

MISSION RESULTS

2.1. GENERAL CONCLUSIONS

Based on the activities of the mission, the IAEA team concluded that in addition to the intensive work that has been performed during the past several years to deal with ageing effects, HFR has made significant progress in the establishment of a systematic ageing management programme and preparation for continued safe operation (CSO). The IAEA safety standards were used as a main reference for the development and implementation of this programme and activities.

The IAEA team also assessed that the IAEA safety standards have been considered in the development and implementation of the facility's operating programmes that have interface with aging management and CSO, including maintenance, surveillance, inspection, periodic safety review and equipment qualification. The team **encouraged** the continuation of this practice in all activities related to these programmes, as there is still a large amount of work to be completed and there may be a number of challenges to be overcome to ensure the effective implementation of ageing management.

The IAEA team evaluated that basis for ageing management, including regulatory requirements, exists and that HFR has made significant efforts over the years to reconstitute the design basis of the SSCs. In this regard, the IAEA team **encouraged** HFR to finalize the development of the document on "*Criteria for design of structures, systems, and components for HFR*", which covers engineering codes and standards that are used as basis for ageing management.

The IAEA team appreciated the high quality of the discussions during the mission and noted the professionalism of the HFR management and staff as well as their commitment and involvement in the relevant activities. The team noted **good performances** with respect to:

- Establishment of a clear policy for ageing management and CSO, and the demonstrated strong commitment of the NRG senior management to safety and to the effective implementation of the relevant activities;
- Assignment of a dedicated ageing management coordinator at the facility level;
- Planning and implementation of modification projects and refurbishment in accordance with the IAEA safety standards;
- Systematic planning and implementation of a multi-disciplinary surveillance programme on the embrittlement of the reactor vessel, considering modelling, measurements, and use of scientific research to ensure compliance with the design requirements;
- Implementation of periodic safety reviews since 2002 and use of their findings in ageing management.

The IAEA team observed that a number of reportable events occurred during the period between 2008 and 2022. Ageing has been identified as the main root cause of these events. Most of these events at the HFR have not resulted in radioactive release, although they are of safety significance. Some of these events were repetitive (e.g. the deformation of beryllium reflectors in 2020) and could have been prevented if feedback from the facility experience were used more effectively. The team noted an improved facility performance, where lessons from the 2020 beryllium deformation were used to establish ageing management activities to prevent the recurrence of such events in the future. The team **encouraged** HFR to continue this practice.

The IAEA team also identified issues and gaps against the IAEA safety standards and provided **recommendations** and **suggestions** to address these issues. These recommendations and suggestions were related to the need for:

- Ensuring systematic implementation of the obsolescence programme, including establishing procedures covering all relevant management actions and providing training on implementation of the programme;

- Improving the methodology and implementation of SSCs screening for ageing management and CSO through:
 - Covering the SSCs that are not important to safety, but their failure can prevent those important to safety from performing their safety functions;
 - Ensuring that all SSCs classified as Safety Class 1, 2, and 3 are covered by the scope;
 - Establishing procedures to ensure the completeness of the master list of SSCs and conducting dedicated walkdowns.
- Completing the establishment of appropriate acceptance criteria for all ageing management programmes (AMPs), thus supporting the timely identification and implementation of necessary ageing management actions;
- Further enhancing ageing management through establishing procedures for:
 - Addressing the interaction (interface) of ageing management activities with the plant operating programmes; and
 - Ensuring systematic trending analysis.
- Updating the ageing management review (AMR) methodology in accordance with the IAEA safety standards and performing AMRs for all in-scope civil structures and components ensuring identification of design basis, current condition, and degradation mechanisms and their effects;
- Reviewing and revising, as necessary, the AMPs to ensure they are in accordance with ageing management attributes (elements) established by the IAEA safety standards, including ensuring their specificity to the SSCs under consideration, identification of condition indicators, degradation mechanisms, monitoring, and ageing management actions;
- Initiating a process for identification of cables, and accordingly, installing proper labelling, and considering the implementation of physical separation between redundant safety channels in future modernization of electrical and I&C systems;
- Performing periodical chemical analysis of leaking water from the pools and utilizing the results to improve the ageing management of pools' structure;
- Establishing a maintenance programme for the spare parts of SSCs important to safety and controlling and monitoring of the storage conditions.

The evaluation of each review area, including discussions of the recommendations and suggestions, is included in the following subsections.

2.2 DETAILED CONCLUSIONS FOR REVIEW AREAS

2.2.1 ORGANIZATION OF AGEING MANAGEMENT AND CSO ACTIVITIES

Related regulatory requirements, codes and standards for ageing management and regulatory review

The basis for ageing management and CSO is defined for HFR. The IAEA safety standards are used as the main reference for developing the plant level ageing management programme (PLAMP) and AMPs as well as the related operating documents.

Codes and standards are included in the SAR but not for all the SSCs. These codes and standards were defined for all refurbishment and modernization projects and are being documented. The IAEA team **encouraged** HFR to finalize the development of the document on “Criteria for design of structures, systems, and components for HFR” which covers engineering codes and standards that are used as basis for ageing management.

Principles and approach to ageing management and CSO

A clear policy, in line with the IAEA safety standards, on ageing management and CSO is established and being implemented. The strong commitment of the NRG senior management to safety and to the effective implementation of the relevant activities is **good performance**.

Organizational arrangements for ageing management and CSO

The organizational structure approach for ageing management and CSO followed by the facility is in line with the IAEA safety standards. An ageing management coordinator was recruited and assigned relevant responsibilities in 2021. The assignment of a dedicated ageing management coordinator at the facility level is a **good performance**.

Periodic safety review

The IAEA team evaluated that the implementation of periodic safety reviews since 2002 and use of their findings in ageing management is a **good performance**.

Ageing management programme

HFR has not yet considered all obsolescence management actions that are established by the IAEA safety standards (i.e. identification of useful service life with foresight and anticipation, preparation of modification projects, provision of spare parts, or identification of alternative suppliers). Additionally, there is no formal training of the staff on the implementation of the obsolescence management programme. The IAEA team **recommended** that systematic implementation of the obsolescence management programme should be ensured, including among others by establishing procedures considering all relevant management actions that are recommended by the IAEA Safety Standards No SSG-10. A formal training programme should be established for the involved HFR staff across the mechanical, electrical, I&C, and civil areas, to ensure the effectiveness in the implementation of the programme (see *Issue Sheet A-1*).

Some of AMPs (or the procedures referenced thereof) are lacking acceptance criteria, and some others include inappropriate acceptance criteria. The IAEA team recommended that appropriate acceptance criteria should be established for all AMPs, thus supporting the timely identification and implementation of necessary ageing management actions. Such criteria should be established based on design basis, technical requirements, applicable codes and standards, and considering availability of sufficient safety margins (see *Issue Sheet A-2*).

Configuration management, utilization and modification

Modifications on the HFR are planned and implemented as per a dedicated procedure for managing of changes (MoC) which is in accordance with the IAEA safety standards. The configuration of the facility is managed in different databases (asset management, documentation management, SCsML). The planning and implementation of modification projects and refurbishment in accordance with the IAEA safety standards is a **good performance**.

Safety analysis report

The safety analysis report (SAR), complementing the safety report that is required by the national regulator, is under development. HFR staff mentioned that the PLAMP will be updated based on the approved SAR. No recommendations, suggestions, encouragements, good practices or good performances were identified in this area

2.2.2 SCREENING OF SSCS AND REACTOR PROGRAMMES

Methodology and criteria for screening of SSCs for ageing management and CSO

The IAEA team evaluated that the screening methodology does not cover SSCs that are not important to safety, but their failure may prevent those important to safety from performing their intended safety functions. The scope of SSCs for ageing management and CSO does not cover all SSCs important to safety. The IAEA team **recommended** that the screening methodology should be further aligned with the IAEA safety standards by including items that are not important to safety but their failure may prevent SSCs important to safety from performing their intended safety functions. The scope for ageing management and CSO should be expanded to cover all the SSCs classified as Safety Class 1, 2, and 3 (see *Issue Sheet B-1*).

The team also provided a **recommendation** to further enhance application of the screening methodology through development of procedures for dedicated walkdowns and ensuring the completeness of the Master list (see *Issue Sheet B-2*).

Maintenance, in-service inspection, and surveillance programmes

There is a maintenance programme at HFR including preventive and corrective maintenance activities and aligned with IAEA safety standards. The feedback from the corrective maintenance is used for adjusting AMP activities. For mechanical SSCs, the IAEA team provided recommendation on the maintenance of the spare parts (see Section 2.2.3 and *Issue Sheet C-2*). In addition, for electrical and I&C components, there is no maintenance programme, or database, for spare parts (see Section 2.2.4).

There is an in-service inspection programme established based on the IAEA safety standards and it covers the reactor vessel and the primary cooling system. This programme defines relevant baseline data, including for adjustment of the inspection frequency.

There is a surveillance programme on embrittlement of the reactor vessel established at HFR. Other surveillance activities are covered by the maintenance programme.

There is a water chemistry programme, as recommended by the IAEA safety standards, in place at HFR. The IAEA team provided suggestion on further enhancement of this programme (see Section 2.2.5 and *Issue Sheet E-1*).

The IAEA team **recommended** the enhancement of the effectiveness of ageing management activities by establishing procedures for (see *Issue Sheet B-2*):

- Adequately addressing the interaction (interface) and ensuring consistency of activities on ageing management and CSO with the other plant operating programmes and documentation such as maintenance, inspection, surveillance, modification, safety analysis, and SAR.
- Systematic collection, analyses, and trending of the reactor operating data, including those from functional and periodic testing, maintenance, inspection, and surveillance, and utilizing the results for continuous improvement of the ageing management programmes.

Equipment qualification programme

An equipment qualification programme, developed based on the IAEA safety standards, is in place. The programme takes into account the harsh conditions identified in the deterministic safety report. The IAEA team **encouraged** the HFR for continuing considering the IAEA safety standards in the development and implementation of the facility's operating programmes that have interface with aging management and CSO, including equipment qualification.

2.2.3 AGEING MANAGEMENT OF MECHANICAL SSCS

Ageing management review of mechanical SSCs

The AMR of mechanical SSCs important to safety has generally been performed based on the IAEA safety standards. No recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

Ageing management programme of mechanical SSCs

HFR has developed a PLAMP and tens of AMPs for the SSCs. These programmes are incorporating references to other facility programmes such as maintenance, and inspections that support the ageing management. Most AMPs were developed in 2020, and majority of them were recently revised.

Many AMPs have not yet been implemented. Not all attributes (elements) that are recommended by the IAEA safety standards are addressed by several AMPs. The IAEA team observed the deficiencies in sample AMPs, which were reviewed during the mission. The IAEA team **recommended** that AMPs for mechanical SSCs should be reviewed and revised, as needed, to ensure that they are in accordance with the ageing management attributes (elements) established by the IAEA safety standards, including ensuring their specificity to the SSCs under consideration covering applicable degradation mechanisms, monitoring, acceptance criteria, and ageing management actions (*Issue Sheet C-1*).

There is no programme for maintenance of spare parts for SSCs important to safety. The storage conditions are not controlled or monitored. The spare parts management system does not take into account the shelf life and storage conditions. There is no database for spare electrical and I&C components and the stock is maintained by technicians within well marked drawers. The IAEA team **recommended** that a maintenance programme of spare parts for SSCs important to safety should be established, including control and monitoring of the storage conditions (*Issue Sheet C-2*).

TLAAs of mechanical SSCs

Time limited ageing analysis (TLAAs) were performed following the International Generic Ageing Lessons Learned (IGALL) for Nuclear Power Plants reports with examples of the TLAAs, taking into account the applicable and relevant ones. Eight TLAAs were identified and among which six for mechanical components were performed. Identified TLAAs for beryllium reflectors and equipment qualification are not included in the TLAAs, but they are covered by other programmes for ageing management. Useful service life for the stainless-steel components of the reactor vessel internals such as grid plates, fasteners, and springs for control rods guide rollers is managed by the AMPs.

Systematic planning and implementation of a multi-disciplinary surveillance programme on the embrittlement of the reactor vessel, considering modelling, measurements, and use of scientific research to ensure compliance with the design requirements was identified by the IAEA team as a **good performance**.

SSCs screening results verification for mechanical SSCs

The screening of mechanical SSCs for ageing management was performed based on the safety classification. There are some deficiencies in screening of SSCs for ageing management and CSO. Without comprehensive screening, ageing effects of SSCs that are not in scope will not be properly managed, which may have potential operational safety aspects. Lack of documentation of justification of exclusion from scope of SSCs, or non-consideration of potential effects of SSCs that are not important to safety on those that are important to safety can jeopardize safety. The IAEA team provided recommendation in this area (see Section 2.2.2 and *Issue Sheet B-1*).

Data collection and record keeping for mechanical SSCs

A data collection and record keeping system exists within the NRG management system. A management tool (i.e. SAP) initiates a scheduled activity and records its completion. All results of the activities such as maintenance, and inspections performed are recorded currently in the paper format. The IAEA team was informed that format of the relevant records will be modified to link them with the ageing 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.

Documentation of ageing management in support of CSO for mechanical SSCs

Documentation for ageing management is available on a Share Point that contains all related documents, such as PLAMP, AMPs, TLAAAs, and EQ. 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 OF ELECTRICAL AND I&C SSCS

Ageing management review of electrical and I&C SSCs

The AMR of electrical and I&C SSCs important to safety has generally been performed based on the IAEA safety standards. The IAEA team observed that the analysis and identification of ageing effects for electrical and I&C SSCs important to safety is incomplete, e.g. I&C for the primary core cooling and pool cooling systems. The IAEA team also observed that further investigation is needed on testing of response time of the temperature, flow, pressure, level sensors. During the walkdown of the facility, it was observed that physical separation between some redundant components is not ensured. The IAEA team **suggested** that physical separation between redundant safety channels should be considered in future modernization of the I&C system.

Ageing management programme of electrical and I&C SSCs

The review of AMPs of electrical and I&C SSCs showed that there are deficiencies in several of them. The IAEA team **recommended** to develop of AMPs that should be finalized for all in scope electrical and I&C components, ensuring identification of relevant ageing effects, monitoring, and aging management actions. For effective implementation of AMPs, a process should be initiated for identification of cables, and accordingly, install proper labelling.

TLAAs and technological obsolescence management for electrical and I&C SSCs

Useful service life of electrical and I&C SSCs is addressed by the maintenance, periodic testing, inspection and is based on the obsolescence management. In the past recent years, two safety channels were modernized from use of analogue to digital technology, and modernization of another two is ongoing. Work was also initiated for identification of alternative suppliers for old or obsolete I&C equipment. The team provided recommendation in this area (see Section 2.2.1 and *Issue Sheet A-1*).

SSCs screening results verification for electrical and I&C SSCs

Screening of SSCs has been performed to identify SSCs in scope for ageing management and CSO. There are some deficiencies in screening of SSCs for ageing management and CSO. Without comprehensive screening, ageing effects of SSCs that are not in scope will not be properly managed, which may have potential operational safety aspects. Lack of documentation of justification of exclusion from scope of SSCs, or non-consideration of potential effects of SSCs that are not important to safety on those that are important to safety can jeopardize safety.

The team provided recommendation in this area (see Section 2.2.2 and *Issue Sheet B-1*).

Data collection and record keeping for electrical and I&C SSCs

It was observed that trending of failure rates of electrical and I&C systems and components is not systematically performed. The team provided recommendation in this area (see Section 2.2.2 and *Issue Sheet B-2*).

Documentation of ageing management in support of CSO for electrical and I&C SSCs

Documentation for ageing management is available on a Share Point that contains all related documents, such as PLAMP, AMPs, TLAAs, and EQ. 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 OF CIVIL SSCS

Ageing management review of civil SSCs

AMRs of civil SSCs have been performed in 2014 and reviewed/updated in 2019 to identify service conditions and degradation mechanisms. However, there are shortcomings in ageing management review of civil structures and components. Without comprehensive AMR, it cannot be ensured that all degradation mechanisms and their effects will be adequately managed.

The team **recommended** HFR to update the methodology for AMR in accordance with the IAEA safety standards and to perform AMR for all in-scope civil structures and components to ensure that all relevant elements are effectively addressed, including identification of design basis, current condition, degradation mechanisms, and their effects (see *Issue Sheet E-1*).

A study related to leakage of demineralized water from the pools has been performed to determine effects of the leakage on the integrity of the pools' structure.

The IAEA team **suggested** to perform periodical chemical analysis of leaking water from the pools and to utilize the results to improve the ageing management of pools' structure (see *Issue Sheet E-1*).

Ageing management programme of civil SSCs

AMPs have recently been developed to address ageing of civil structures and commodities. AMPs refer to the procedures for activities to minimize, detect, and mitigate ageing effects. Many of these

procedures have not yet been developed, although activities may have been ongoing as part of other programmes.

There are shortcomings in development of AMPs for civil structures. Without comprehensive development of AMPs for all in-scope civil structures, effective ageing management cannot be ensured.

The team **recommended** HFR to review and revise AMPs for civil structures, as needed, to ensure that they are in accordance with the ageing management attributes (elements) established by the IAEA safety standards, including identification of condition indicators, acceptance criteria, and ageing management actions (see *Issue Sheet E-2*).

Acceptance criteria are not established or incomplete for several AMPs. The team provided recommendation in this area (see Section 2.2.1 and *Issue Sheet A-2*).

TLAAs of civil SSCs

There is a methodology document for identification of TLAAs. No TLAAs for civil structures have been identified. IGALL TLAAs have been considered not applicable to the HFR civil structures. However, justification has not been provided in the facility documents. No recommendations, suggestions, encouragements, good practices or good performances were identified in this area.

SSCs screening results verification for civil SSCs

Screening of SSCs has been performed to identify SSCs in scope for ageing management and CSO. There are some deficiencies in screening of SSCs for ageing management and CSO. Without comprehensive screening, ageing effects of SSCs that are not in scope will not be properly managed, which may have potential operational safety aspects. Lack of documentation of justification of exclusion from scope of SSCs, or non-consideration of potential effects of SSCs that are not important to safety on those that are important to safety can jeopardize safety.

The team provided recommendation in this area (see Section 2.2.2 and *Issue Sheet B-1*).

Data collection and record keeping for civil SSCs

A data collection and record keeping system exists within the NRG management system. A management tool (i.e. SAP) initiates a scheduled activity and records its completion. All results of the activities such as maintenance, and inspections performed are recorded currently in the paper format. 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.

Documentation of ageing management in support of CSO for civil SSCs

Documentation for ageing management is available on a Share Point that contains all related documents, such as PLAMP, AMPs, TLAAs, and EQ. 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.