/M2/ YYY2 |
| n.a. | |
| **5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** D3/M3/ YYY3 |
| **5.1 – FACTS:**<br>**F1)** n.a. | |
| **5.2 – DOCUMENTS REVIEWED:**<br>n.a. | |

| **5.3 – RESOLUTION DEGREE:** | | |
|---|---|---|
| **1.** | **Insufficient progress to date** | n.a. |
| **2.** | **Satisfactory progress to date** | n.a. |
| **3.** | **Issue resolved** | n.a. |

n.a.: not applicable for the present mission.

| 1. ISSUE IDENTIFICATION | Issue Number: C - 2 |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Ageing management review, review of ageing management programmes and revalidation of time limited ageing analyses for mechanical components** | |
| **Issue Title:** Inadequate identification of ageing effects | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>The approach used for identification of ageing effects does not ensure that all ageing effects are managed. | |
| **2.2 – IAEA BASIS:**<br>SSR-3 Requirement 86: Ageing management<br>The operating organization for a research reactor facility shall ensure that an effective ageing management programme is implemented to manage the ageing of items important to safety so that the required safety functions of structures, systems and components are fulfilled over the entire operating lifetime of the research reactor.<br>SSG-10<br>IDENTIFICATION AND UNDERSTANDING OF AGEING DEGRADATION<br>5.9. To understand the ageing degradation of a structure or component, it's ageing mechanisms and effects should be identified and understood; understanding ageing is the basis for the effective monitoring and mitigation of ageing effects.<br>5.10. Interactions between materials, and service conditions, should be assessed to identify degradation mechanisms. This assessment should be performed using available analytical or empirical models for evaluating past ageing degradation and predicting future ageing degradation.<br>5.11. Existing methods for inspection, testing, surveillance, monitoring and assessment should be evaluated, with account taken of relevant operating experience and research results, to determine whether they are effective for timely detection of ageing degradation before failure of the structure or component occurs.<br>SSG-10 ANNEX I: EFFECT OF AGEING FOR DIFFERENT SERVICE CONDITIONS<br>ANNEX II: EXAMPLE FOR SCREENING OF RESEARCH REACTOR SSCs FOR AGEING MANAGEMENT PURPOSES. | |

| 3. ASSESSMENT BY THE IAEA REVIEW TEAM | Date: 14/11/2017 |
|---|---|

**3.1 – FACTS:**

**F1)** The ageing assessment of SSCs has not been systematically based on an overall set of identified ageing effects and degradation mechanisms.

**F2)** For example, the methodology used to assess the risk profiles of AC-A and AC-B SSCs considers each SSC in the context of failure of subcomponents rather than in the context of degradation mechanisms.

**F3)** It could not be verified from the approach followed that no potential ageing effects have been missed in establishing the interface programmes such as maintenance and in-service inspection (ISI) that manage ageing effects.

**3.2 – SAFETY CONSEQUENCE:**

Without managing all ageing effects, safety function of SSCs important to safety will not be always fulfilled.

**3.3 – RECOMMENDATION/SUGGESTION:**

**S)** The facility should consider to ensure that all ageing effects in accordance with the IAEA safety standards SSG-10 are taken into account in ageing management review.

**3.4 – DOCUMENTS REVIEWED:**

- ICM Methodology Report: SCKCEN/20023942002394 "Maintenance Concepts and Risk Profiles for AC A, B, C & D SSCs".

| 4. COUNTERPART ACTIONS | Date: D2/M2/ YYY2 |
|---|---|

n.a.

| 5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM | Date: D3/M3/ YYY3 |
|---|---|

**5.1 – FACTS:**

**F1)** n.a.

**5.2 – DOCUMENTS REVIEWED:**

n.a.

**5.3 – RESOLUTION DEGREE:**

| | | |
|---|---|---|
| **1.** | **Insufficient progress to date** | n.a. |
| **2.** | **Satisfactory progress to date** | n.a. |
| **3.** | **Issue resolved** | n.a. |

n.a.: not applicable for the present mission.

| 1. ISSUE IDENTIFICATION | Issue Number: C - 3 |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Ageing management review, review of ageing management programmes and revalidation of time limited ageing analyses for mechanical components** | |
| **Issue Title:** Insufficient feedback from maintenance, inspection and surveillance programmes for ageing management | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>Feedback from maintenance, inspection and surveillance programmes is not systematically taken into account for continuous improvement of ageing management. | |
| **2.2 – IAEA BASIS:**<br>SSR-3 Requirement 86: Ageing management<br>The operating organization for a research reactor facility shall ensure that an effective ageing management programme is implemented to manage the ageing of items important to safety so that the required safety functions of structures, systems and components are fulfilled over the entire operating lifetime of the research reactor.<br>7.120. The ageing management programme shall determine the consequences of ageing and the activities necessary to maintain the operability and reliability of structures, systems and components. The ageing management programme shall be coordinated with, and be consistent with, other relevant programmes, including the programmes for in-service inspections, periodic safety review and maintenance.<br>SSG-10 OPERATION<br>4.15. The following issues should be taken into account in implementing a systematic ageing management programme:<br>(m) Use of databases on SSC reliability and maintenance histories;<br>MINIMIZATION OF AGEING DEGRADATION<br>5.12. Preventive actions should be continuously improved, with account taken of relevant operating experience and research results, and should include:<br>(a) An assessment of the effectiveness of current maintenance and restoration methods and practices (including refurbishment and periodic replacement of parts and consumables) to control ageing degradation of components;<br>5.20. The results of performance tests undertaken as part of the maintenance programme should be periodically examined for evidence of trends that indicate ageing degradation.<br>5.26. Current knowledge should be acquired from information on the operation of SSCs, surveillance and maintenance records, lessons learned from other similar facilities and information from the results of research; | |

5.32. The data required in relation to ageing management may be divided into the following three categories

(3) Maintenance records, including information on the condition of the SSCs.

| **3. ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** 14/11/2017 |
|---|---|

**3.1 – FACTS:**

**F1)** There is not an established process for obtaining information (trends, MTBF, etc.) from maintenance records about the condition of SSCs, other than through the NCR database, which records only those deviations that have resulted in reportable incidents.

**F2)** A new maintenance database for the whole of SCK.CEN including BR-2 is currently under development.

**F3)** ISI findings (i.e. non-conformances) are registered in the NCR database, which provides feedback to the PAM. This is specific for ISI and not for all inspections.

**F4)** A means to obtain an overview of all SSCs under surveillance and monitoring programmes, and the nature, frequency and other aspects thereof, is missing.

**F5)** Information about the more obvious surveillance and monitoring of SSCs is easily accessible on the PAM database, e.g. the RPV, the Be reflector and the CR guide tubes. Information about the surveillance and monitoring of other SSCs is not adequately documented for ready retrieval, e.g. surveillance and monitoring of the control rod absorbers, fuel elements and irradiation devices.

**F6)** The records of pressure shocks actually experienced by RPV are not maintained.

**3.2 – SAFETY CONSEQUENCE:**

Without relevant feedback from maintenance, inspection and surveillance programmes, continuous improvement of ageing management cannot be ensured.

**3.3 – RECOMMENDATION/SUGGESTION:**

**S)** The facility should consider systematically incorporating feedback from maintenance, inspection and surveillance programmes for continuous improvement of ageing management.

**3.4 – DOCUMENTS REVIEWED:**

- Evaluation of Neutron Fluences in Al Vessel of BR2: From 1963 to end 2016;
- MCNP Evaluation of Neutron Fluences in the 4th Be Matrix of BR2 in Year 2016;
- Methodology Report for Reactor Load and Core Physic Management;
- SCKCEN/2230879, Evaluation of the input data for the assessment of the RPV;
- Numerical data of cycle 05/2017.

| **4. COUNTERPART ACTIONS** | **Date:** D2/M2/ YYY2 |
|---|---|

n.a.

| 5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM | | Date: D3/M3/ YYY3 |
|---|---|---|
| **5.1 – FACTS:**<br>**F1)** n.a. | | |
| **5.2 – DOCUMENTS REVIEWED:**<br>n.a. | | |
| **5.3 – RESOLUTION DEGREE:** | | |
| **1.** | **Insufficient progress to date** | n.a. |
| **2.** | **Satisfactory progress to date** | n.a. |
| **3.** | **Issue resolved** | n.a. |

n.a.: not applicable for the present mission.

| 1. ISSUE IDENTIFICATION | Issue Number: D - 1 |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Ageing management and time limited ageing analyses of electrical, and instruments and control components** | |
| **Issue Title:** Incomplete equipment qualification programme | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>Equipment qualification programme is not established. | |
| **2.2 – IAEA BASIS:**<br>SSR-3<br>6.73 ensure that the equipment can be qualified,<br>Requirement 29: Qualification of items important to safety<br>6.82-6.84<br>SSG-10<br>7.8 Equipment qualification activities should provide for minimization of ageing degradation<br>SSG-37<br>Equipment qualification<br>4.52-4.56<br>NS-G-4.2<br>8.5. The factors to be taken into account in developing administrative procedures for maintenance, periodic testing and inspection should include: Equipment requalification | |
| **3. ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** 14/11/2017 |
| **3.1 – FACTS:**<br>**F1)** Equipment qualification programme is not developed.<br>**F2)** Seismic qualification of electrical and I&C systems and components important to safety was not performed.<br>**F3)** There was no analysis performed to verify if there is a need to qualify SSCs important to safety for accident conditions.<br>**F4)** Only flow and pressure measurement equipment was purchased as qualified for accident conditions. | |

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| **3.2 – SAFETY CONSEQUENCE:**<br>Without equipment qualification programme, fulfilment of function of SSCs important to safety during and after accident conditions cannot be ensured. |
| **3.3 – RECOMMENDATION/SUGGESTION:**<br>**R)** The facility should establish equipment qualification programme (This applies to all SSCs important to safety). |
| **3.4 – DOCUMENTS REVIEWED:**<br>– Magazine spare parts Database of Electrical and Non-Nuclear Instrumentation SSCs. |

| **4. COUNTERPART ACTIONS** | **Date:** D2/M2/ YYY2 |
|---|---|
| *n.a.* | |
| **5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** D3/M3/ YYY3 |
| **5.1 – FACTS:**<br>***F1)*** *n.a.* | |
| **5.2 – DOCUMENTS REVIEWED:**<br>*n.a.* | |

| **5.3 – RESOLUTION DEGREE:** | | |
|---|---|---|
| **1.** | **Insufficient progress to date** | |
| **2.** | **Satisfactory progress to date** | |
| **3.** | **Issue resolved** | |

n.a.: not applicable for the present mission.

| 1. ISSUE IDENTIFICATION | Issue Number: D - 2 |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Ageing management and time limited ageing analyses of electrical, and instruments and control components** | |
| **Issue Title:** Inadequate ageing management of electrical and I&C systems and components | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>Ageing management of electrical and I&C systems and components important to safety is not adequate. | |
| **2.2 – IAEA BASIS:**<br>SSG-10<br>4.26 Particular consideration should be given to inspections for degradation of and electrical SSCs.<br>5.11 Existing methods for inspection, testing, surveillance, monitoring and assessment should be evaluated, with account taken of relevant operating experience and research results, to determine whether they are effective for timely detection of ageing degradation before failure of the structure or component occurs.<br>5.19 Ageing effects may be detected and trends determined, in order to predict the onset of ageing degradation in a timely manner.<br>5.20 maintenance programme should be periodically examined for evidence of trends that indicate ageing degradation.<br>SSG-37<br>4.54. Qualification should be based upon a combination of methods, including: (f) Ageing analysis as applicable. | |
| **3. ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** 14/11/2017 |
| **3.1 – FACTS:**<br>**F1)** Monitoring of conditions of electrical and I&C systems and components is performed only for batteries, cables and temperature effects.<br>**F2)** Trending of failure rates of electrical and I&C systems and components was not performed.<br>**F3)** The analysis and identification of ageing effects for electrical and I&C systems and components important to safety was not performed.<br>**F4)** During the walk-down at the facility, the following was observed:<br>– Degraded insulation of some electrical cables; | |

- Cables with obsolete insulation technology in use;
- Incomplete identification of electrical and I&C components.

**3.2 – SAFETY CONSEQUENCE:**

Without adequate ageing management of electrical and I&C systems and components, fulfilment of function of electrical and I&C systems and components important to safety cannot be ensured.

**3.3 – RECOMMENDATION/SUGGESTION:**

**R)** The facility should develop and establish adequate ageing management of electrical and I&C systems and components important to safety.

**3.4 – DOCUMENTS REVIEWED:**

- BR2-NBR2-2020-00, SCK•CEN/20110279 – Asset Configuration Management Report;
- Electrical and I&C ICM database in excel format output;
- ST/H002, Standard procedure for walkthrough each week (Standaard procedure voor de wekelijkse rondgang door dienst elektriciteit);
- SO/040 - Niet standard operatie – Operation non-standard form;
- Specific failure forms per battery type (Specifiek faalvormen per batterijtype);
- Intervention Sheet - Intermediate Team EWOKI (Interventiefiche – Tussenkomst Ploeg EWOKI;
- 10:00 hr. Every day meeting (Dagverslag BR2 van 07 November 2017 POST 3;
- SF/O/08, Modification Order to modify the installation BR2 (Demande d´etude ou de modification de l´installations BR2;
- NFPA 70 B, Recommended Practice for Electrical Equipment Maintenance, (2010 Edition in excel format output;
- Thermographic inspection of electrical installations in operation (Thermo-grafisch Onderzoek van de elektrische installaties in werking);
- Testing the reverse by diesel groups (Testen van de reverse door dieselgroepen);
- Battery follow up sheet database;
- Control Rod test form (Controlestaven/ barres de controle form);
- Regelstaaf R2 Cyclus 03/17 PD 0m3/h, Regulating rod control test form, 21-04-2017;
- Regelstaaf R2 Cyclus 03/17 PD 6000/m3/h, Regulating rod control test form, 01-05-2017;
- Linear Channels data logger trend chart during operational state, Yokogawa chart records;
- Linear Channels data logger trend chart during operational state, Bidasse chart records;
- Technical Support Office database outputs.

| **4. COUNTERPART ACTIONS** | | **Date:** D2/M2/ YYY2 |
|---|---|---|
| *n.a.* | | |
| **5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM** | | **Date:** D3/M3/ YYY3 |
| **5.1 – FACTS:**<br>*F1) n.a.* | | |
| **5.2 – DOCUMENTS REVIEWED:**<br>*n.a.* | | |
| **5.3 – RESOLUTION DEGREE:** | | |
| **1.** | **Insufficient progress to date** | |
| **2.** | **Satisfactory progress to date** | |
| **3.** | **Issue resolved** | |

n.a.: not applicable for the present mission.

| 1. ISSUE IDENTIFICATION | Issue Number: E - 1 |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Ageing management review, review of ageing management programmes and revalidation of time limited ageing analyses for civil structures** | |
| **Issue Title:** Incomplete ageing management review for civil structures and components | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>The facility has not performed a comprehensive ageing management review for civil structures and components. | |
| **2.2 – IAEA BASIS:**<br>SSG-10<br>5.2 A systematic ageing management programme for the research reactor should be applied, comprising the following elements:<br>– Screening of SSCs for ageing management review;<br>5.9 To understand the ageing degradation of a structure or component, its ageing mechanisms and effects should be identified<br>5.19 Ageing effects may be detected and trends determined, in order to predict the onset of ageing degradation in a timely manner.<br>5.20 Maintenance programme should be periodically examined for evidence of trends that indicate ageing degradation. | |
| **3. ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** 14/11/2017 |
| **3.1 – FACTS:**<br>**F1)** Some components in the building structures are not defined for ageing management, e.g. in the containment building, components such as concrete, metal, welds, stairs are defined but sealant, floor epoxy paint are not defined.<br>**F2)** Review of ageing management for the in-scope civil structures and components is not complete since the second and third phases of the PAM project are still in progress.<br>**F3)** Currently for civil structures and components, only observed ageing effects by operation staff are accounted for. Experienced and possible ageing mechanisms are not taken into account in the current maintenance programmes in order to determine suitable method for the detection of ageing effects in civil structures and components.<br>**F4)** The last condition assessment for the civil structures and components was performed in 1996. There is no condition assessment performed recently for the civil structures and components in BR2. | |

**F5)** The plant does not have an efficient data collection and record-keeping systems for trending analysis, e.g. some plant staffs use different format of equipment tag identifiers or different building names for the same building when they input the data into the maintenance database and the NCR database, e.g. plant staff may input pump 'F 18-514' as 'F18-514' or 'F-18-514'; and 'Containment Building' as 'Reactor Building' or as 'Containment Structure'. These make database searches for trending of SSCs to predict performance difficult and ineffective.

**F6)** Reference to the current leak test procedures ST/A 101, ST/W101 and ST/W103 for the airlocks are missing in the Section 5 'Maintenance Task Record' of the ICM reports for Personnel Airlock (SCK-CEN/2424012) and Emergency Airlock (SCK-CEN/2423905).

**F7)** During walk-down of the containment building, concrete block walls were observed inside the building. These concrete block walls have not been considered for potential seismic interaction.

**F8)** During walk-down of the containment building and the machine building, ageing effects and degradation such as cracks, spalling, holes, honeycomb in the concrete structures and dried-out of sealant material were observed.

**3.2 – SAFETY CONSEQUENCE:**

Without a complete ageing management review, the facility would not be able to manage the ageing effects of the civil structures and components and the safe operation of the facility cannot be assured.

**3.3 – RECOMMENDATION/SUGGESTION:**

**R)** The facility should perform a comprehensive ageing management review for civil structures and components.

**3.4 – DOCUMENTS REVIEWED:**

- BR2-VF4-1.1, Rev. 2, BR2 - Plant Asset Management – ACM –fase, 18/02/2015;
- BR2-VF4-1.2, BR2 - Plant Asset Management – ICM-fase31/10/2013;
- BR2-VF4-1.3, BR2 - Plant Asset Management – WMS-fase, 01/09/2014;
- SCK-CEN/2440484, BR2 Plant Asset Management 01:Containment Building, Installation Concept Management Report, 2017-05-03;
- SCK-CEN/2440154, BR2 Plant Asset Management 02:Machine Building, Installation Concept Management Report, 2017-04-30;
- SCK-CEN/2471250, BR2 Plant Asset Management 05:Hall T&C, Installation Concept Management Report, 2017-06-05;
- BR2 Plant Asset Management 06: Hot Cell, Installation Concept Management;
- SCK-CEN/2471245, BR2 Plant Asset Management 08:Diesel Building, Installation Concept Management Report, 2017-05-05;
- SCK-CEN/24712059, BR2 Plant Asset Management 061:Substation Cooling Towers, Installation Concept Management Report, 2017-05-04;
- DE 71.036, SCK – MOL Inspektie Van Het Reaktorgebouw en de Hot Cells Uitgevoerd Door Het;

- NBR2EX04, SCK-CEN Verslag dichtheidstest CB-BR2, 14.04.2016;
- NBR2EX04, SCK-CEN Verslag dichtheidstest CB-BR2, 06.08.2017;
- SCK-CEN/2472003, Report, 2017-04-30;
- ST/W107, Rev. 5, Procedure voor het onder druk plaatsen van de SPR voor de controle van de dichtheid, 25/10/2012;
- SAR001-4.10-ed. 5, Reactor BR2 Safety Analysis Report;
- Report VNS-TR-11-044 Rev.5, Belgium Stress Tests BR2 Seismic Reassessment, 9/12/2011;
- No. 779, Rev. 0, CEN BR2 Containment Building Plan au niv 3.35 (Coffrage) Plan El. 11'-0", 1960-02-16;
- No. 5946, Rev. F, CEN BR2 Containment Building Plan Goujons a Souder a la Coupole pour Gaines, Cables, Revetement, Main Courante, Prise de Courant et Solin, 1960-02-29;
- No. 1879, CEN BR2 Containment Building Etude des Colonnes dans la Paroi Circulaire vue Developpee (3-1-4), 1958-09-25;
- BR2 Containment Building Requirements NDA 68-5, June 27, 1957;
- 4205, Rev. A, BR2 Containment Building Poutre Circulaire au Niv. 3.35 (11'-0"0 Armatures, 29/7/1959;
- BR2 "Containment and Siting of Nuclear Power Plants", 1967;
- ST/W109 Rev. 1, Dichtheidstest Reaktorgebouw, 2014-06-13;
- ST/A101 Rev. 29, Dichtheidskontrole van de Mobiele Organen van het Reactorgebouw;
- ST/W101 Rev. 23, Technische procedure, Nazien van de Weking van de Mobiele Organen;
- ST/W103 Rev. 10, Technische procedure, Bediening van de Mobiele Organen, 12/06/20;
- Procedure voor het onder druk plaatsen van de SPR voor de Controle van de Dichtheid.

| **4. COUNTERPART ACTIONS** | **Date:** D2/M2/ YYY2 |
|---|---|
| n.a. | |
| **5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** D3/M3/ YYY3 |
| **5.1 – FACTS:**<br>**F1)** n.a. | |

| 5.2 – DOCUMENTS REVIEWED: | | |
|---|---|---|
| n.a. | | |
| **5.3 – RESOLUTION DEGREE:** | | |
| **1.** | **Insufficient progress to date** | n.a. |
| **2.** | **Satisfactory progress to date** | n.a. |
| **3.** | **Issue resolved** | n.a. |

n.a.: not applicable for the present mission.

| 1. ISSUE IDENTIFICATION | Issue Number: E - 2 |
|---|---|
| **Research reactor: BR2** | |
| **Reviewed Area: Ageing management review, review of ageing management programmes and revalidation of time limited ageing analyses for civil structures** | |
| **Issue Title:** Incomplete review and update of ageing management programmes for civil structures and components | |
| **2. ISSUE CLARIFICATION** | |
| **2.1 – FUNDAMENTAL OVERALL PROBLEM:**<br>The facility has not completed the review and update of the ageing management programme for civil structures and components, including those for radioisotope production. | |
| **2.2 – IAEA BASIS:**<br>SSG-10<br>2.8 Successful implementation of the ageing management programme requires: Establishing appropriate operating procedures following relevant standards, including procedures for assessing and correcting non-conforming items;<br>2.15 Inspection and tests should be performed by qualified personnel and be in accordance with approved procedures.<br>2.17 Measures should be established to ensure that ageing management activities are accomplished as specified in the appropriate procedures. Such measures should include:<br>– Reviews of procedures;<br>– Verification by inspection, witnessing and surveillance;<br>4.15. The following issues should be taken into account in implementing a systematic ageing management programme:<br>(m) Use of databases on SSC reliability and maintenance histories;<br>4.26 Particular consideration should be given to inspections for degradation of civil structures (including biological shielding),<br>NS-G-4.2<br>2.13 Plant maintenance work should be monitored and trends should be evaluated to identify necessary improvements. | |
| **3. ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** 14/11/2017 |
| **3.1 – FACTS:**<br>**F1)** Periodic leak tests for the sub-pile room, containment building, airlocks and penetrations are performed. However, most of the components of the building structures are not subjected to other appropriate AMP such as visual inspection. | |

**F2)** Other than the roofs and the containment building, the current approach used by the plant for civil structures and components is based on a corrective maintenance approach using the NCR process and they are not inspected on a periodic basis.

**F3)** The new inspection procedures for civil structures and components to be prepared under phase 3 of the PAM project for BR2 are not yet completed.

**F4)** The facility has not considered the attributes of an effective ageing programme (i.e screening of SSCs for ageing management review; identification and understanding of ageing degradation; minimization of ageing degradation; detection, monitoring and trending of ageing degradation; mitigation of ageing degradation; continuous improvement of the ageing management programme; record keeping) in developing or planning a facility ageing management programmes.

**F5)** Currently the existing maintenance and test procedures for civil structures and components, including those for radioisotope production are not coordinated by ageing management programme.

**F6)** The current maintenance programme is not periodically evaluated based on maintenance history, new knowledge and research finding.

**F7)** In the current maintenance programme, the evaluation of the collected data does not include trending analysis.

**F8)** The facility currently does not have a process and a database that support the evaluation of the effectiveness of the current maintenance programme for civil structures and components, including those for radioisotope production.

**F9)** In the visual inspection procedure (ST/Z001) for the canal, acceptance criteria and some potential ageing effects/ degradation mechanisms such as pop-out, honeycomb, exposure of rebars and their corrosion are not identified.

**3.2 – SAFETY CONSEQUENCE:**

Without completing the review and update of the ageing management programme, the ageing effects of the civil structures and components will not be effectively managed and the safe operation of the facility cannot be assured.

**3.3 – RECOMMENDATION/SUGGESTION:**

**R)** The facility should complete the review and update of the ageing management programme for civil structures and components, including those for radioisotope production.

**3.4 – DOCUMENTS REVIEWED:**

- SCK-CEN/2002394, BR2 – Plant Asset Management – Maintenance Concepts and Risk Profiles for AC A, B, C & D SSCs;
- BR2-VF4-1.2, BR2 - Plant Asset Management – ICM-fase, 31/10/2013;
- BR2-VF4-1.3,BR2 - Plant Asset Management – WMS-fase, 01/09/2014;
- ST/W107, Procedure voor het onder druk plaatsen van de SPR voor de controle van de dichtheid, Rev. 5, 25/10/2012;
- ST/W109 Rev. 1, Dichtheidstest Reaktorgebouw, 2014-06-13;
- ST/A101 Rev. 29, Dichtheidskontrole van de Mobiele Organen van het Reactorgebouw;

- Procedure voor het onder druk plaatsen van de SPR voor de Controle van de Dichtheid;
- ST/Z001 Periodieke Controle van de Kanaal Wanden Visuele Inspectie;
- SCK-CEN/2440484, BR2 Plant Asset Management 01:Containment Building, Installation Concept Management Report, 2017-05-03;
- SCK-CEN/2440154, BR2 Plant Asset Management 02:Machine Building, Installation Concept Management Report, 2017-04-30;
- SCK-CEN/2471250BR2 Plant Asset Management 05:Hall T&C, Installation Concept Management Report, 2017-06-05;
- SCK-CEN/2472003, BR2 Plant Asset Management 06:Hot Cell, Installation Concept Management 2017-04-30;
- SCK-CEN/2471245, BR2 Plant Asset Management 08:Diesel Building, Installation Concept Management Report, 2017-05-05;
- SCK-CEN/24712059, BR2 Plant Asset Management 061:Substation Cooling Towers, Installation Concept Management Report, 2017-05-04;
- SCK – MOL DE 71.036, Inspektie Van Het Reaktorgebouw en de Hot Cells Uitgevoerd Door Het;
- NBR2EX04/14.04.2016, SCK-CEN Verslag dichtheidstest CB-BR2;
- NBR2EX04/06.08.2017, SCK-CEN Verslag dichtheidstest CB-BR2;
- SCK-CEN/2472003 Report, 2017-04-30.

| **4. COUNTERPART ACTIONS** | **Date:** D2/M2/ YYY2 |
|---|---|
| n.a. | |

| **5. FOLLOW-UP ASSESSMENT BY THE IAEA REVIEW TEAM** | **Date:** D3/M3/ YYY3 |
|---|---|

**5.1 – FACTS:**

**F1)** n.a.

**5.2 – DOCUMENTS REVIEWED:**

n.a.

**5.3 – RESOLUTION DEGREE:**

| | | |
|---|---|---|
| **1.** | **Insufficient progress to date** | n.a. |
| **2.** | **Satisfactory progress to date** | n.a. |
| **3.** | **Issue resolved** | n.a. |

n.a.: not applicable for the present mission.

## APPENDIX IV – DOCUMENTS AND INFORMATION USED DURING THE REVIEW

*Review area A - Organizational aspects for ageing management and continued safe operation and Review area B - Scoping and screening of SSCs relevant to ageing management*

- Royal Decree on safety of nuclear installations published on 21.12.2011;
- BR-2 72S7680 all volumes, Safety Analysis Report;
- BR-2 72S7680 Vol 3: Technical Specifications;
- R-SER-16-046-0-n_BR-2: Safety Evaluation Report by BEL V;
- 20022438 PAM, Methodology Asset Configuration Management, 8.04.2014;
- 2001799 PAM, Methodology Installation Concept Management, 8.04.2014;
- 2012411 Plant Asset Management, Work order Management and Skills;
- Integrated Management System Portal;
- Database SFO/008 and 013;
- GEC ALSTHOM NT 0000 0001, 17.11.1994;
- Database Document Management System Alexandria Dagverslag-2017;
- BR-2 – NBR2-2020-00;
- SAR Vol 4 CH 7, The Reactor Vessel References 1- 24;
- Meeting Report: BR-2 Co-ordination meeting;
- 169-INS-1530: INS- Work Instruction;
- SFH/606 and SFB/941 equipment test reports;
- BR2/SVD/NBR2-2020-2012-03;
- BR2-VF1-1.2;
- BR-2-VF4-1.1 rev 2;
- BR-2-VF4-1.2;
- BR2-V4-1.1.pdf.
- Electrical and I&C database.

*Review area C – Ageing management and time limited ageing analyses of mechanical components*

- SCKCEN/2423998, ABV-4-1301: PAM: ICM Report;
- ICM Methodology Report: SCKCEN/20023942002394, Maintenance Concepts and Risk Profiles for AC A, B, C & D SSCs;
- SCKCEN/3659969, ABV 30-4-617; ABV 30-4-619; ABV 30-4-621;
- SCKCEN/2450926, H 4-501; H 4-502; H 4-503;
- SCKCEN/2413182, ABV 4-1304; ABV 4-1305;
- SCKCEN/2449844, T 4-801;

- SF/G 115, Cyclus: 05/2017 A;
- RCA/2017-195/PV, Certificaat van Analyse;
- BR2 Opleidingsmatrix ROP: Continue (Herkwalificatieperiode 3 jaar), Periode 2016 – 2018;
- Evaluation of Neutron Fluences in Al Vessel of BR2: From 1963 to end 2016;
- Methodology Report for Reactor Load and Core Physic Management;
- SCKCEN/2230879, Evaluation of the input data for the assessment of the RPV;
- MCNP Evaluation of Neutron Fluences in the 4th Be Matrix of BR2 in Year 2016;
- Numerical data of cycle 05/2017.

*Review area D – Ageing management and time limited ageing analyses of electrical and I&C components*

- Magazine spare parts Database of Electrical and Non-Nuclear Instrumentation SSCs;
- BR2-NBR2-2020-00, SCK•CEN/20110279 – Asset Configuration Management Report;
- Electrical and I&C ICM database in excel format output;
- ST/H002, Standard procedure for walkthrough each week (Standaard procedure voor de wekelijkse rondgang door dienst elektriciteit);
- SO/040 - Niet standard operatie – Operation non-standard form;
- Specific failure forms per battery type (Specifiek faalvormen per batterijtype);
- Intervention Sheet - Intermediate Team EWOKI (Interventiefiche – Tussenkomst Ploeg EWOKI;
- 10:00 hr. Every day meeting (Dagverslag BR2 van 07 November 2017 POST 3;
- SF/O/08, Modification Order to modify the installation BR2 (Demande d'etude ou de modification de l'installations BR2;
- NFPA 70 B, Recommended Practice for Electrical Equipment Maintenance, (2010 Edition in excel format output;
- Thermographic inspection of electrical installations in operation (Thermo-grafisch Onderzoek van de elektrische installaties in werking);
- Testing the reverse by diesel groups (Testen van de reverse door dieselgroepen);
- Battery follow up sheet database;
- Control Rod test form (Controlestaven/ barres de controle form);
- Regelstaaf R2 Cyclus 03/17 PD 0m3/h, Regulating rod control test form, 21-04-2017;
- Regelstaaf R2 Cyclus 03/17 PD 6000/m3/h, Regulating rod control test form, 01-05-2017;
- Linear Channels data logger trend chart during operational state, Yokogawa chart records;

– Linear Channels data logger trend chart during operational state, Bidasse chart records;

– Technical Support Office database outputs.

*Review area E – Ageing management and time limited ageing analyses of civil structures*

– SCK-CEN/2002394, BR2 – Plant Asset Management – Maintenance Concepts and Risk Profiles for AC A, B, C & D SSCs;

– BR2-VF4-1.1, Rev. 2, BR2 - Plant Asset Management – ACM –fase, 18/02/2015;

– BR2-VF4-1.2, BR2 - Plant Asset Management – ICM-fase31/10/2013;

– BR2-VF4-1.3, BR2 - Plant Asset Management – WMS-fase, 01/09/2014;

– SCK-CEN/2440484, BR2 Plant Asset Management 01:Containment Building, Installation Concept Management Report, 2017-05-03;

– SCK-CEN/2440154, BR2 Plant Asset Management 02:Machine Building, Installation Concept Management Report, 2017-04-30;

– SCK-CEN/2471250, BR2 Plant Asset Management 05:Hall T&C, Installation Concept Management Report, 2017-06-05;

– BR2 Plant Asset Management 06: Hot Cell, Installation Concept Management;

– SCK-CEN/2471245, BR2 Plant Asset Management 08:Diesel Building, Installation Concept Management Report, 2017-05-05;

– SCK-CEN/24712059, BR2 Plant Asset Management 061:Substation Cooling Towers, Installation Concept Management Report, 2017-05-04;

– DE 71.036, SCK – MOL Inspektie Van Het Reaktorgebouw en de Hot Cells Uitgevoerd Door Het;

– NBR2EX04, SCK-CEN Verslag dichtheidstest CB-BR2, 14.04.2016;

– NBR2EX04, SCK-CEN Verslag dichtheidstest CB-BR2, 06.08.2017;

– SCK-CEN/2472003, Report, 2017-04-30;

– ST/W107, Rev. 5, Procedure voor het onder druk plaatsen van de SPR voor de controle van de dichtheid, 25/10/2012;

– SAR001-4.10-ed. 5, Reactor BR2 Safety Analysis Report;

– Report VNS-TR-11-044 Rev.5, Belgium Stress Tests BR2 Seismic Reassessment, 9/12/2011;

– No. 779, Rev. 0, CEN BR2 Containment Building Plan au niv 3.35 (Coffrage) Plan El. 11'-0", 1960-02-16;

– No. 5946, Rev. F, CEN BR2 Containment Building Plan Goujons a Souder a la Coupole pour Gaines, Cables, Revetement, Main Courante, Prise de Courant et Solin, 1960-02-29;

– No. 1879, CEN BR2 Containment Building Etude des Colonnes dans la Paroi Circulaire vue Developpee (3-1-4), 1958-09-25;

– BR2 Containment Building Requirements NDA 68-5, June 27, 1957;

– 4205, Rev. A, BR2 Containment Building Poutre Circulaire au Niv. 3.35 (11'-0"0 Armatures, 29/7/1959;

- BR2 "Containment and Siting of Nuclear Power Plants", 1967;
- ST/W109 Rev. 1, Dichtheidstest Reaktorgebouw, 2014-06-13;
- ST/A101 Rev. 29, Dichtheidskontrole van de Mobiele Organen van het Reactorgebouw;
- ST/W101 Rev. 23, Technische procedure, Nazien van de Weking van de Mobiele Organen;
- ST/W103 Rev. 10, Technische procedure, Bediening van de Mobiele Organen, 12/06/20;
- Procedure voor het onder druk plaatsen van de SPR voor de Controle van de Dichtheid;
- ST/Z001 Periodieke Controle van de Kanaal Wanden Visuele Inspectie;
- SCK – MOL DE 71.036, Inspektie Van Het Reaktorgebouw en de Hot Cells Uitgevoerd Door Het.