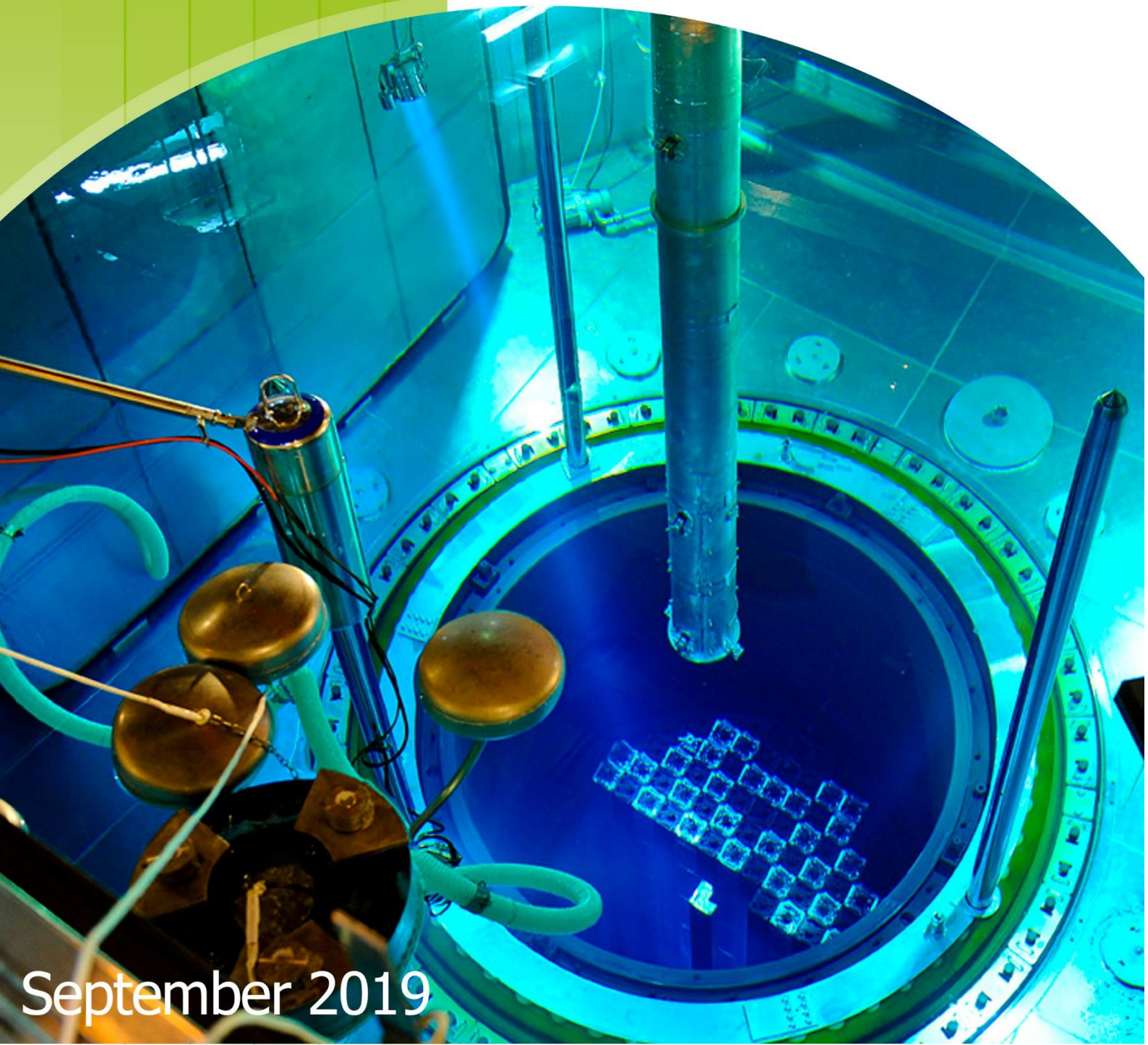
ENSREG TOPICAL PEER REVIEW 2019

FANC

federal agency for nuclear control

Ageing Management

Belgian Action Plan



September 2019

EU Topical Peer Review

Ageing Management of

nuclear power plants and research reactors

Belgian National Action Plan

Federal Agency for Nuclear Control

2019

Content

1. INTRODUCTION

Context

In 2014, the European Union (EU) Council adopted directive 2014/87/EURATOM amending the 2009 Nuclear Safety Directive to incorporate lessons learned following the accident at the Fukushima Daiichi nuclear power plant in 2011. Recognising the importance of peer review in delivering continuous improvement to nuclear safety, the revised Nuclear Safety Directive introduces a European system of topical peer review which will commence in 2017 and will be repeated every six years thereafter. The purpose is to provide a mechanism for EU Member States to examine topics of strategic importance to nuclear safety, to exchange experience and to identify opportunities to strengthen nuclear safety. The member states, acting through the European Nuclear Safety Regulators Group (ENSREG), have decided that the topic for the first topical peer review is **Ageing Management**.

Scope

It was decided that topical peer review will cover the following types of nuclear installations:

- Nuclear power plants;
- Research reactors with a power equal to 1 MW_{th} or more;

that are still in operation on 31st December 2017 or under construction on 31st December 2016.

Ageing Management

Ageing and ageing management are defined as below in the terms of reference of the Topical Peer Review :

- **Ageing** is considered as a process by which the physical characteristics of a structure, system or component (SSC) change with time (ageing) or use (wear-out).
- **Ageing management** is understood as the engineering, operations and maintenance actions undertaken by a licensee to prevent or to control within acceptable limits ageing degradation of structures, systems and components (SSC) of its installation. With regard to safety it ensures the availability of required safety functions throughout the service life of the plant, with account taken of changes that occur with time and use and by considering all service conditions.

Topical Peer Review Process

National Assessment Report (NAR)

The first stage of the peer review process was the production of a national assessment report for each country participating in the topical peer review by December 2017.

The objectives of the National Assessment Report (NAR) were to:

- describe the overall ageing management program including:
  - Programmatic aspects;
  - Implementation of overall ageing management program;
  - Experience of the application of ageing management;
- assess the outcomes to identify main strengths and weaknesses;
- identify actions to address any significant areas of improvement;
- produce a report in sufficient detail to allow a meaningful peer review.

Full specifications for achieving the NAR were provided by ENSREG.

Peer Review

The second stage of the peer review process was the peer-review itself during which National Assessment Reports were examined by other countries in order to share operating experience, identify good practices, common issues and follow-up actions to address the challenges posed by ageing management of nuclear facilities.

Action Plan

The third phase of the peer review process is the definition of a National Action Plan for addressing the challenges and areas of improvement allocated during the peer review and to meet the identified expected level of performances. In accordance with the Council Conclusions of March 18th 2019 and the ENSREG decision of March 25th 2019, countries that participated in the 1st TPR process should deliver their National Action Plans (NAcPs) for Nuclear Power Plants and Research Reactors by the end of September 2019.

A report on the implementation status is foreseen at the end of a follow-up phase, in December 2023.

Full details on the complete process for developing the Topical Peer Review are presented in the terms of reference and technical specifications by ENSREG.

A new topical peer review will take place in 2024 on another topic, still to be defined.

Belgian national Action Plan

Scope

This document presents the Belgian National Action Plan developed to tackle the findings identified concerning the ageing management and ageing management programs for both the NPP licensee and the Research reactors licensee, in each step of the Topical Peer Review.

The Belgian situation and, so the Belgian NAcP, may differ from other countries as no specific findings were attributed from the peer review phase of the National Reports and in the final ENSREG report on ageing and ageing management, while several findings were identified by the licensee itself or by the Belgian Safety Authority during the self-assessment phase.

As a consequence of that the NPP licensee had already addressed and resolved most of the issues identified during the self-assessment phase before the redaction of the Belgian National Assessment Report. As most self-assessed findings were already resolved in the self-assessment phase and no specific finding was attributed to Belgian NPP, the Belgian NAcP for NPP is mostly limited to position Belgium in relation to the Good Practices attributed to other countries and to present the situation with respect to generic ENSREG findings on cables management.

For the Research Reactor BR2, most findings identified during the self-assessment had still to be answered at the end of the self-assessment phase and the way for their resolution is detailed in the present report.

No specific findings were attributed to any Research Reactors during the peer review phase, while BR2 meets all Good Practices identified for Research Reactors, so that no additional actions to the ones self-assessed by Belgium is considered for the BR2 research reactor.

Finally, in order to fulfil the board recommendation detailed in chapter 6 of the present report, it is the intention for Belgium to present on a voluntary basis the ageing management and ageing management programs for other nuclear facilities in Belgium in a forthcoming revision of this NAcP.

Process

- **Self-assessment**

In parallel to the Belgian NAR, the Belgian Safety Authority requested the licensees to address in an action plan all the findings identified during the self-assessment phase. The NPP licensee resolved on-line the weaknesses identified during the self-assessment. This step mainly concerns thus the SCK•CEN, license holder of the BR2 research reactor.

As mentioned in section 2.B.3.1 of the NAR, the overall Ageing Management Program by the BR2 is conducted since 2012-2013 in the framework of the preparation for a LTO for the BR2 as well as the preparation for the last PSR and the transposition of the WENRA Reference levels in the Belgian regulation.

As mentioned in section 2.B.6 of the NAR, SCK•CEN was required by the Safety Authority to carry out a periodic safety evaluation and report on it before June 2016 (PSR 2016), accordingly to IAEA safety standards. In accordance, the ageing management program of the BR2 was part of this PSR 2016, throughout the Safety Factor 4 of the PSR. The Safety Authority reviewed and approved in December 2016 the first stage of the ageing management program which concerned the overall methodology and the scoring of SSCs. Through the action plan resulting from the PSR 2016, SCK•CEN was required to complete the second and third stages (concerning respectively the development of inspection and maintenance strategy and the development of maintenance and inspection procedures) of the ageing management program before June 2019.

Still in section 2.B.6 of the NAR, it was indicated that the recommendations and observations relevant to the overall ageing management program that were provided during the IAEA Safety Review Mission on ageing management and continued operation of the BR2 carried out in November 2017, had to be integrated in an update of the PSR 2016 action plan to address these issues.

Similarly, it was requested by the Safety Authority to update the BR2 PSR 2016 action plan to address the findings on ageing and ageing management program identified during the self-assessment phase. SCK•CEN was required to improve and implement the ageing management program of the BR2 to reach a level that is commensurable with the best international standards and practices for research reactors. The BR2 Action Plan was therefore integrating the action plan issued from the PSR safety assessment, as much as possible, the recommendations of latest IAEA standards and guidance, the recommendations and observations from IAEA Safety Review Mission on ageing management and continued operation of the BR2 carried out in November 2017 and the recommendations from the Safety Authority in order to fill the gaps identified throughout the TPR assessment.

The BR2 Action Plan was originally planned to be fully implemented by June 2019. However, it suffers some delays and should be finalized by the end of 2019 instead of June 2019.

- **Peer review**

Since no specific findings were attributed from the peer review phase of the National Assessment Reports and in the final ENSREG report on ageing and ageing management, the Belgian Safety Authority requested the NPP licensee to address in an action plan the generic findings on cable management and to position themselves with reference to the Good Practices identified by ENSREG.

The action plan was finalized by the licensee in early 2019 and approved by the Safety Authority. Concerning the gaps with reference to the generic findings on cable management, most actions have already been finalized or have been incorporated in ongoing research programs. Concerning the position with reference to the Good Practices, two situations appears. In the first case, the

remedial action would take an important time that would bring too few added value taking into account the short remaining lifetime of the Belgian units. This is the case for example of the implementation of a shielding within the core to reduce neutron flux on the RPV wall. In those cases, it was decided to not follow those Good Practices. In the second case, whenever the remedial action is possible in a timely manner, an action was launched.

Outputs

The NAcP is intended to enable progress to be monitored against the range of findings emerging from the TPR and it will also inform future TPR follow-up activities by ENSREG.

2. FINDINGS RESULTING FROM THE SELF-ASSESSMENT

2.1. Overall Ageing Management Programmes (OAMPs)

2.1.1. Belgian finding AMP-1- Challenge

Nuclear Power plants : Extension of the new ageing management program to the ageing management program of Tihange 2&3 and Doel 3&4 based on the program installed for the LTO units, and using the most recent international standards and guidance.

2.1.2. Belgian position and action on AMP-1

As mentioned in the Belgian NAR (p. 13, 33, 35, 36, 37), ENGIE Electrabel takes currently action for these units to move towards an ageing management program based on the program installed in the LTO units (Tihange 1 and Doel 1&2) and on the most recent international guidelines. This action is included within the upcoming PSRs of these units.

The Belgian Safety Authority agrees with the proposed deadlines for the four units. The action is considered closed.

2.1.3. Belgian finding AMP-2- Area for improvement

Nuclear Power plants : Investigate whether and how the ageing programs need to be adapted to avoid ageing issues, inadequate ageing monitoring and inadequate remedial actions for some concrete degradations.

2.1.4. Belgian position and action on AMP-2

The Belgian Safety Authority conducted several inspections in 2018-2019 in both Doel and Tihange NPPs specifically dedicated to the process and performances for In-Service Inspections (ISI) of the concrete structures and buildings of the NPPs.

Those inspections conclude that the ageing management program for concrete buildings, and more specifically the ISI program for the concrete structures, were uncomplete and insufficient to guarantee that most concrete degradations can be identified and followed-up for years, but mainly to guarantee that the potential impact of those identified concrete degradations on the safety functions of the structure is systematically assessed. The ISI program was suitable for classic civil structures in relatively standard external conditions and was not adapted for tackling specific issues related to civil structures in unusual external conditions (temperature, humidity, steam jets…).

The Belgian Safety Authority requested in accordance the licensee to develop a new process, based on the latest international standards, for performing In-Service Inspections on civil structures, assessing the impact of the defects identified, guarantying a follow-up of the defects and assuring an adequate AQ of the process. The Safety Authority required the licensee to perform a complete new ISI campaign of all civil structures once the new process and the underlying procedures for inspection will be approved by the Safety Authority

The licensee presented in early 2019 an action plan for answering all the findings of the Safety Authority in a timely manner. The action plan and the associated planning were discussed and approved by the Safety Authority. Most actions were due by June or September 2019 and have been realized in due time. The few remaining actions are due for December 2019. The licensee started in June 2019 the new ISI program and plans to complete its application to all civil structures by 2021.

The Belgian Safety Authority has planned a last inspection by the end of 2019 in order to assess the progresses brought on the ISI process.

2.1.5. Belgian finding AMP-3- Area for improvement

Research Reactor BR2 : The licensee shall extend the scope of the ageing management program to include all SSCs relevant for safety that are present within the premises of the BR2. Notably the hot cells, experimental devices and spent fuel storage system should be included. In addition, spare parts for safety related SSCs that are in stock should also be included.

2.1.6. Belgian position and action on AMP-3

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment. The licensee proposed the following actions in order to address the finding:

- Completeness of the inventory
  - Hot cell facilities

    The operation of the hot cell facilities was not included in the in the original scope of the ageing management program because the operation is the responsibility of a different expertise group. However, the components that can have an effect on the safety and operation of BR2 are included as part of other systems. These are the ventilation, the structure and hoisting devices.

    Action

    Assets necessary for the operation of the hot cell (such as manipulators, internal locks) are to be included in the ageing management program. The action is to be completed within the scope of the AMP.

  - Experiments

    An irradiation device is considered as an experiment if the following criteria are fulfilled:

    - The device can be easily loaded and unloaded from the core. Unloading can be done in a normal shutdown without special precautions.
    - The device has a limited utilization period, although this can be a number of years.
    - The device is not intended for radioisotope production

    Approval of an experiment is obtained after the advice of the Committee for the Evaluation of Experiments (CEE). The requirement of the actual CEE procedure foresee a review of the experiment after 5 years of operation.

    Action

    The CEE procedure will be modified such that an ageing management is included in the evaluation of the experiment. At this time no experiments are loaded with an irradiation time that would require a formal ageing management. Existing experimental devices that are not in use will be checked and an AMP will be defined if necessary. The action can finished within the scope of the AMP.

  - Irradiation rigs

    Irradiations rigs are usually intended for isotope production or silicon irradiation and remain for a long time in the core. They are within the scope of the AMP.

    Action

    It is to be checked that all irradiation rigs are indeed included within the AMP.

- Spent fuel

  Spent fuel is a separate system in BR2 and is therefore not found in the AMP in an explicit manner. However , all assets which must guarantee the safety of the spent fuel are included in the AMP. These are:

  - System A: Buildings for the structure of the storage pool
  - System D: Pool and canal circuits
  - System M: Ventilation
  - System P: Manipulation

  No further action is required.

- Spare part management

  The spare parts management strategy is part of the Workorder Management and Skills (WMS) phase of the AMP. The methodology will be reviewed and eventually adapted to include ageing management of spare parts.

  No dedicated action or significant modification of the WMS procedure is necessary.

The Belgian Safety Authority accepted the proposed actions by the licensee.

2.1.7. Belgian finding AMP-4- Area for improvement

Research Reactor BR2 : the on-going development of the ageing management program should be focused on safety-related SSCs.

2.1.8. Belgian position and action on AMP-4

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment. The licensee proposed the following actions in order to address the finding:

- Safety classification

  The Ageing Management Program is developed in 3 steps:

  1. The Asset Configuration Management (ACM)
  2. The Installation Concept Management (ICM)
  3. The Workorder Management and Skills (WMS)

  The ACM phase is a first scoring of all assets. It is a system to define the most important assets. It obvious that priority must be given to safety related systems. The scoring is made using 3 numbers:

  - Safety relevance: 0, 1 or 2, with 0 for safety critical components
  - Impact of failure on the operation: 1, 2 or 3, with 1 for the components with the most important impact.
  - Replacement cost: 1, 2, 4 or 6, with 1 for the most expensive component to replace.

  These three score are multiplied in order to obtain a global asset score and to divide all assets in 4 classes:

  - Class A: global score 0 to 4
  - Class B: global score 5 to 18
  - Class C: global score 19 to 24
  - Class D: global score 25 to 36.

  Class A will get the most developed maintenance, while for class D repair in case of failure is sufficient.

It is to noted that all safety critical assets (safety score 0) are in class A, no matter their other scores. All safety related assets are in class A or B, no matter their other scores. However, it is possible that an asset without safety importance (safety score 2) is classified in A or B.

The ACM classification is only used as a way to determine which assets would require a more detailed ICM analysis. This ICM document, which is made for all class A and B assets, lists all safety functions of the asset and defines what kind of maintenance and replacement procedures must be developed (WMS phase). WMS procedures that deal with the safety aspects of an asset have priority for execution.

Action

In order to clarify the safety aspects in a more explicit way, the original safety score is to be repeated on the WMS procedures, together with the instruction that procedures about assets with safety score 0 have first priority. The action is included in the process of the Plant Asset Management (PAM) assessment and will be completed as foreseen in the PAM process.

The Belgian Safety Authority accepted the proposed action and planning by the licensee.

2.1.9. Belgian finding AMP-5- Area for improvement

Research Reactor BR2 : The licensee shall develop procedures to review and update the ageing management program once the current implementation phase is completed and to measure its effectiveness.

2.1.10. Belgian position and action on AMP-5

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment. The licensee proposed the following actions in order to address the finding:

Revision of the AMP is one of the items of the 10 year periodical safety review (safety factor 4). The AMP was evaluated on the occasion of the periodical safety review of 2016 and will be reviewed during the periodic safety review of 2026. Between these revision periods updates will be made in case of significant return of experience. It is to noted that an AMP is a continuous and cyclic process. A continuous evaluation is necessary and updates can be performed at any time.

2.2. Electrical cables

2.2.1. Belgian finding EC-1- Area for improvement

Research Reactor BR2 : The licensee shall establish a formal ageing assessment program for all safety related electrical cables. Priority should be given to neutron flux instrumentation cables and the 110V cables. The ageing management program should then be upgraded in accordance.

2.2.2. Belgian position and action on EC-1

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment.

Electrical cables are included in the actual ageing management program. A separate approach is made for the ICM phase for electrical assets, as it is not possible to treat each component separate. The WMS phase is under development.

Action

The current ICM methodology is to be reviewed using IEEE standard 1205-2014 “IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Electrical Equipment Used in Nuclear Power

Generating Stations and Other Nuclear Facilities". This actions requires resources beyond the original PAM project. This action is planned to be finished by the end of 2019.

The Belgian Safety Authority approved the scope and the planning of the proposed remedial action by the BR2 licensee.

2.2.3. Belgian finding EC-2 - Area for improvement

Research Reactor BR2 : The licensee shall perform walk-downs in order to confirm the absence of adverse environment (e.g. wetting or abnormal local cable's heating mechanisms) and in support of the development of the ageing assessment program for the electrical cables. Particular attention is needed for the safety related cables that were not recently replaced or that are not planned to be replaced in the future (for instance the 110V cables and instrumentation cables).

2.2.4. Belgian position and action on EC-2

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment.

- Neutron flux measurement cables

  Failure of the neutron flux measurement cables (due to ageing or other causes such as mechanical damage) is not a safety critical failure mode, due to the fail safe design of the SCRAM logic. The nuclear instrument cables are mineral insulated coax, which have no observable known ageing mechanism. Spare cables are available as part of the spare part management of WMS.

  Action

  The Failure Mode Effects and Criticality Analysis (FMECA) of the cables were to be reviewed by June 2019.

- High voltage and 110 VDC cables

  The electrical feed systems is part of the FMECA.

  - The safety critical failure modes of the 110 VDC can be identified in the ICM reports. The impact of ageing is limited due to:
    - Mild operation conditions (moderate temperature and limited radiation)
    - The system is single failure proof for earthing faults, because the grid is not earthed (floating potential) such that 1 earthing fault will result in a earthed grid that remains fully functional. The systems is continuously checked for earthing faults , with alarm if a fault is detected. The resistance towards earth is reported each week.
  - All the high voltage cables with safety functions are renewed on the occasion of the renewal of the substation 2 and the preparation for the new diesel generators.

  Action

  The FMECA of the cables were to be reviewed by June 2019.

The Belgian Safety Authority approved the scope and the planning of the proposed remedial action by the BR2 licensee.

2.2.5. Belgian finding EC-3 - Area for improvement

Research Reactor BR2 : The licensee shall demonstrate that the safety related cables can fulfil their safety function in all relevant accidental conditions.

2.2.6. Belgian position and action on EC-3

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment.

The ICM analysis of the electrical cables gives no severe adverse conditions. The normal operating conditions are mild (temperature below 50 °C, dry environment, low radiation). Controls and monitoring are done according to the Belgian regulation on electrical installations.

Actions

The WMS procedures for building is to be completed with instructions for monitoring the environment of electrical cables. The action is integrated within the scope of the current PSR program (June 2016).

The Belgian Safety Authority approved the scope and the planning of the proposed remedial action by the BR2 licensee.

2.3. Concealed pipework

2.3.1. Belgian finding CP-1- Area for improvement

Research Reactor BR2 : Additional monitoring, testing, sampling or inspection activities should be implemented for:

- the piping for transport of pool water from the reactor building to the storage basin under the ventilation building,
- the fuel transport piping for the Diesel generators and
- the concealed part of the feed water line for firefighting in the reactor building.

2.3.2. Belgian position and action on CP-1

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment.

- Pool water transfer piping

  The piping for transport of pool water between the reactor building and the storage basin under the ventilation building was replaced in 2016 by stainless steel piping. This is no longer a concealed pipe as it is placed in a concrete trench which is accessible.

  Action

  The IMS and WMS phase is to be completed. This is part of the normal PAM process and will be completed as foreseen.

- Fuel piping for diesel generator

  The fuel piping for the diesel generators was replaced in 1995, on the occasion of the removal of the old fuel tanks. The new piping is placed according the current regulation for environmental protection and is equipped with a leak detection system. The piping has to be replaced again due to the new location of the new diesel generators

  Action

  The ageing management program for the new fuel piping will be defined when the new diesel generators are installed. This is foreseen at the end of 2019.

- Feed water line for fire extinguishing

  The fire extinguishing system is not included in the PAM system, as this system in managed by the internal fire brigade for all SCK installations. The piping is periodically tested by the internal fire brigade.

Action

The follow up of the fire extinguishing system is to be included. This can be completed within the normal period to the PAM project for the piping between the fire water feed system and the containment building.

2.3.3. Belgian finding CP-2- Area for improvement

Research Reactor BR2 : The need for a replacement of the piping for city water should, based on the projections provided by SCK•CEN, be investigated.

2.3.4. Belgian position and action on CP-2

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment.

- City water

  The only safety function of city water is the cooling of the diesel generators. The new generators will be air cooled and the feed of city water will have no longer a safety function. On rare occasions, the city water was also used for experiments. For future experiments, it will be stated that the city water feed is not a safety element.

  Action

  No dedicated action is necessary.

2.3.5. Belgian finding CP-3- Area for improvement

Research Reactor BR2 : It is suggested to consider additional monitoring, testing, sampling or inspection activities for city water and feed line for cooling water from the lagoon;

2.3.6. Belgian position and action on CP-3

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment.

- City water: see §2.3.4
- Lagoon water

  The piping of the lagoon water cooling has been replaced in 2016. Its main use is the cooling of hydraulic speed regulators of the primary pumps. This function is required for safety. The lagoon water circuit can also be used as a backup cooling for the diesel generators.

  Action

  No dedicated action is necessary.

The Belgian Safety Authority accepted the position of BR2 licensee. No additional action were deemed necessary concerning the feed line for cooling water from the lagoon since their replacement was part of the overall PSR action plan.

2.3.7. Belgian finding CP-4- Area for improvement

Research Reactor BR2 : It is suggested to update or validate the ageing management program for concealed piping based on data obtained from the piping that was removed.

2.3.8. Belgian position and action on CP-4

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment. However it is recalled that the amount of concealed pipeworks is very limited for the BR2 research reactor.

2.4. Reactor pressure vessel

2.4.1. Belgian finding RPV-1- Area for improvement

Research Reactor BR2 : The ageing management of the RPV of BR2 should be extended by explicitly tracking the number of stops that provide the most severe loads for low cycle fatigue and compare this number with the established limit.

2.4.2. Belgian position and action on RPV-1

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment.

The low cycle fatigue analysis of the vessel gives, according to the conservative assumption of this analysis, a limit of 175 fast pressure drops from nominal pressure (12 bar) to a pressure lower than 5 bar. This occurs only when, after a scram, the secondary cooling remains in full operation. The pressure drop is caused by a fast reduction of the temperature of the primary water which results in the contraction of the water. The automatic pressurizer system cannot compensate this fast transient. However, in most cases the secondary flow is reduced after a scram, which makes that the temperature of the primary water remains high enough to avoid the pressure drop. The number of transients is low (it has been checked in 1996 and lies far below the calculated limit). The actual number could not be readily given.

Action

The documentation about the reactor operation will be checked and the number of emergency stops with pressure drop below 5 bar will be counted. This action was planned to be completed in June 2018. The number will be noted in the documents prepared for each cycle.

The Belgian Safety Authority approved the scope and the planning of the proposed remedial action by the BR2 licensee.

2.5. Concrete containment structure and pre-stressed concrete pressure vessel

2.5.1. Belgian finding CC-1- Area for improvement

Research Reactor BR2 : the need for monitoring, testing, sampling and inspection activities as well as for preventive and remedial actions should be determined on the basis of a dedicated ageing assessment.

2.5.2. Belgian position and action on CC-1

As mentioned in the Belgian presentation during the TPR workshop, this finding was integrated in the PSR action plan in order to fill the gaps identified throughout the TPR self-assessment.

The containment building is included in the PAM project. It has a safety score 0 in the ACM table. Therefore, a detailed ICM analysis is prepared. The last phase of the definition of the ageing management program (WMS instructions) must still be defined.

In 1996 an inspection of the building structure was made by a specialized organisation. No structural damage was found. A few cracks were repaired. However this inspection was not completed with a

formal follow up program. It is to be noted the a periodical test of the tightness (confinement) of the reactor building is done according to the requirement of the licence.

Action

An inspection and follow up program is to be defined according to a qualified norm. The action (inspection and definition of the program) was to be finished within the scope of the normal PAM project (June 2019).

The Belgian Safety Authority approved the scope and the planning of the proposed remedial action by the BR2 licensee.

3. COUNTRY SPECIFIC FINDINGS RESULTING FROM THE TPR

There were no country specific findings addressed to Belgium resulting from the Topical Peer Review.

4. GENERIC FINDINGS RELATED TO ELECTRICAL CABLES

The situation of the ageing management program of the NPP Licensee with respect to the generic ENSREG findings on cables management is described below.

4.1. Good practice: characterize the state of the degradation of cables aged at the plant

Cables are aged within the actual power plant environment and tested to assess cable condition and determine residual lifetime.

4.1.1. Country implementation

For the cable deposit of Doel 2, generations 3 and 4 samples were extracted and investigated in 2018. Cables characteristics are determined by a set of tests: elongation at break, FTIR, electrical tests… The investigations have shown that no unexpected ageing occurred on the cables. The cables did not reach their end of life and the results are compared with the test data from previous RSQ programs. For the cable deposit installed in Doel 3 and Tihange 2, sample extraction is foreseen after 5 years of operation of the plants. This time frame has not been reached yet for these cable deposits.

Currently no LOCA test has been performed on 3rd and 4th generation cables extracted from the cable deposits. ENGIE Electrabel will take a LOCA-test in consideration when new samples will be extracted from the cable deposits if significant ageing-degradation is observed after execution of our test program.

For the LTO of Tihange 1 and Doel 12, ENGIE Electrabel has successfully performed LOCA tests on the first generation cables Hypalon and PVC cables which served for 40 years in the power plants and which were thereafter additionally aged. Ad hoc, ex-service cables of interest are investigated in the laboratory.

ENGIE Electrabel does not calculate the residual life time but gives a monitoring mark to the cables which is linked to the condition of the cable.

During the SALTO mission in Tihange 1 in 2015, IAEA reviewers concluded that *"the cable deposit for the ongoing ageing management programme and equipment qualification is well organised and in accordance with the international state of the art. The team considered this as a good performance."*

4.1.2. Country planned action if relevant

Based on the ongoing study program and the assessment performed during the LTO reviews for Doel 1&2 and Tihange 1, and for the TPR self-assessment, the Belgian Safety Authority does not consider that an additional action is required.

4.2. TPR expected level of performance: documentation of the cable ageing management program

The AMP is sufficiently well-documented to support any internal or external reviews in a fully traceable manner.

4.2.1. Country implementation

As extensively discussed in the NAR, sections 2.A.3, 2.A.4, 3.A.1 and 3.A.2, the AMP's are updated on a regular base. The overall Ageing Management Program has been reviewed in the framework of the latest PSR (2012-2015), under Safety Factor 4 "Ageing" according to IAEA Safety Guide NS-G-2.10.

The assessments performed in the framework of the PSRs showed that the scope of the overall Ageing Management Program is complete. They cover all ageing mechanisms and can be managed in line with international standards (IAEA's Safety Guide NS-G-2.12).

SALTO peer review missions were organized at Tihange 1 in January 2015 and at Doel 1&2 in 2017. The IAEA teams concluded that those plants have worked extensively in the field of LTO and ageing management. IAEA review teams did not raise any comments, suggestions or recommendations on this specific topic.

Specifically for electrical cables, the NAR describes in section 3.A.1.1 the additional tools developed to strengthen the cable ageing management program. *"ENGIE Electrabel improved its existing cable management practices, leading to the development of an action plan in 2011 and the launch of a Cable Management Program (CMP) in 2013. The objective of the CMP is to identify and manage general ageing problems, anticipate failures and trace and transfer knowledge about this infrastructure (inventory, inspection results and maintenance history). ENGIE Electrabel has deployed the CMP in all seven Belgian nuclear units. To support the CMP and facilitate its deployment, ENGIE Electrabel implemented a software platform. The tool is used to capitalize on information (e.g. REX, cable environments, etc.) and it encourages the standardisation of practices in ENGIE Electrabel NPPs. In addition, it enables better management of cable ageing by facilitating the exploitation of test results and inspections and by providing decision-making tools."*

4.2.2. Country planned action if relevant

The Belgian Safety Authority fully supports the statement expressed in this ENSREG finding. This finding applies to all the Ageing Management Programs.

The Belgian Safety Authority considers that the documentation of the cable management program of ENGIE Electrabel is in line with the expectations.

4.3. TPR expected level of performance: methods for monitoring and directing all AMP-activities

Methods to collect NPP cable ageing and performance data are established and used effectively to support the AMP for cables.

4.3.1. Country implementation

The cable databases are updated and are used to support the AMPs.

For Tihange 1 and Doel 12 a list of inaccessible HV-cables exists. This list was part of AMPE3 which is described for the LTO-projects.

Meanwhile initiatives were started in Tihange and Doel to identify the inaccessible HV, MV and I&C-cables for the other reactor units. Projects are running till end 2019.

4.3.2. Country planned action if relevant

The ongoing actions are adequate and no additional action was required in the framework of the TPR findings on Electrical Cables Ageing Management.

4.4. TPR expected level of performance: Systematic identification of ageing degradation mechanisms considering cable characteristics and stressors

Degradation mechanisms and stressors are systematically identified and reviewed to ensure that any missed or newly occurring stressors are revealed before challenging the operability of cables.

4.4.1. Country implementation

ENGIE Electrabel has different R&D project related to the ageing mechanisms of cables.

ENGIE Electrabel is continuously looking for new degradation mechanisms when following the condition of the cables by the CMP. The AMP's are reviewed on a regular base. This review integrates the latest findings of the REX and additional degradation mechanisms if necessary.

ENGIE Electrabel participated in the last years in the European ADVANCE project and the IAEA-coordinated research project (international). ENGIE Electrabel participates each year as well to the EPRI users conference. Engie Laborelec is as well actively involved in the follow up of cable ageing of other industries. The REX of these activities is implemented in the CMP.

4.4.2. Country planned action if relevant

The ongoing actions and research programs by ENGIE Electrabel seems appropriate for strengthening the cable management programs. No additional specific action was deemed necessary by the licensee and the Belgian Safety Authority.

4.5. TPR expected level of performance: prevention and detection of water treeing

Approaches are used to ensure that water treeing in cables with polymeric insulation is minimised, either by removing stressors contributing to its growth or by detecting degradation by applying appropriate methods and related criteria.

4.5.1. Country implementation

Based on the walkdown results, stressors are removed where possible. ENGIE Electrabel has developed their own acceptance criteria for HV (6kV) cables based on the results of many electrical measurements. ENGIE Electrabel uses different techniques and is testing new techniques as well to continuously improve their assessment techniques. ENGIE Electrabel agrees this is a challenge for MV (380V) cables and is working on this.

Tihange has a project running to complete their inventories for the end of 2019.

Laborelec, based on the experience they acquired for identifying the inaccessible-HV-cables, will further support Doel to identify the inaccessible HV, MV and I&C cables before end of 2019.

The lab ageing and testing of the MV (380V) and I&C cables continues in 2019. More than 3700 hours (generation 3) and 7000 hours (generation 4) of ageing are already applied at 135°C. The first site tests were planned at Doel 3 in 2019. A REX meeting is planned as well with Krsko power plant from Slovenia.

The lab ageing and testing will continue in 2019 up till relevant degradation is observed. At the end of 2019, the next phase of the project will be determined based on all the project results (lab testing, on site testing and REX exchange).

4.5.2. Country planned action if relevant

Several initiatives have already be taken by the licensee. The ongoing project is deemed adequate.

4.6. TPR expected level of performance: consideration of uncertainties in the initial EQ

The accuracy of the representation of the stressors used in the initial Environmental Qualification is assessed with regard to the expected stressors during normal operation and Design Basis Accidents.

4.6.1. Country implementation

ENGIE Electrabel has used naturally aged cables from the plant for requalification in case of plant long term operation. This has been realized for the LTO of Tihange 1 and Doel 1&2.

ENGIE Electrabel makes use of cables deposits as well and will evaluate if the samples from the cable deposits can be used for future requalifications.

ENGIE Electrabel considers that it is not necessary to evaluate the representativeness of the initial qualification tests on the basis of feedback from the AMP because the AMP's do not contain the qualified cables in its scope.

In practice, ENGIE Electrabel follows the cables passing through aggressive zones and therefore the monitoring of qualified cables is also carried out. ENGIE Electrabel did not observe exceptional degradation up till now which would indicate that the qualifications test carried out in the past are not representative.

LTO qualification tests are qualification tests that are completely based on the natural ageing of the cables installed for the time already elapsed (since the construction until now, the cables subject to qualification tests being original cables taken from the installation) and for the actual environmental conditions to which these cables are exposed.

4.6.2. Country planned action if relevant

No specific action was deemed necessary by the licensee and the Belgian Safety Authority.

4.7. TPR expected level of performance: determining cables' performance under highest stressors

Cables necessary for accident mitigation are tested to determine their capabilities to fulfil their functions under Design Extension Conditions and throughout their expected lifetime.

4.7.1. Country implementation

Within the framework of the WENRA 2014 reference levels (RL), a gap analysis was performed by the licensee and the Belgian Safety Authority.

In particular the gap analysis concluded for RL F4.2 and F4.15 that there was no gap between the current situation in the Belgian NPP and the new WENRA RLs for DEC A. For DEC B however, the following gap was identified : *"If the management of DEC B requires equipment initially planned for DBC or DEC A, it will indeed be necessary to check their availability or their possibility of recovery in DEC B".* For the I&C used in DEC B conditions, an analysis of the survivability of the instrumentation not qualified for DEC B but that could be used during a severe accident is ongoing in the framework of a study work initiated within the project aiming at being conform to the transposition of the WENRA 2014 RLs in the Belgian regulation.

4.7.2. Country planned action if relevant

An action is ongoing within the compliance project with the WENRA 2014 RLs. The study should determine which actions should be performed the I&C cables used in DEC B conditions. The planning of the study was discussed with the Belgian Safety Authority.

4.8. TPR expected level of performance: techniques to detect the degradation of inaccessible cables

Based on international experience, appropriate techniques are used to detect degradation of inaccessible cables.

4.8.1. Country implementation

ENGIE Electrabel has developed their own acceptance criteria for HV (6kV) cables based on the results of many electrical measurements. ENGIE Electrabel agrees this is a challenge for MV (380V) cables and is working on this. Engie uses different techniques and is testing new techniques as well to continuously improve their assessment techniques.

4.8.2. Country planned action if relevant

Regarding the MV (380V) cables and I&C cable, projects have been launched in 2019 to update the inventories of the inaccessible cables.

The action was judged adequate by the Safety Authority and is part of the approved action plan.

5. ALL OTHER GENERIC FINDINGS

The situation of the ageing management program of the NPP and RR Licensee with respect to the relevant generic ENSREG findings is described below.

5.1. Overall Ageing Management Programmes (OAMPs)

5.1.1. Good practice: External peer review services

External peer review services (e.g. SALTO, OSART-LTO, INSARR-Ageing) are used to provide independent advice and assessment of licensees' ageing management programmes.

Allocation by the TPR

A **Good Practice** was allocated to Belgium by the TPR, both for nuclear power plants and research reactors.

Country position and action

As mentioned in the Belgian NAR, and during the TPR Workshop, Belgium fully supports the use of external peer review services to provide independent advice and assessment of licensees' ageing management programmes.

Upon request of the Belgian Government, IAEA peer review missions on safe long-term operation (SALTO) were conducted to review the programs and activities of the Doel Nuclear Power Plant units 1 and 2 and Tihange Nuclear Power Plant unit 1, respectively in 2017 and 2015. The results and conclusions of these IAEA peer review missions are publicly available on the FANC website.

5.1.2. TPR expected level of performance: Data collection, record keeping and international cooperation

Participation in international R&D projects, experience exchange within groups of common reactor design and the use of existing international databases are used to improve the effectiveness of the NPPs OAMP.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

As mentioned in the Belgian NAR, and during the TPR Workshop, both NPP and RR licensees actively participate in international R&D projects. The Belgian Safety Authority strongly encourages the Belgian licensees to continue on this path. Participation of the Belgian licensees to international R&D projects are mentioned in the NAR for all the topics of the TPR (Electrical cables, Reactor pressure vessels…).

5.1.3. TPR expected level of performance: Methodology for scoping the SSCs subject to ageing management

The scope of the OAMP for NPPs is reviewed and, if necessary, updated, in line with the new IAEA Safety Standard after its publication.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

The IAEA safety standard is well followed (SSR 2/2) - This standard has two requirements related to ageing management :

- Requirement 14: Ageing management

- Requirement 16 : Programme for long term operation

The new SSG 48 is an ageing guideline, as it is a safety guide, it presents international good practices (cfr. IAEA definition). This last IAEA guide (SSG48) is not fully followed in term of scope setting, but the gaps for the Tihange 1 and Doel 1&2 unit are very limited. An extract of the SSG 48 scoping criteria, and the LTO G1 criteria used for the LTO of Doel 1&2 and Tihange 1 can be found below:

A. The SSG48 criteria are :

[1] SSCs important to safety that are necessary to fulfil the fundamental safety functions:

i. Control of reactivity;

ii. Removal of heat from the reactor and from the fuel store;

iii. Confinement of radioactive material, shielding against radiation and control of planned radioactive releases, as well as limitation of accidental radioactive releases.

[2] Other SSCs whose failure may prevent SSC important to safety from fulfilling their intended functions. Examples of such potential failures are:

- Missile impact from rotating machines;
- Failures of lifting equipment;
- Flooding;
- High energy line break;
- Leakage of liquids (e.g. from piping or other pressure boundary components).

[3] Other SSCs that are credited in the safety analyses (deterministic and probabilistic) as performing the function of coping with certain types of events, consistent with national regulatory requirements, such as:

- SSCs needed to cope with internal events, e.g. internal fire and internal flooding;
- SSCs needed to cope with external hazards, e.g. extreme weather conditions, earthquake, tsunami, external flooding, tornado and external fire;
- SSCs needed to cope with specific regulated events, e.g. pressurized thermal shock, anticipated transient without scram and station blackout;
- SSCs needed to cope with design extension conditions or to mitigate the consequences of severe accidents

B. The criteria used for LTO was :

(1) Safety-related systems, structures, and components which are those relied upon to remain functional during and following design-basis events (as defined as in 10 CFR 50.49 (b)(1)) to ensure the following functions:

(i) The integrity of the reactor coolant pressure boundary;

(ii) The capability to shut down the reactor and maintain it in a safe shutdown condition; or

(iii) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the guidelines in § 50.34(a)(1), 50.67(b)(2), or § 100.11 of Title 10 CFR, as applicable.

(2) All non-safety-related systems, structures, and components whose failure could prevent satisfactory accomplishment of any of the functions identified in paragraphs (a)(1)(i), (ii), or (iii) of Title 10 CFR 54.4.

(3) All systems, structures, and components relied on in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for:

(i) fire protection (10 CFR 50.48),

(ii) environmental qualification (10 CFR 50.49),

(iii) pressurized thermal shock (10 CFR 50.61)

(iv) anticipated transients without scram (10 CFR 50.62), and

(v) station blackout (10 CFR 50.63)."

The delta between both criteria is limited.

In conclusion, ENGIE Electrabel follows the IAEA safety standard SSR 2/2 and the GAP with the new IAEA guideline SSG48 is limited.

5.1.4. TPR expected level of performance: Delayed NPP projects and extended shutdown

During long construction periods or extended shutdown of NPPs, relevant ageing mechanisms are identified and appropriate measures are implemented to control any incipient ageing or other effects.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

ENGIE Electrabel launches specific measures during long outages to avoid ageing degradation due to long or extended stop. The expected degradation concerned mainly the potential initiation of corrosion problem in the primary & secondary circuits .

The evaluation and implementation of the necessary measures is performed on a case by case basis, as it depends on the "stop" period & the nature of the works to be performed – due to this fact no generic procedure has been developed.

5.1.5. TPR expected level of performance: Overall Ageing Management Programmes of research reactors

A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, the applicable national requirements, international safety standards and best practices.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

The OAMP for the Belgian research reactor is extensively described in the Belgian NAR. The details below were described in sections 2.1 and 2.B.2.

The Western European Nuclear Regulators Association (WENRA) issued in 2008 the Reactor Safety Reference Levels to harmonize the safety requirements for European reactors. These reference levels have been included in Belgian regulation by the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations (SRNI-2011), including NPPs but also other nuclear facilities, like the research reactors, the waste storage facilities or the isotope production facilities.

Ageing Management of Systems, Structures and Components (SSCs) important to nuclear safety is addressed in Article 10 of SRNI-2011, stipulating that the licensee of a nuclear installation shall set up an Ageing Management Program (transposition of the RL I1.1). All nuclear facilities have an ageing management program in accordance with that royal decree.

The BR2 license included at the commissioning an end-of-life date after 30 years of operation. The license was updated to require a PSR every 10 years similarly to nuclear power plants. In this framework during the lifetime of the reactor, continuous modernization projects have been executed. On the occasion of the last PSR (2016), a major refurbishment program was realized. For a number of components and systems design upgrades were made to improve the safety and reliability. In this framework the development of a complete ageing management program of the BR2 was therefore part of the Periodic Safety Review that was completed in 2016. SCK•CEN was required to improve and implement the ageing management program of the BR2 to reach a level that is commensurable with the best international standards and practices for research reactors.

Upon request of the Belgian Government, an IAEA expert peer review mission on safe long-term operation was conducted in November 2017 to review the programs and activities concerning ageing of the SCK•CEN research reactor BR2.

5.2. Concealed pipework

5.2.1. Good practice: use of results from regular monitoring of the condition of civil structures

In addition to providing information on soil and building settlement, the results from regular monitoring of the condition of civil structures are used as input to the ageing management programme for concealed pipework.

Allocation by the TPR

A **Good Practice** was allocated by the TPR to Belgium.

Country position and action

The program engineer responsible for the follow-up of the civil structure gives regularly feedback to the program engineer responsible for concealed piping. This lead to specific inspections when necessary.

5.2.2. Good practice: performance checks for new or novel materials

In order to establish the integrity of new or novel materials, sections of pipework are removed after a period of operation and inspected to confirm the properties are as expected.

Allocation by the TPR

The TPR does not allocate this Good Practice to Belgium.

Country position and action

At Tihange new or novel materials such as glass-reinforced epoxy were used. This material is corrosion-resistant and has a long life expectancy. In addition, the physical properties of these filament wound pipes, in combination with the used resin and glass quality, makes the glass-reinforced epoxy resistant against the most severe chemical and mechanical forces.

For future replacement in new material with low operating experience, this good practice will be evaluated on a case by case basis.

5.2.3. TPR expected level of performance: inspection of safety-related pipework penetrations

Inspection of safety-related pipework penetrations through concrete structures are part of ageing management programmes, unless it can be demonstrated that there is no active degradation mechanism.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

As explained during the allocation of the TPR findings, inspection of safety-related pipework penetrations through concrete structures is part of the concealed pipeworks AMPs. The limit of concealed piping is defined by the penetration of the outside wall of a building. The concealed piping inspection include these penetrations.

5.2.4. TPR expected level of performance: scope of concealed pipework included in AMPs

The scope of concealed pipework included in ageing management includes those performing safety functions, and also non-safety-related pipework whose failure may impact SSCs performing safety functions.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

During the TPR workshop, it was requested by the concealed piping subgroup's chairman to provide some evidence on that issue. It was indicated that this evidence is actually already indirectly available in the NAR in section 4.A.1.1.1 (p.78). It is indicated there that for the LTO-units Tihange 1 and Doel 1&2, the safety-related pipework has been identified systematically using the criteria in the scope of the U.S. License Renewal Rule 10CFR54.4. Below, the criteria from 10CFR54.4 are cited:

"Plant systems, structures, and components within the scope of this part are--

(1) Safety-related systems, structures, and components which are those relied upon to remain functional during and following design-basis events (as defined in 10 CFR 50.49 (b)(1)) to ensure the following functions--

(i) The integrity of the reactor coolant pressure boundary;

(ii) The capability to shut down the reactor and maintain it in a safe shutdown condition; or

(iii) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to those referred to in § 50.34(a)(1), § 50.67(b)(2), or § 100.11 of this chapter, as applicable.

(2) All non safety-related systems, structures, and components whose failure could prevent satisfactory accomplishment of any of the functions identified in paragraphs (a)(1)(i), (ii), or (iii) of this section.

(3) All systems, structures, and components relied on in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection (10 CFR 50.48), environmental qualification (10 CFR 50.49), pressurized thermal shock (10 CFR 50.61), anticipated transients without scram (10 CFR 50.62), and station blackout (10 CFR 50.63)."

Non-safety-related pipework whose failure may impact SSCs performing safety functions are thus taken into consideration in the scope of the ageing management for the LTO-units. For the non-LTO-units, it is mentioned in § 4.A.1.1.1 of the NAR that the scope is based on the scoping methodology for the LTO-units. Non-safety-related pipework whose failure may impact SSCs performing safety functions are thus also taken into consideration in the scope of the ageing management for the non-LTO-units.

5.2.5. TPR expected level of performance: opportunistic inspections

Opportunistic inspection of concealed pipework is undertaken whenever the pipework becomes accessible for other purposes.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

As mentioned during the allocation of the findings, AMPs M34 is implemented in Belgian NPPs so that opportunistic inspections are undertaken.

5.3. Reactor pressure vessel

5.3.1. Good practice: Hydrogen water chemistry

Hydrogen Water Chemistry (HWC) is used in BWRs which may be sensitive to Intergranular Stress Corrosion Cracking.

Allocation by the TPR

The TPR does not allocate this **Good Practice** to Belgium as Belgium's reactor pressure vessels are not concerned (Belgium reactors are PWR type).

Country position and action

Belgium is not concerned.

5.3.2. Good practice: Implementation of a shield

Shielding in the core of PWRs with relatively high fluence is implemented to preventively reduce neutron flux on the RPV wall.

Allocation by the TPR

The TPR does not allocate this **Good Practice** to Belgium.

Country position and action

Shielding in the core of PWRs with relatively high fluence to preventively reduce neutron flux on the RPV wall is not considered necessary for the predicted embrittlement of the RPV (experimental surveillance results are available for fluences corresponding to more than end of life), taking into account the limited residual lifetime of the Belgian units.

5.3.3. TPR expected level of performance: Volumetric inspection for nickel base alloy penetration

Periodic volumetric inspection is performed for nickel base alloy penetrations which are susceptible to Primary Water Stress Corrosion Cracking for PWRs to detect cracking at as early a stage as possible.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium

Country position and action

The in-service inspection program according to ASME XI and the augmented programs implemented by ENGIE Electrabel to address specific issues such as the PWSCC of Ni-based alloys or the underclad defects ensure the identification of degradation mechanisms inducing material cracking. Those provisions for identifying unexpected degradation were described in the NAR Section 5.A.1.1.

Additional evidences and example were given during the TPR workshop.

5.3.4. TPR expected level of performance: Non-destructive examination in the base material of beltline region

Comprehensive NDE is performed in the base material of the beltline region in order to detect defects

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

Following the RPV issue in Doel 3 and Tihange 2 in Belgium, it was required to perform a comprehensive NDE of all the forged components of the primary circuits of all units in Belgium. ENGIE Electrabel performed those NDE on all forgings.

Comprehensive NDE in the base material of the beltline region are performed every three years in Doel 3 and Tihange 2, and every 10 years in other reactors.

5.3.5. TPR expected level of performance: Environmental effect of the coolant

Fatigue analyses have to take into account the environmental effect of the coolant.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

Taking into account the environmental effect of the coolant on fatigue analysis is described in the NAR (page 25) as an example of the international programs in which both the licensees of the NPPs and of the research reactors in Belgium participate.

Additional evidences and example were given during the TPR workshop.

5.3.6. TPR expected level of performance: Suitable and sufficient irradiation specimens

For new reactors, suitable and sufficient irradiation specimens and archive materials are provided to support the reactor through its full operational life.

Allocation by the TPR

The nuclear phase-out law in Belgium forbids the construction of new nuclear power plants. Belgium cannot be concerned by this finding.

Country position and action

If a new research reactor should be built in Belgium, it will be strongly recommended to foresee suitable and sufficient irradiation specimens and archive materials to support the reactor through its full operational life. As this topic is a key research topic of the Belgian research centre, this should not be an issue.

5.4. Concrete containment structure and pre-stressed concrete pressure vessel

5.4.1. Good practice: monitoring of concrete structures

Complementary instrumentation is used to better predict the mechanical behaviour of the containment and to compensate for loss of sensors throughout the life of the plant.

Allocation by the TPR

The TPR does not allocate this **Good Practice** to Belgium

Country position and action

The number of sensors on the containment are currently still sufficient for the ageing management program of the concrete containment structure of the NPPs. The adequacy of the ageing management

program and an eventual need for compensating for a loss of sensors is to be revaluated in the framework of the review of the dedicated AMP or during the forthcoming PSR.

The topic should be addressed in the framework of the forthcoming PSR in Belgium.

5.4.2. Good practice: assessment of inaccessible and/or limited access structures

A proactive and comprehensive methodology is implemented to inspect, monitor and assess inaccessible structures or structures with limited access

Allocation by the TPR

The TPR does not allocate this **Good Practice** to Belgium.

Country position and action

Guideline ENSI -B01 was not used by ENGIE Electrabel up to now. This document will be evaluated to check what can be applied in Belgium in the framework of the forthcoming PSR.

5.4.3. TPR expected level of performance: monitoring of pre-stressing forces

Pre-stressing forces are monitored on a periodic basis to ensure the containment fulfils its safety function.

Allocation by the TPR

A **Good Performance** was allocated by the TPR to Belgium.

Country position and action

The monitoring of the Primary containment pre-stress losses is described in section 7.A.1.1.2 of the NAR.

6. STATUS OF THE REGULATION AND IMPLEMENTATION OF AMP TO OTHER RISK SIGNIFICANT NUCLEAR INSTALLATIONS

6.1. Board recommendation

The Board recommends that countries explore the regulation and implementation of Ageing Management Programmes of other risk significant nuclear installations while developing and implementing National Action Plans to ensure they exist and are effective.

6.2. Country position and action (fuel cycle facilities, installations under decommissioning, waste facilities, etc.)

Specific regulatory requirements on ageing management have already been included in Belgian regulation by the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations (SRNI-2011). These requirements are listed in article 10 and are applicable to NPPs but also other nuclear facilities, like the research reactors, the waste storage facilities or the isotope production facilities.

An inspection program was implemented by the Safety Authority in 2018 to verify the implementation of these regulatory requirements.

This section will be completed more in detail by Belgium on a voluntary basis during 2020 for other significant nuclear installations.

7. TABLE: SUMMARY OF THE PLANNED ACTIONS

Installation	Thematics	Finding	Planned action	Deadline	Regulator's Approach to Monitoring
NPP 1	OAMP	Extension of the new ageing management program to the ageing management program of Tihange 2&3 and Doel 3&4 based on the program installed for the LTO units, and using the most recent international standards and guidance.	Included in the upcoming PSRs of these units	Next PSR action plan	The Belgian Safety Authority has included this request within the expectations for the upcoming PSRs. The action is closed.

NPP 2	OAMP	Investigate whether and how the ageing programs need to be adapted to avoid ageing issues, inadequate ageing monitoring and inadequate remedial actions for some concrete degradations.	The Belgian Safety Authority conducted several inspections in 2018-2019 in both Doel and Tihange NPPs specifically dedicated to the process and performances for In-Service Inspections (ISI) of the concrete structures and buildings of the NPPs. Those inspections conclude that the ageing management program for concrete buildings, and more specifically the ISI program for the concrete structures, were uncomplete and insufficient to guarantee that most concrete degradations can be identified and followed-up for years, but mainly to guarantee that the potential impact of those identified concrete degradations on the safety functions of the structure is systematically assessed. The ISI program was suitable for classic civil structures in relatively standard external conditions and was not adapted for tackling specific issues related to civil structures in unusual external conditions (temperature, humidity, steam jets…). The Belgian Safety Authority requested in accordance the licensee to develop a new process, based on the latest international standards, for performing In-Service Inspections on civil structures, assessing the impact of the defects identified, guarantying	Most actions were due by June or September 2019 and have been realized in due time. The few remaining actions are due for December 2019.	This topic is subject to significant follow-up by the Safety Authority. The Belgian Safety Authority has planned a new inspection by the end of 2019 in order to assess the progresses brought on the ISI process. Additional and recurrent inspections will be carried out until the Safety Authority be fully reassured about the efficiency and quality of the process.

			a follow-up of the defects and assuring an adequate AQ of the process. The Safety Authority required the licensee to perform a complete new ISI campaign of all civil structures once the new process and the underlying procedures for inspection will be approved by the Safety Authority The licensee presented in early 2019 an action plan for answering all the findings of the Safety Authority in a timely manner. The action plan and the associated planning were discussed and approved by the Safety Authority. The licensee started in June 2019 the new ISI program and plans to complete its application to all civil structures by 2021. In parallel, the systematic and specific controls on the field concerning civil structures have been intensified by the Safety Authority.		
RR 1	OAMP	The licensee shall extend the scope of the ageing management program to include all SSCs relevant for safety that are present within the premises of the BR2. Notably the hot cells, experimental devices and spent fuel storage system should be included. In addition, spare parts for safety related SSCs that are in stock should also be included.	Included in the BR2 action plan	June 2019 (December 2019)	The Belgian Safety Authority asked the licensee to add all those actions in the PSR action plan for the BR2 reactor. All the actions are followed in this framework. The full implementation was due for June 2019, but was slightly delayed to December 2019.

RR 2	OAMP	The on-going development of the ageing management program should be focused on safety-related SSCs.			
RR 3	OAMP	The licensee shall develop procedures to review and update the ageing management program once the current implementation phase is completed and to measure its effectiveness.			
RR 4	Electrical cables	The licensee shall establish a formal ageing assessment program for all safety related electrical cables. Priority should be given to neutron flux instrumentation cables and the 110V cables. The ageing management program should then be upgraded in accordance.			

RR 5	Electrical cables	The licensee shall perform walk-downs in order to confirm the absence of adverse environment (e.g. wetting or abnormal local cable's heating mechanisms) and in support of the development of the ageing assessment program for the electrical cables. Particular attention is needed for the safety related cables that were not recently replaced or that are not planned to be replaced in the future (for instance the 110V cables and instrumentation cables).			
RR 6	Electrical cables	The licensee shall demonstrate that the safety related cables can fulfil their safety function in all relevant accidental conditions.			
RR 7	Concealed pipeworks	Additional monitoring, testing, sampling or inspection activities should be implemented for: the piping for transport of pool water from the reactor building to the storage basin under the ventilation building, the fuel transport piping for the Diesel generators and the concealed part of the feed water line for firefighting in the reactor building.			

RR 8	Concealed pipeworks	The need for a replacement of the piping for city water should, based on the projections provided by SCK•CEN, be investigated.			
RR 9	Concealed pipeworks	It is suggested to consider additional monitoring, testing, sampling or inspection activities for city water and feed line for cooling water from the lagoon;			
RR 10	Concealed pipeworks	It is suggested to update or validate the ageing management program for concealed piping based on data obtained from the piping that was removed.			
RR 11	Reactor Pressure Vessels	The ageing management of the RPV of BR2 should be extended by explicitly tracking the number of stops that provide the most severe loads for low cycle fatigue and compare this number with the established limit.			
RR 12	Reactor Pressure Vessels	The ageing management of the RPV of BR2 should be extended by explicitly tracking the number of stops that provide the most severe loads for low cycle fatigue and compare this number with the established limit.			

RR 13	Concrete containment structures	The need for monitoring, testing, sampling and inspection activities as well as for preventive and remedial actions should be determined on the basis of a dedicated ageing assessment.			
NPP 3	Electrical cables	Cables necessary for accident mitigation are tested to determine their capabilities to fulfil their functions under Design Extension Conditions and throughout their expected lifetime.	An action is ongoing within the compliance project with the WENRA 2014 RLs. The study should determine which actions should be performed the I&C cables used in DEC B conditions. The planning of the study was discussed with the Belgian Safety Authority.	Within the WENRA 2014 Action Plan	The action is followed in the framework of the project aiming at establishing the compliance with the 2014 WENRA Reference Levels.
NPP 4	Electrical cables	Based on international experience, appropriate techniques are used to detect degradation of inaccessible cables.	Regarding the MV (380V) cables and I&C cable, projects have been launched in 2019 to update the inventories of the inaccessible cables.	Continuous	The status of the action and an update of these specific projects is requested as part of the annual meeting on Ageing Management and should be detailed in the next annual report on Ageing Management by the licensee.
NPP 5	Concealed pipeworks	In order to establish the integrity of new or novel materials, sections of pipework are removed after a period of operation and inspected to confirm the properties are as expected.	For future replacement in new material with low operating experience, this good practice will be evaluated on a case by case basis.	Continuous	The Safety Authority does not plan a specific follow-up of the action.

NPP 6	Concrete containment structures	Complementary instrumentation is used to better predict the mechanical behaviour of the containment and to compensate for loss of sensors throughout the life of the plant.	The number of sensors on the containment are currently still sufficient for the ageing management program of the concrete containment structure of the NPPs. The adequacy of the ageing management program and an eventual need for compensating for a loss of sensors is to be revaluated in the framework of the review of the dedicated AMP or during the forthcoming PSR. The topic should be addressed in the framework of the forthcoming PSR in Belgium.	Next PSR	If appropriate, the action should be followed in the framework of the next PSRs.
NPP 7	Concrete containment structures	A proactive and comprehensive methodology is implemented to inspect, monitor and assess inaccessible structures or structures with limited access	Guideline ENSI -B01 was not used by ENGIE Electrabel up to now. This document will be evaluated to check what can be applied in Belgium in the framework of the forthcoming PSR.	Next PSR	If appropriate, the action should be followed in the framework of the next PSRs.
NPP 8	OAMP	Finding not retained by ENSREG: Some countries request their licensees to provide an annual summary report an Ageing and Ageing Management	Request the licensee for an annual report on Ageing and Ageing Management	January 2019	The action is closed, as the request was made and the first yearly report has been received.