IAEA-NSNI/INSARR
ORIGINAL: ENGLISH

MISSION REPORT

REPORT OF THE

FOLLOW-UP INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (Follow-up INSARR)

TO THE

High Flux Reactor (HFR)

Petten, The Netherlands
8-11 April 2019

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
Division of Nuclear Installation Safety
Research Reactor Safety Section

INTERNATIONAL ATOMIC ENERGY AGENCY

Mission date:	8-11 April 2019
Location:	Petten, The Netherlands
Facility:	HFR Research Reactor
Organized by:	IAEA
Conducted by:	
Mr A. Shokr	SH/RRSS/NSNI, Team leader
Mr G. Storr	Australia
Mr H. Abou Yehia	France
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EXECTIVE SUMMARY

Following a request from the Authority of Nuclear Safety and Radiation Protection (ANVS), the IAEA conducted a Follow-up Integrated Safety Assessment of Research Reactors (Follow-up INSARR) mission at the HFR research reactor. The objective of the mission was to review the implementation of the recommendations provided by the main INSARR mission, which was conducted in October 2016. The mission also followed up on the implementation of the recommendations of the INSARR 2011 mission that remained open.

The follow-up INSARR mission was conducted in parallel with the Follow-up Independent Safety Culture Assessment (ISCA) mission. The main ISCA mission was conducted in 2017. The two follow-up missions mutually benefited from each other, including by consolidating the team conclusions on the implementation of the recommendations of the review areas that were covered by the scope of both missions - specifically the management system, safety committee, and training and qualification.

The mission team was composed of an IAEA staff member: Mr A. M. Shokr (Head, Research Reactor Safety Section (RRSS) - team leader) and three international experts: Mr D. Rao (India), Mr H. Abou Yehia (France), and Mr G. Storr (Australia). The main technical counterpart of the mission was Mr O. Wouters, HFR Reactor Manager. The discussions during the mission were held with the participation of NRG and HFR senior managers and staff. Staff members of ANVS attended almost all the sessions of the missions as observers. Representatives from JRC also participated in the entry and exit meetings.

For the conduct of the mission, the following activities were performed:

- Examination and assessment of technical documentation;
- A detailed walkthrough of the reactor facility;
- Discussions with the NRG and HFR management and the reactor operating personnel;
- Discussions among IAEA team members;
- Preparation of the mission summary report.

The IAEA team noted a high level of implementation of the recommendations of the main INSARR mission. The team assessed that a total of 17 out of 20 recommendations have been either fully implemented or where minor actions remain (and their full implementation is ongoing). Actions have been taken and some others are planned for the three remaining recommendations. The team also assessed that five out of the eight INSARR 2011 recommendations have now been implemented, and work is ongoing to complete the implementation of the remaining three recommendations.

The team also noted the continued implementation by NRG of an effective integrated management system covering the HFR operation, and following the INSARR recommendations, the adoption of a policy on periodic assessment of safety culture and establishment of relevant procedures within the management system. The team also noted the conduct of training on application of the system for the HFR staff. These actions, in addition to those taken or planned in responding to the recommendations of the ISCA mission, will provide for further development and maintenance of a strong culture for safety.

The team concluded that this high level of implementation of the INSARR recommendations contributes to further enhancement of the reactor operational safety, through improved organizational effectiveness, operating programmes, documentation, and safety aspects of technical modifications of the facility.

The team assessed that the following measures have been taken by NRG, following the INSARR recommendations, to enhance the reactor organizational effectiveness that include revision of the HFR operating organizational structure and appointment of the maintenance manager; improvement of the effectiveness of the reactor safety committee; and coordination and cooperation with JRC with respect to development of the decommissioning plan (2017 revision); and improvement of the training and qualification programme.

With respect to operational safety programmes and documentation, the team assessed that the measures that have been taken by NRG, following the INSARR recommendations, included revision of OLCs, revision of the management system processes to facilitate timely revision of the reactor documents important to safety and to improve the modifications process; improvement of the contents of operation cycle reports; completion of the safety assessment aiming at minimizing accidental water leakage through the sub-pile room and the pipes penetrating the reactor pool; and revision of the maintenance programme.

In responding to INSARR recommendations, several actions aimed at safety improvements have also been taken by NRG with respect to technical modifications of the facility. These included installation of a new trolley of the polar crane qualified to nuclear standards; confirmation that safety margins are available in the seismic capacity of pipes in the safe shutdown paths; renewal of the radiation monitoring and alarm system at the beam tubes that are still in operation; determination and control of the water leakage rate and paths from the reactor pools. In this regard, the team highlighted the importance of continued monitoring and investigating leakage paths and rates and implementing, if needed, corrective actions.

Some of the INSARR recommendations have not yet been implemented, although some actions have been taken (or planned) in this regard. These recommendations remain valid and further actions need to be taken by NRG to implement them. These are related to:

- Classification of the reactor structures, systems and components with respect to safety and establishment of the associated quality and seismic requirements;
- Revision of the safety analysis report in accordance with the IAEA safety standards;
- Implementation of the technical and administrative measures that have been identified to prevent uncovering of spent fuel in the case of accidental situations that may occur during mis-handling of heavy loads and which affect the integrity of the pool floor;
- Implementation of the results of seismic walkdown, and installation of an automatic shutdown signal in the case of seismic events;
- Inclusion of HFR specific knowledge in the training of the staff of the Research and Development and Irradiation Solution Units; and
- Consideration of establishment of practical arrangements to ensure the independence of the radiation protection function during the reactor operation shifts.

Two additional recommendations were also provided by the IAEA team to further enhance coordination between JRC and NRG on HFR decommissioning and the effectiveness of the safety committee.

The IAEA team appreciated the openness and transparency of the NRG staff and HFR operating personnel and acknowledged their technical knowledge and excellent preparation for the mission. The team also would like to express its appreciation to the ANVS, NRG and HFR management for their commitment to safety and continuous improvement.

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1. INTRODUCTION

1.1 BACKGROUND

Following a request from the Authority of Nuclear Safety and Radiation Protection (ANVS), the regulatory body of the Netherlands, the IAEA conducted a Follow-up Integrated Safety Assessment of Research Reactors (Follow-up INSARR) mission at the High Flux Reactor (HFR). The reactor is located in Petten, 50 kilometres north of Amsterdam. It is a tank-in-pool type research reactor of 50 MW thermal power, cooled and moderated by light water, that uses low enriched uranium plate-type fuel elements with beryllium as a reflector. The reactor is owned by the Joint Research Centre (JRC) and operated by the Nuclear Research and consultancy Group (NRG).

HFR has been operating since 1961 with an average utilization time of 220 to 265 days of operation per year in the last 5 years. It has 8 to 9 operating cycles per year with a 4 days maintenance outage between the operating cycles and two long outages for maintenance activities and larger modifications every year. The HFR has 20 in-core and 12 pool-side irradiation positions, plus 12 beam tubes. The in-core positions are mainly employed for material irradiation, experiments and fuel irradiation programmes. Radioisotopes production is performed in both irradiation positions. At present, the use of beam tubes is limited to the use of two positions.

The HFR is operated at 45 MW nominal power and at constant and pre-set conditions in order to maintain the nuclear characteristics constant throughout operation. The HFR provides irradiation services, neutron radiography and neutron diffraction. The facility is an important tool for European programmes such as: European Network Ageing Materials Evaluations and Studies, High Temperature Reactor Technology Network, Fusion for Energy, European Network on Neutron Techniques Standardisation for Structural Integrity, European Network for Medical Radioisotopes and Beam Research, Medical Radioisotope Production, Fuel Irradiation, Experiments with Thorium and Fusion Power Development. The services of the HFR include post irradiation studies. HFR produces more than 60% of the current medical isotopes demand of Europe and about 30% of the worldwide demand.

INSARR Missions were conducted at the reactor in 2005. In February 2009 and January 2010, the IAEA implemented two safety review missions on the repair of the reducers of the primary coolant pipes (bottom plug liner, BPL). The mission made recommendations and suggestions to improve the reactor safety and to ensure the safe implementation of the repair plan. Another two INSARR missions were conducted in 2011 and 2016. These missions provided recommendations and suggestions for safety improvements. Follow-up on the implementation of the recommendations provided by the INSARR 2011 mission was conducted at the INSARR 2016.

The IAEA also implemented at NRG an Independent Safety Culture Assessment (ISCA) mission in 2017. The IAEA also held in 2018 a preparatory meeting for the proposed mission on ageing management for continued safe operation of HFR, which planned to be conducted in 2020.

1.2 OBJECTIVE AND SCOPE OF THE MISSION

The objective of the follow-up INSARR mission was to review the level of implementation of the recommendations provided by the INSARR 2016 mission and to evaluate the safety improvements since that mission.

These recommendations covered several safety areas:

- Operating organization and reactor management;
- Management system;
- Safety culture;
- Safety committee;
- Training and qualification of operating personnel;
- Safety analysis;
- Siting and protection against external hazards;
- Operational limits and conditions (OLCs);
- Conduct of operations;
- Maintenance and periodic testing;
- Safety of utilization;
- Safety of modifications;
- Operational radiation protection;
- Operational waste management;
- Decommissioning planning.

The mission also followed up on the implementation of the recommendations of the INSARR 2011 mission that remained open.

Upon request from HFR and ANVS, the mission also held discussions on the methodology for scoping and screening of the reactor structure, systems, and components (SSCs) for ageing management for continued safe operation.

1.3 BASIS AND REFERENCES FOR THE REVIEW

The basis for the safety review was the IAEA Safety Standards and Guidelines. The following IAEA documents were used as the basis of this review:

a) IAEA Services Series No. 25: Guidelines for the Review of Research Reactor Safety (INSARR Guidelines), 2013;

b) IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016;

c) Maintenance, Periodic Testing and Inspection of Research Reactors, IAEA Safety Standards Series No. NS-G-4.2, IAEA, 2006;

d) Core Management and Fuel Handling for Research Reactors, IAEA Safety Standards Series No. NS-G-4.3, IAEA, 2008;

e) Operational Limits and Conditions and Operating Procedures for Research Reactors, IAEA Safety Standards Series No. NS-G-4.4, IAEA, 2008;

f) The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors, IAEA Safety Standards Series No. NS-G-4.5, IAEA, 2008;

g) Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, IAEA Safety Standards Series No. NS-G-4.6, IAEA, 2008;
h) Ageing Management for Research Reactors, IAEA Safety Standards Series No. SSG-10, IAEA, 2010;
i) Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, IAEA Safety Standards Series No. SSG-20, IAEA, 2012;
j) Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors, IAEA Safety Standards Series No. SSG-22, IAEA, 2012;
k) Safety in the Utilization and Modification of Research Reactors, IAEA Safety Standards Series No. SSG-24, IAEA, 2012;
l) SSG-10: Ageing Management for Research Reactors, 2010;
m) IAEA Safety Standards GSR Part 6: Decommissioning of Nuclear Facilities, 2014;
n) IAEA Safety Standards Series No. SSG 37: Instrumentation & Control Systems and Software important to Safety of Research Reactors, 2014;
o) IAEA Safety Standards Series No. GSR Part 2: Leadership and Management for Safety;
p) INSARR Main Mission Report, IAEA, December 2016;
q) ISCA Main Mission report;
r) Draft Guidelines for Ageing Management for Continued Safe Operation for Research Reactors, IAEA;
s) NRG INSARR 2016 Status of follow-up, NRG, February 2019;
t) CSO Scope Step 1 – Identification of SSCs important to safety, NRG, February 2019;
u) CSO HFR Scope – Methodology, NRG, February 2019;
v) Continued Safe Operation of High Flux reactor – Conceptual document, NRG, February 2019.

Several HFR operating documents and records which were presented are made available by HFR to the IAEA team during the follow-up mission.

1.4 CONDUCT OF THE MISSION

The mission was conducted in parallel with the Follow-up ISCA mission. The main ISCA mission was conducted in 2017. The two follow-up missions mutually benefited from each other, including by consolidating the team conclusions on the implementation of the recommendations of the review areas that were covered by the scope of both missions - specifically the management system, safety committee, and training and qualification.

The mission team was composed of an IAEA staff member: Mr A. M. Shokr (Head, Research Reactor Safety Section (RRSS) - team leader) and three international experts: Mr D. Rao (India), Mr H. Abou Yehia (France), and Mr G. Storr (Australia). The main technical counterpart of the mission was Mr O. Wouters, HFR Reactor Manager. The discussions during the mission were held with the participation of NRG and HFR senior managers and staff, including Mr J. Offerein, Director of Operations. Mr R. Jansen, Senior Coordinator Policy, Regulations and International Affairs for Nuclear Safety ANVS, was the counterpart from ANVS and attended the entry meeting. Staff members of ANVS attended almost all the sessions of the missions as observers. Mr P. Szymanski, Director of JRC, has also participated in the entry and exit meetings.

The entry meeting started with a welcome address by Mr H. Cuijpers, NRG Managing Director, Mr J. Offerein, Mr P. Szymanski, and Mr R. Jansen. In their opening remarks, they highlighted the background of request for the Follow-up INSARR and ISCA missions, the importance to safety of international peer reviews, and the cooperation of NRG and ANVS with IAEA on safety of nuclear installations. During the opening session, the HFR management provided an overview of the safety status of the reactor and the major activities implemented since the main INSARR mission. The IAEA team leader reviewed the mission objectives, scope, and expected results.

For the conduct of the mission, the following activities were performed:

- Examination and assessment of technical documentation;
- A detailed walkthrough of the reactor facility;
- Discussions with the NRG and HFR management and the reactor operating personnel;
- Discussions among IAEA team members;
- Preparation of the mission summary report.

During the first day of the mission, the IAEA team and the counterparts conducted a detailed walkthrough of the reactor and associated facilities. The walkthrough was an opportunity to verify in the field the physical status of the reactor facility and the progress made regarding the implementation of some of the INSARR recommendations. During the walkthrough, the reactor was in shutdown mode undergoing routine maintenance, in-service inspection of the reactor pool's internal components, and for the installation of a new trolley of the polar crane. With respect to the installation of the crane, the team observed that good engineering practices were followed particularly with respect to nuclear and industrial safety, including protection of fuel and reactor pools and their internal components against incidental dropping of heavy loads, control of the work performed by the external contractors and housekeeping. The team also noted that a new platform and connecting staircases had been installed which will be used for activities related to radioisotope production. The platform was being used during the shutdown for the staging of the mechanism used for the installation of the new trolley of the polar crane.

Most of the mission time was dedicated to a series of technical meetings and plenary sessions with the technical counterparts, including discussions on the implementation of the recommendations of the main INSARR mission and addressing its observations and suggestions. Within the framework of the mission, scoping and screening of SSCs for ageing management for continued safe operation of the HFR was also discussed. The agenda and the list of the participants of the mission are provided in ANNEX I and ANNEX II, respectively.

On Wednesday 10th April, the IAEA team leader briefed the ANVS representatives on the results of the INSARR follow-up mission.

The follow-up mission conclusions and recommendations were discussed with the NRG and HFR management, the technical staff and the reactor operating personnel during the exit meeting held on 11 April 2019 with the participation of the NRG Managing Director, JRC Director, and observers from ANVS. There was general agreement by the counterparts on the mission recommendations.

2. CONCLUSIONS AND RECOMMENDATIONS OF THE MISSION

The IAEA team noted a high level of implementation of the recommendations of the main INSARR mission. The team assessed that a total of 17 out of 20 recommendations have been either fully implemented or where minor actions remain (and their full implementation is ongoing). Actions have been taken and some others are planned for the three remaining recommendations.

The team also assessed that five out of the eight INSARR 2011 recommendations (that were still open at the time of the 2016 main INSARR mission have now been implemented), and work is ongoing to complete the implementation of the remaining three recommendations.

The team also noted the continued implementation by NRG of an effective integrated management system covering the HFR operation, and following the INSARR recommendations, the adoption of a policy on periodic assessment of safety culture and establishment of relevant procedures within the management system. The team also noted the conduct of training on application of the system for the HFR staff. These actions, in addition to those taken or planned in responding to the recommendations of the ISCA mission, will provide for further development and maintenance of a strong culture for safety.

The team concluded that this high level of implementation of the INSARR recommendations contributes to further enhancement of the reactor operational safety, through improved organizational effectiveness, operating programmes, documentation, and safety aspects of technical modifications of the facility.

The team assessed that the following measures have been taken by NRG, following the INSARR recommendations, to enhance the reactor organizational effectiveness:

- Revision of the HFR operating organizational structure to avoid the overlap and potential conflict of the duties and authorities of the installation manager and reactor manager and filling in all the vacant positions, in particular appointment of the maintenance manager;
- Improvement of the effectiveness of the reactor safety committee through establishment of work procedures to provide for follow-up by the committee on the implementation of the actions associated with its recommendations;
- Coordination and cooperation with JRC with respect to development of the decommissioning plan (2017 revision);
- Improvement of the training and qualification programme by establishment of requirements on retraining and requalification of the operating personnel if the personnel are absent for an extended period of time from the activities that they are certified for.

With respect to operational safety programmes and documentation, the team assessed that the following measures have been taken by NRG following the INSARR recommendations:

- Performing the following activities and planning to include them in the OLCs:
    - Periodic verification (once per year) by measurements of the values of reactivity shutdown margins;
    - Establishment of technical and administrative requirements during prolonged shutdown periods of the reactor;
    - Identification of the actions to be taken in case of alarms triggered by the radiation monitoring equipment, as well as the location and the associated alarm settings values;

    - Performing periodic (twice a year) monitoring of radioactivity contents of underground water using existing sample wells that are located around the reactor facility;
- Revision of the management system processes to:
    - Facilitate timely revision of the reactor documents important to safety, and reduction of the accumulation of the reactor documents pending revision;
    - Ensure that the postponed modifications are subjected to evaluation of the impact of the sub-sequent modifications and to reapproval before initiation of the relevant work.
- Improvement of the contents of operation cycle reports providing the reactor management with information to verify and perform trending of the reactor operational safety performance;
- Completion of the safety assessment aiming at minimizing accidental water leakage through the sub-pile room and the pipes penetrating the reactor pool;
- Inclusion of the civil engineering structures in the maintenance programme, and revision of the work order procedures to include quality checks concerning completion of maintenance and return to service checks.

In responding to INSARR recommendations, several actions have also been taken by NRG with respect to technical modifications of the facility aimed at safety improvements. These include:

- Installation of a new trolley of the polar crane qualified to nuclear standards;
- Installation adjacent to the reactor pool of a new platform and connecting staircases to be used for activities related to radioisotope production;
- Confirmation that safety margins are available in the seismic capacity of pipes in the safe shutdown paths;
- Renewal of the radiation monitoring and alarm system at the beam tubes that are still in operation (HB4 and HB5), and establishment of operating procedures for beam tube operation;
- Determination and control of the water leakage rate and paths from the reactor pools. In this regard the team highlighted the importance of continued monitoring and investigating leakage paths and rates and implementing, if needed, corrective actions.

The team also ascertained that all the suggestions of the INSARR missions of 2011 and 2016 were considered by NRG. The majority of the suggested actions have been implemented and resulted in improvement of the:

- Operational radiation protection programme: Enhanced exchanges between the quality, safety, and environment department and the reactor management on operational radiation protection issues, significant reduction (reported to be more than 50%) of the Ar-41 releases through the reactor stack, and reduction of the volume of the stored ion-exchange resins;
- Quality of probabilistic safety analysis;
- Exchanges with ANVS on the status of postponed Category I and II modifications.

Some of the INSARR recommendations have not yet been implemented, although some actions have been taken (or planned) in this regard. The team concluded that these recommendations, remain valid and further actions need to be taken by NRG to implement the recommendations. These recommendations are related to:

- Classification of the reactor structures, systems and components (SSCs) with respect to safety and establishment of the associated quality and seismic requirements. This classification should be consistently used across all programmes and activities, including maintenance, modification, ageing management, and continued safe operation;
- Revision of the safety analysis report (SAR) in accordance with the IAEA safety standards;
- Implementation of the technical and administrative measures that have been identified to prevent uncovering of spent fuel in the case of accidental situations that may occur during mis-handling of heavy loads and which affect the integrity of the pool floor;
- Implementation of the results of seismic walkdown, and installation of an automatic shutdown signal in the case of seismic events;
- Inclusion of HFR specific knowledge (e.g. design safety features, safety analysis, SAR, and OLCs) in the training of the staff of the Research and Development and Irradiation Solution Units;
- Consideration of establishment of practical arrangements to ensure the independence of the radiation protection function during the reactor operation shifts.

The process of review of the implementation of the INSARR recommendations, including review of documents and discussions, resulted in the following additional recommendations:

- NRG, JRC and the relevant authorities should develop a policy which ensures effective and sustainable ongoing coordination and cooperation for decommissioning of the HFR facility This would include development and revision of the decommissioning plan;
- The “type of treatment” of documents submitted to the safety committee that are currently defined as “only for information” should also be reviewed by the committee as they are important to the reactor safety, including, for example, incident reports and potentially unsafe situations, annual and quarterly reports on safety performance, HFR cycle reports, and regulatory inspection reports.

Detailed discussions on the bases for these recommendations and on the follow-up of the INSARR recommendations is provided in Section 3 of this report.

In preparation for the IAEA mission on HFR ageing management and continued safe operation (planned for 2020), discussions and exchanges of information and experience were held between the IAEA team and HFR technical staff on the scoping and screening methodology for the SSCs.

Finally, the IAEA team appreciated the openness and transparency of the NRG staff and HFR operating personnel and acknowledged their technical knowledge and excellent preparation for the mission. The team also would like to express its appreciation to the ANVS, NRG and HFR management for their commitment to safety and continuous improvement.

3. RESULTS OF THE MISSION

3.1 FACILITY WALKTHROUGH

During the first day of the mission, the IAEA team and the counterparts conducted a detailed walkthrough of the reactor and associated facilities. The walkthrough was an opportunity to verify in the field the physical status of the reactor facility and the progress made regarding the implementation of some of the INSARR recommendations.

During the walkthrough, the reactor was in shutdown mode undergoing routine maintenance, in-service inspection of the reactor pool's internal components, and for the installation of a new trolley of the polar crane in place of the old one. With respect to the installation of the trolley of the crane, the team observed that good engineering practices were followed particularly with respect to nuclear and industrial safety, including protection of fuel and reactor pools and their internal components against incidental dropping of heavy loads, control of the work performed by the external contractors and housekeeping.

The team also noted that a new platform and connecting staircases had been installed which will be used for activities related to radioisotope production. The platform was being used during the shutdown for the staging of the mechanism used for the installation of the new trolley of the polar crane.

3.2 FOLLOW-UP OF THE IMPLEMENTATION OF THE RECOMMENDATIONS OF THE INSARR MISSION

This Section provides the results of the follow-up of the implementation of the INSARR 2016 mission recommendations and suggestions. This section also covers follow-up of the recommendations of the INSARR 2011 mission that were not fully implemented at the time of follow-up mission of INSARR 2016 (which was conducted along with INSARR 2016 mission).

The results are presented for each recommendation and suggestion in all safety review areas covered by the main INSARR mission. This follow-up process and the observations made by the team and their discussion with the reactor operating personnel are provided under the **"Implementation"** part of the text below. For immediate reference for the readers of this report, the recommendations made in the main INSARR mission are also reproduced in this section and presented in *italic font*.

The team identified additional recommendations, and these are indicated at the end of the relevant sub-sections under "**Recommendations of this mission**". These recommendations are numbered as FRX).

3.2.1 Operating organization and reactor management

"***R1)*** *To ensure the effectiveness in managing the HFR operation safety, NRG is recommended to:*

- *Revise the reactor operating organizational structure to avoid the overlap and potential conflicts of the duties and authorities of the HFR Installation Manager and the HFR Reactor Manager;*
- *Fill in the position of Maintenance Manager, which has been vacant since 2014 and is currently occupied by the Operation Manager;*

- *Evaluate, with respect to safety, the situation of having the same person carrying out the functions of reactor manager for HFR and Low Flux Reactor (LFR, currently in decommissioning stage). Actions are taken accordingly to ensure adequate supervision of activities important to safety in both facilities;*
- *Consider establishing administrative procedures and practical arrangements to ensure the independence of the radiation protection function during the reactor operation shifts. This will supplement the actions taken by NRG in response to the 2011 INSARR recommendation on the independence this function."*

Implementation

Several actions have been taken and completed by NRG to implement this recommendation. The roles and responsibilities of HFR Installation Manager and HFR Reactor Manager were fully separated in 2018 and job descriptions, including tasks and responsibilities for safety. The HFR installation Manager position has been filled in. The job descriptions of the two positions were revised and included in the management system documentation. The discussions made during the mission showed that there is no overlap or potential conflicts of duties and authorities between the two posts.

A dedicated Maintenance Manager was hired in April 2017. The Operation Manager and Maintenance Manager roles have been separated again to ensure that both functions are carried out adequately.

The situation that the same person (Reactor Manager) is heading both LFR and HFR was evaluated by NRG after the INSARR 2016. Since the LFR was no longer in operation and its decommissioning has been conducted, a decommissioning manager for LFR was hired. The situation at the time of the INSARR Follow-up mission was that the HFR Reactor Manager is no longer responsible for the LFR since the decommissioning of the LFR has been carried out successfully. The job description of the HFR Reactor Manager was revised and documented in the management system documentation.

The team also noted the revision of the HFR organizational structure to reflect the above mentioned actions, which will further enhance the effectiveness of the HFR organizational structure.

The issue of the independence of the radiation protection function during operational shifts was discussed again between the IAEA team and HFR management during this mission. There is no radiation protection officer during the night shifts and the operators (who are also trained on the function of radiation protection officers) carry out this function by exchanging the roles (i.e. operators and radiation protection officers) between them periodically. HFR evaluated this situation (Note: K.6150/18.151856, February 2019) and concluded that since no non-routine activities are performed during night shifts; the operators are well-trained on radiation protection officer function; and that several improvements were introduced to the operating procedures, the existing practice is sufficient. The IAEA team further clarified the issue and confirmed the validity of the conclusion of the INSARR 2016 mission in this regard. The IAEA team also concluded that the relevant part of the INSARR recommendation remains valid and should be implemented. This part is on consideration of establishment of practical arrangements to ensure the independence of the radiation protection function during the reactor operation shifts.

On this basis, the team concluded that adequate actions have been taken to implement the recommendation related to duties, authorities and responsibilities of the HFR Manager and Installation Manager, finning the position of Maintenance Manager, and responsibility for safety of HFR and LFR and that this issue should be closed. However, the part related to assurance of the independence of the radiation protection function during the reactor night shifts remains open and should be resolved.

3.2.2 Safety Committee

*"**R4)** For further enhancing the effectiveness of the [Reactor Safety Committee] RSC, it is recommended that the committee is informed by the NRG management on the implementation of the actions associated with its recommendations."*

Implementation

The "rules and regulations of the RSC" have been revised (and reviewed by ANVS) in 2018 (approved by NRG in March 2019). In accordance with the revised rules and regulations, the HFR reactor manager will attend (twice per year) the RSC meetings to describe and discuss safety aspects of the facility including:

- Safety performance, including incidents and deviations;
- An overview on the implementation of the actions associated with the RSC advices and recommendations;
- Realization of safety enhancing measures;
- New and modified processes;
- Safety culture.

The participation of the HFR Reactor Manager in the RSC meetings, described above, aims also at informing the committee on the overall safety performance of the reactor and at ensuring that the committee is made up to date with latest developments at the installations (see also the implementation of the INSARR 2011 SC-01 R1, below).

The team considered that this recommendation is implemented and the issue is closed.

"INSARR2011 SC-01 R1*) The terms of reference for RSC should be revised to include review of the radiological safety issues and changes in the safety documentations. The RSC should make a necessary follow-up on the implementation of the actions associated with their recommendations, including INSARR mission recommendations."*

Implementation

The discussion made during the mission, including review of the relevant HFR documentation (see also the implementation of R4 of INSARR 2016) showed that adequate actions have been taken by NRG to implement this recommendation. The "rules and regulations of the RSC" have been revised based on the comments from both INSARR and ISCA 2017 missions and remarks made by the ANVS following a dedicated inspection into the RSC in 2018. The major changes to the RSC rules and regulations were:

- The documents that are required to be submitted to the RSC (either for "safety review", for "comments" or "for information only") are explicitly listed. These documents are in line with that list established by the IAEA safety standards;
- The RSC is to advise on organizational changes relevant to safety;
- The RSC review the facility safety once per year to evaluate what the effect on safety of their advices/recommendations (e.g. follow up on implementation of modifications and performance of experiments – related to R4 of the INSARR 2016);
- HFR Reactor Managers regularly participates in the RSC to update on the safety status of the reactor facility (see also implementation of R4 of INSARR 2016).

The team discussed in detail the "type of treatment" of the documents to be submitted to the RSC. Some of these documents are submitted "only for information", and it is not expected that they will be reviewed from safety point of view by the RSC. Most of these documents are important to safety, including, for example, reports on incidents and potentially unsafe situations, annual and quarterly reports on safety performance, HFR operating cycle and regulatory inspection reports. The team clarified, based on the IAEA safety standards, the need to have these documents within the scope of the RSC review (and advice as needed).

The team concluded that adequate actions have been taken by NRG to implement the recommendation "INSARR 2011 SC-01 R1", and that the relevant issue should be treated as closed. However, the team provided additional recommendation to further enhance the effectiveness of the review process of the RSC (provided below).

Recommendation of this mission

FR 01) The "type of treatment" of documents submitted to the safety committee that are currently defined as "only for information" should also be reviewed by the committee as they are important to the reactor safety, including, for example, incident reports and potentially unsafe situations, annual and quarterly reports on safety performance, HFR cycle reports, and regulatory inspection reports.

3.2.3 Training and qualification

"R5) *For further enhancement of the training and qualification programme, it is recommended to establish a requirement on requalification of certified operating personnel if they are away for an extended period of time, from the activities that they are licensed for".*

Implementation

The training and qualification programme for HFR operating personnel has been revised following the 2016 INSARR mission recommendation. The revised programme includes section on "requalification after an extended period without operational experience", (BV-A18, NO-O-HFR-OD-0112). Every licenses operator who has not been a part of operation shifts for a period of six months will have to be re-certified by the HFR Reactor Manager. A dedicated training programme will be drafted for that operator which will (as a minimum) consist of participation in a reactor training; study of all new and revised operational procedures and modification to the facility; and participation for one month in an operation shift under supervision of a licensed person.

The team considers this recommendation as implemented and the issue as closed.

The INSARR 2016 also provided suggestion in this area. This suggestion was: ***"S3)*** *It is suggested to consider adopting a power level, lesser than the currently established 30 MW, for retraining of personnel with due consideration of minimisation of the overall potential risk of operating the reactor during the training process."* In this regard, the team ascertained actions have been taken by NRG to address this suggestion. NRG has adopted a power level of 15 MW (instead of previously established 30 MW). The reactor shift supervisors evaluated this action and concluded no loss of retraining quality. Accordingly, the training procedures have been revised (and included adoption of safety system settings at 18 MW for the training mode of the reactor).

3.2.4 Safety Analysis

"R13) *To complement the safety reassessment performed following the lessons from the Fukushima accident, it is recommended to define and implement measures aiming at minimizing accidental water leakage through the sub-pile room and the pipes penetrating the reactor pool. This is to reduce the risk of core un-coverage, taking into consideration combination of an earthquake and loss of electrical power supply."*

Implementation

A risk assessment of the water leakage in the vicinity of the sub-pile room was performed by HFR. The assessment identified five possible leak paths and the effect of any leaks as follows:

(i) Jacketed piping between bottom plug reducer and vacuum breaker: Since the piping has double wall and the annular space is connected to a drain line with two in-series isolating valves, any leak in the primary pipe will be revealed and can be contained.

(ii) The two single wall bottom plug reducers: The reducer is surrounded by heavy concrete and any leak in the reducer will be very slow and will not result into uncontrolled loss of water from the pool. Further, these reducers are periodically inspected.

(iii) The bottom plug and bottom plug liner: This joint has double seals and failure of a single seal will not result into any water leak.

(iv) The primary system drain line: This line has a valve and a blind flange. Another cover has been mounted on the drain line including the valve. Any breakage of the pipe before the drain valve will contain the leaks.

(v) The penetrations in the bottom plug: These penetrations are mainly for control rod assemblies and except one penetration, all have double seals. Further, the analysis performed showed that any leakage will be within the makeup system capabilities.

HFR also explained that door of the sub-pile room to contain any leakage into sub-pile room cannot be sealed due to engineering and operational reasons. Seismic analysis performed for the seismic and black out situation showed that the primary system and pool will remain intact up to an acceleration of 4 m/s^2 and removal of the decay heat will not be affected. The probability of an earthquake beyond this value is very low (see also implementation of R7, below).

On this basis, the team concluded that this recommendation is implemented and the issue is considered as closed.

HFR has also addressed the suggestion ***"S5"*** that has been provided by the INSARR 2016 on the quality of the probabilistic safety analysis. In this regard, the team noted that the full scope PSA that has been ongoing over the past years has been completed and is currently under review by ANVS. The review of the Level 1 PSA is nearly complete. With respect to S5, HFR informed the team the following:

Mo-irradiation targets: All irradiation facilities are considered in the initiating event analysis: in-core and ex-core. The initiating events report analyses the impact of irradiation targets on the reactor by assessing 1) unwanted criticality effects of irradiation targets and 2) the impact of failure of in-core targets on the primary flow. Secondly the targets are analysed as separate initiating events leading to consequences limited to the targets themselves. Intrinsic failure of targets and loss of cooling (including to early removal) are included in the analysis.

(Radiation) incidents during handling of targets outside the core and outside the pool side facility are treated in the deterministic safety analysis and workers safety analyses.

The parameters used in the accident scenarios (event trees) are in principle described in the success criteria report: Definition of PSA Level1 end states such as core damage, spent fuel damage, and target damage; and success criteria of safety systems: criticality, cooling and confinement.

Some specific issues, such as building resistance against flooding, earthquake and high wind are addressed in the initiating event report (Chapters 5, 6 and 7 on hazards) and the accident sequence delineation report, for specific accident sequences.

Every safety (related) system used in the accident sequence delineation has its own report. This report contains a short description of the system, its safety function(s), the success criteria, the dependencies on support systems, a description of the fault tree(s), the common cause failures (CCF) factors etc.

The data report contains two annexes that list the failure data of all components used in the PSA. Annex A of the data report contains the independent failure data and if applicable the test interval. For every data point: the source including page/table is given. The CCF factors together with source and page/table are listed in annex B of the data report.

The discussion showed that the PSA is based on the generic data obtained from the various sources including from non-nuclear industries.

The team also followed up on the implementation of the two recommendations provided by the INSARR 2011 mission (i.e. INSARR SAR-01 R1, and R2) on safety analysis and safety analysis report. Follow-up on the implementation of these two recommendations is as follows.

"INSARR2011 SAR-01 R1) *The content of SAR should be in conformance with the IAEA safety standards and should integrate the necessary technical information presented in other documents in order to ensure its stand-alone character. SAR should include an analysis of an enveloping postulated accident involving the reactor core fuel with radiological consequences. Such an accident should be also considered as a basis for the emergency plan."*

Implementation

HFR has initiated in 2018 the work on the revision of the SAR, which will systematically organize existing information in a structured way that can be maintained. Nearly all information that should be part of a SAR does exist for HFR and is available in various documents. The revised SAR will be a standalone document and will serve the following additional purposes:

- To include the results of the studies that have been performed over the years, especially for hazard analyses, site characterization, and ageing management;
- To be aligned with the IAEA safety standards.
- To provide a useful reference for engineers and project managers with trustworthy installation data and a clear design basis.
- To help create a learning tool for all HFR staff.

ANVS requires that the SAR to be compliant with the "Technical Review Plan", which was developed based on several sources, including the IAEA Safety Standards Series No SSG-20. The table of contents of the SAR was presented and the team during the mission. The team noted that the content is generally consistent with the IAEA safety standards. HFR expects to complete the ongoing work on revision of SAR by 2020.

The team considers that the work on full development of the SAR based on the IAEA safety standards is ongoing and the issue is open**.**

"INSARR2011 SAR-01 R2) *The HFR should establish a list of the SSCs important to safety with the associated seismic and quality requirements."*

Implementation

As part of the development of the SAR a re-classification of the SSCs of the HFR has been considered. All SSCs (or clearly defined groups of components) of the systems described in the SAR will be safety classified as safety class: 1, 2, 3, n/a, and a seismic classification as seismic class: 1, n/a.

The safety classification is based on the safety functions and the consequences of failure of the SSC not being able to perform the safety function when demanded. First a list of SSC function(s) to achieve main safety function(s) is defined. These functions are given a safety category based on the consequences on nuclear safety due to failure to fulfil the function. When classifying the components of a system described in the SAR, first it is determined which of the main safety functions are fulfilled by the component. The safety class of the component is equal to the highest safety category of any of the main safety functions associated with the component, where the component has multiple functions.

For the seismic classification, all SSCs that are required for the safe shutdown path following an earthquake will be seismic class 1 and these SSCs will need to be seismically qualified either by analysis or seismic walk down.

The IAEA team discussed the process of safety classification process and advised that the list of items important to safety has to be identified based on the safety functions they need to perform. Further safety classification and associated seismic class and quality class can then be defined. The team was informed that about 18% of SSCs have been classified and the classification process will be completed by 2020. The team also emphasized that this safety classification should be consistently applied to all other HFR activities and programmes such as maintenance, modification, ageing management, and continued safe operation.

The team also recognized that HFR is an old design and after safety classification of SSCs, certain requirements (such as those related to fabrication and installation of some components such as core structure) may not be possible on some of the SSCs. Compensatory measures need to be adopted in such case(s), including for example monitoring and inspection.

The team acknowledges the ongoing work to implement the recommendation but considers it as not yet implemented and the issue is open.

3.2.5 Operational Limits and Conditions

*"**R14)**. The OLCs should be revised to:*

- *Include periodic verification by measurements of the reactivity shutdown margin, taking into account the relevant enveloping conditions of the proposed core configuration;*
- *Include the list of radiation monitoring equipment, their locations, and the associated alarm setting values, as well as the required actions in case of alarm triggering;*
- *Establish technical and administrative requirements during prolonged shutdown periods, including ensuring sub-criticality of core/fuel storage, restrictions on operation of the over-head crane, availability of electrical power supply, minimum staffing, etc.;*
- *Include periodic monitoring of the radioactivity contents of the underground water using existing sampling wells near the facility."*

Implementation

HFR is in the process of revising the OLCs and since the INSARR2016 mission. Five OLCs changes have been submitted for review by the RSC and will be submitted for approval by the ANVS:

i. Requirements for minimum shift size: These requirements existed in the HFR operating procedures but were not included in the OLCs. Now the minimum operation shift size is five persons, including at least three qualified operators. This requirement has been included in the OLCs;

ii. Requirement to conduct periodic verification measurements of the reactivity shutdown margin: Following the INSARR 2016, the first measurement was conducted in 2018. During two consecutive shifts, control rod reactivity worth measurement using period method for one control rod and compensation method for other control rods were performed at very low power levels. HFR plans to repeat the measurement in the second half of 2019 and the requirement to verify the reactivity shutdown margin periodically (once per year) will be included in the revised OLCs;

iii. Identification of the actions to be taken in case of alarms triggered by the radiation monitoring equipment, as well as the location and the associated alarm settings values: This item was part of the HFR operating procedures and will be added to the OLCs;

iv. Establishment of technical and administrative requirements during prolonged shutdown periods of the reactor: Normal operating procedure in HFR is to unload the core in case of a prolonged shutdown, and technical and administrative requirements for prolonged shutdown periods are included in these procedures. These requirements will be included in the revised OLCs;

v. Requirement on periodic monitoring of the ground water: Since the 2011 INSARR mission the ground water is monitored periodically from extraction points all around the HFR facility. The water samples are analysed by gamma spectrometry and for tritium contamination. The results are reported to ANVS. The periodic monitoring of ground water will be included in the OLCs.

The team assessed that the actions have been taken by HFR to implement the recommendations and subject to its final implementation, the issue is considered as closed.

3.2.6 Operational Radiation Protection Programme

"***R15)*** *Adequate radiation monitors for neutron dose should be installed at the beam tube area."*

Implementation

The HFR reported that only two of the thirteen beam tubes are in use, the others have been mechanically and electrically sealed and these are not in use. For the beam tubes still in operation HB4 and HB5, the monitoring and alarm systems have been renewed. They consist of fission chambers connected to gamma monitoring and alarms at both the beam tube itself and in the control room. Furthermore, the operating procedures of the beam tubes have been changed. Every time the shutter is opened or closed the area around the beam tube is monitored with hand held neutron and gamma detectors by either the local radiation protection officer or the radiation protection expert.

Finally, as part of routine radiation protection the area around all of the beam tubes is monitored for radiation on a weekly basis with neutron and gamma monitors at fixed locations that allow for comparative measurements and trending.

The team considered that the actions taken by the HFR on the implementation of the recommendation is adequate and considers the issue as closed.

INSARR 2016 provided also a suggestion in this area "***S6)":*** *It is suggested that periodic meetings are held between the QSE (including the local radiation protection officer) and the HFR management to provide for more effective exchanges on operational radiation protection issues for the purpose of facilitating continuous improvements and optimisation of radiation protection".* The INSARR 2011 also provided a suggestion on operational radiation protection programme "**INSARR2011 RPR-01 S1":** *It is suggested to explore the possibility of reducing the Ar-41 releases through the reactor stack."*

The team noted that HFR has taken several actions to address these suggestions. The implementation of these actions resulted in significant improvements to the operational radiation protection programme.

With respect to the implementation of the suggestion of the INSARR 2016: The HFR management reported that the following meetings are organized on a regular basis:

- Meeting between local radiation protection officer HFR and reactor manager. This meeting addresses all aspects of radiation protection at the HFR;
- Meeting between all local radiation protection officers at NRG with the chief radiation protection officer and his deputy (both QHSE department). This meeting aims at information exchange between installations and between radiation protection at corporate/policy level (QHSE) and at facility level;
- Meeting between the nuclear safety manager HFR and the QHSE department. This meeting aims at informing QHSE of issues dealing with nuclear safety and radiation protection at HFR
- Nuclear safety meeting: This meeting is held between the NRG directors, the reactor manager and/or HFR Nuclear Safety Manager, HCL Installation Manager and/or HCL Nuclear Safety Manager and QHSE. This meeting aims at discussing issues that transcend the individual installation or to inform the directors of issues at the installation that require their attention.

The IAEA team noted the enhanced exchanges between the quality, health, safety, and environment department and the reactor management on operational radiation protection issues and assessed the suggestion as implemented.

With respect to the implementation of the INSARR 2011 suggestion: HFR tested the hypothesis that the Ar-41 releases were caused mainly by the pneumatic rabbit system (PRS). The PRS draws air from the reactor hall through piping that runs very close to the core box and releases the air to the off-gas system. Independent of the operational condition of the PRS, an air flow was present and the Argon in the air was activated causing a yearly release of 4 TBq Ar-41. During the test the air flow through the PRS was stopped for a long period and it was shown that this had a large effect on the releases, which were reduced to background levels. As a result, the operating procedures of the PRS have been revised. The air flow is blocked when the PRS is not used and opened when the PRS is in operation. This practice has been in place during 2018. The total Ar-41 release measured did not exceed the background levels when PRS was not in use, effectively reducing the emissions of the Ar-41 of HFR by more than 50% in terms of Radiotoxicity Equivalents.

3.2.7 Radioactive Waste Management

There was no recommendation provided by INSARR 2016 in this area. However, a suggestion (S7) was provided by the mission: "*For further enhancing the operational radioactive waste management programme, it is suggested to install on-line stack monitors for aerosols, iodine, and particulates. It is also suggested to implement actions to reduce the volume of the stored ion exchange resins, or to increase the existing storage capacity.*"

This suggestion has been addressed by HFR, who reported that no additional stack monitoring has been installed as priority was given to the renewal of other radiation protection relevant equipment.

An additional temporary storage capacity for the radioactive ion exchange resins was realised. Communication was initiated with the central nuclear waste disposal organization for the Netherlands (COVRA), for final disposal of the resins. The required better characterization of the resins was achieved in 2017. By end of 2018, the approval by COVRA and ANVS for transport of both anion and cation resins from HFR to COVRA was obtained. The first anion resin transport took place in December 2018 and the first cation transport is planned for mid-March 2019.

3.2.8 Decommissioning Planning

"R20) *Effective coordination and cooperation between JRC and NRG should be ensured in development of the revised version (and subsequent revisions) of the HFR decommissioning plan. Arrangements should be defined and established to ensure the availability of HFR knowledgeable personnel and up-to-date documentation required for safe decommissioning. These should be addressed in the updated versions of the decommissioning plan."*

Implementation

In accordance with the Dutch law, every five year a revision is made of the plan of approach for the decommissioning of the HFR. In 2017, JRC and NRG developed a revised version of the decommissioning plan of the HFR. This version of the plan includes a detailed cost estimate. The revised plan has been submitted to ANVS (December 2017) and was approved by ANVS in 2018. Considerations on the availability of the relevant information and operational experience are covered in the revised version of the plan. The revised version also defines a preparatory phase (before the decommissioning phase starts) in which the NRG-JRC joint preparation of the decommissioning takes place.

The team considered the implementation of this recommendation is complete and the issue is considered as closed.

The team also discussed the need to ensure sustainable ongoing coordination and cooperation between NRG and JRC with respect to HFR decommissioning and provided the following additional recommendation.

Recommendation of this mission

FR2) NRG, JRC and the relevant authorities should develop a policy which ensures effective and sustainable ongoing coordination and cooperation for decommissioning of the HFR facility This would include development and revision of the decommissioning plan.

3.2.9 Maintenance, Periodic Testing and Inspection

*"**R11**) The HFR should review the maintenance programme to ensure that all SSCs important to safety including civil structures as well as those SSCs that are maintained by external organisations are covered. Additionally, the work order form should be revised to include quality checks concerning completion of maintenance and return to service checkouts."*

Implementation

HFR has developed and is in the process of implementing the maintenance programme under its asset management programme (Ref: K6170/17.146357 NO HFR/SA/SK) and employs a plan-do-check-act cycle, maintenance and modification execution workflow process, and a reliability centred maintenance (RCM) based review and extension of the preventive maintenance programme. The complete asset management programme implementation was initiated in 2017 and expected to be completed by 2020. This programme will have inputs from the ongoing work on safety classification of SSCs. An asset register has been developed that includes all SSCs including civil engineering structures. The discussion showed that the spare parts in storage are not included in the maintenance programme

The review and extension of the maintenance programme is executed by means of failure mode effect and criticality analysis (FMECA). The failure modes of all maintainable units (SSCs that need maintenance) of HFR installation are analysed by maintenance, operations, engineering and nuclear safety experts. Based on the results, maintenance strategies and associated maintenance plans are developed. The FMECA results will also cover SSCs to be maintained by contractors. The results of the FMECA will be transferred to maintenance documents and schedules which are managed in the SAP plant maintenance software. The plant maintenance software works on the structure of the HFR asset register which includes the SSC's included in the FMECA.

The execution workflow process includes preparation, scheduling, execution and report of executed work order tasks. The process includes the quality checks concerning completion of maintenance and return to service checks. The process is managed by SAP plant maintenance process. The workflow process results are checked for corrective actions on the preventive maintenance programme, installation configuration or training programmes by means of a Failure Report Analysis and Corrective Action System (FRACAS). The FRACAS process is automatically generated by the SAP plant maintenance workflow. The workflow will inform the maintenance engineer who will initiate the FRACAS, which is attended by different experts form engineering, maintenance, operations and nuclear safety.

All concerned staff are being trained on the use of new system and the system will include digital check-outs at each stage of the work flow including completion of maintenance work and return to service.

As most of the actions addressing the recommendation have been implemented and the significant progress of the implementation of a new system, the team considers this recommendation as implemented and the issue as closed.

*"**R12)** The leakage rates and paths from the reactor pool should be determined and accordingly adequate corrective actions should be implemented to limit the water leakage."*

A recommendation (***INSARR2011 MPT-01 R1)*** was also provided by the INSARR 2011 mission on the same issue. This recommendation was: *"Efforts are strongly needed to improve the leak-tightness of the reactor pool and to limit, to the extent possible, the water* *leakage. In this regard, it is recommended to determine the leakage rate of the reactor pool, and consequently implement proper actions to limit the water leakage."*

Implementation

Following the INSARR 2016 mission recommendation, HFR initiated a project to:

- Identify all leak paths from the reactor pools using current and historical data;
- Quantify the leak paths;
- Make provisions to monitor the leak paths individually and for trend analysis;
- Identify potential measures to minimize the leak rates;
- Assess the risk for the installation caused by the leakages.

The results from the project are:

- For each of the three pools of the HFR, a drainage system to collect water leakage from the pool liners exists by design. One additional leak path underneath pool 1 was identified. Water that is collected between the liner and the concrete is transported to drain tanks which can be emptied to the hot & warm drain system. A similar system that collects the water coming through the concrete underneath pool 1 has been installed;
- All four collection tanks (one for each pool and one for the concrete pool 1 floor) has been equipped with leak rate monitors with alarms. This information is used to better explain the dependency of the leak rate with parameters such as pool water temperature. Every month the data is collected and reported for each of the four leak paths to the reactor management (and included in the cycle reports);
- Several attempts were made to measure the total loss of water in order to assure that no hidden leak paths present. In this regard, tests were performed under special reactor conditions to measure the rate of evaporation from the pool surface. A test has been also performed during the containment leak test. During this test the pool tops were covered so that the exchange of water from pool to air is minimal as the air is saturated. Although these tests have uncertainty in estimating the evaporation rate, a bounding leak rate of 14 litres/hour could be established. Since the leak rate of the four monitored leak paths is around 4 litres/hour the conclusion was that no leak path larger than 10 litres/hour exists that is not monitored (including the uncertainty in estimating evaporation loss);
- The three leak paths have always existed throughout the history of the reactor and design provisions have been in place to collect the water. NRG assumes that these leak paths do not pose a threat to the safety of the reactor as long as they are monitored and that the leak rate does not increase with time. To assess the risk of the water leak through the concrete an external consultancy firm was hired in 2017 by NRG. The consultant investigated the condition of the concrete. Core samples at different locations from the concrete were taken and chemical and mechanical tests on the core samples were performed. NRG has concluded that the concrete has not deteriorated, the reinforcement bars have not suffered from corrosion and no structural degradation is expected in the foreseeable future. The report also provides recommendation for maintenance of the concrete such as recoating and repairs, which were performed in 2018.

To better understand the location of the water leak in the pools, an inspection programme has been developed for the pool liners. The programme implementation has been initiated in April 2019 and includes visual inspection and ultrasonic testing.

On the bases of the above mentioned, the IAEA team considered the implementation of these recommendations are complete and to be treated as closed. However, the team also noted that uncertainty still exists regarding quantification of the leak rates. In this regard the team highlighted the importance of continued monitoring and investigating leakage paths and rates and implementing, if needed, corrective actions.

3.2.10 Conduct of Operations

*“**R8**) The protection barriers at the platform surrounding the reactor pool should be installed to protect possible personnel from falling into the pool. Additionally, the two seats used for handling operations in the pool should be equipped with security belts.”*

Implementation

The existing protection barriers located on two sides of the pool have been complemented by the installation of removable protection barriers on the east side of pool where maintenance personnel are required to carry out work during reactor shutdowns. The removable protection barriers are installed by reactor operators prior to maintenance work proceeding, and after the reactor pool level is reduced. The additional protection barriers remain in place while the maintenance work is undertaken, and after the work is completed and personnel have left the area, the barriers are removed by reactor operators, and the area is cordoned off to personnel. A minimum of two operators work at the pool-top.

A significant amount of work has been undertaken with respect to the activities performed at the “isotope production table” working area which is located on the opposite side of the reactor pool to where the removable protection barriers are positioned. To address the part of the recommendation on the seats for production handling operations at the pool side a formal “Management of Change procedure” was implemented. This included detailed risk studies of all the activities that are undertaken in the work area. The risk studies included:

- A global hazard identification;
- A detailed hazard identification which was led by a hazard identification specialist, and had direct contributions from a reactor operator, a shift supervisor, a maintenance technician, a human factor specialist, a HSE officer and a radiation protection (RP) officer. The resulting analysis was checked by a different shift supervisor, HSE officer and RP officer, and once finalized was approved by the plant manager;
- A task risk analysis performed by the project manager and an operator and checked and approved by the HSE officer.

These were used as inputs for the overall study of how to make the conduct of handling operations in the area as safe and efficient as possible. Entering the two seats is considered the moment with the highest risk of tripping into the pool, and to prevent slipping of the operator, engineering, process and layout modifications were made to the area as a result of the studies and analyses. This included:

- Addition of dedicated hand-rails close to the working seats at the edge of the reactor pool. Operators are required to use the hand rails to steady themselves before being seated and commencing operations;
- Simplification of the layout of tools used to undertake handling operations, so that handling is made as efficient and reduces time at the pool as much as is possible;
- Removal of redundant equipment and materials so that the work area is free from tripping hazards;
- Updated work procedures and instructions;
- Isolation by tape barriers of the area by the operators so that other personnel are warned not to enter the area;

- The capability to add two tethering points and the use of personnel tethers in the circumstance where reactor pool water temperature exceeds 40^0C.

The analysis demonstrated to the satisfaction of the NRG that the use of personnel tethers provided greater risk of injury than not using tethers when reactor pool temperature is less than 40^0C. Consequently, the addition of security belts is not undertaken except in the unusual circumstance of reactor pool temperature greater than 40^0C.

The team assessed the actions taken and the incorporated improvements. The team considers the recommendation as implemented and the issue as closed.

*“**R9)** For further enhancement of housekeeping, the non-used items (including the equipment of dismantled experimental devices) that are located at several places within the reactor building should be removed.”*

Implementation

Several activities have been implemented with respect to improving housekeeping within the facility. There are two beam tubes still being used for experimental and research purposes. The working areas around both of these facilities (HB4 and HB5) has been reorganized, with unused items removed, new hardware installed, and work practices modified so that neutron dose levels are monitored during use of the facilities. All the other beam tubes in the facility have been closed for use and have been sealed. All the experimental equipment associated with those beam tubes were checked for activation and contamination before being removed. Consequently, those areas now have free floor space and are cleared of surrounding material.

Several other equipment which are either not used or used sporadically have been removed from the reactor building and the pools. These included experimental facilities for silicon doping experiments, neutron radiography camera, four unused non-certified MTR-2 containers (18 ton, used for spent fuel transports), and a large number of old experiments that were irradiated in the past but were still hanging in the pools of the HFR.

On the second floor of the reactor building filters which were used in the past to capture tritium emanating from experiments conducted for certain fusion research studies, are scheduled for removal from the facility following recent agreements between NRG and the national waste facility for acceptance of the filters to the facility.

Further work is now being planned for improved use and layout of equipment and facilities within the reactor pools. This planning is a high priority for the HFR management, and because there is only one route for removal there is potential for interference of this work with other activities and programmes.

On the basis of the actions taken above, the team considers the implementation of this recommendation as complete and the issue as closed.

*“**R10)** The contents of the operation cycle reports should be improved to include the necessary information allowing the reactor management to verify the reactor operational safety, and to perform trending of the reactor safety performance. Information on deviation from OLCs during the cycle and the associated actions should be also included. Additionally, it is suggested that the shift checklist includes acceptance criteria on the relevant safety parameters, and that these checklists to be formally signed by the persons who performed the checks as well as the concerned shift supervisor.”*

Implementation

The template for a new cycle report was presented to the IAEA team, and a detailed description and explanations were given on the content and use of the new cycle report. The new cycle report is in use since 2018-8 cycle. The report is a comprehensive overview of the operating cycle and includes:

- A summary in text of the operating cycle;
- A selection of Key Performance Indicators and the values for the operating cycle, including, number of reports to the regulator, number of reactor scrams, number of full-power days of operation, and others;
- Any breaches of OLCs, including associated explanations;
- Core layout, experimental irradiations and modifications to the facility are described or displayed;
- Trend analysis and graphs on items such as control rod drop times, pool leak rates and paths (over the cycle and long-term), stack emissions, radiological dose to teams and highest accumulated dose for the cycle;
- Failure of equipment relevant to safety;
- A text summary of the cycle.

The IAEA team also verified that the cycle report is available via the management system and is used as a report to inform NRG management and the ANVS.

The IAEA team were shown a copy of a recent daily shift record called the "Day Status Form", which was evidently completed by hand for three shifts over a full operating day. The form is structured so that measurements of the required reactor parameters are recorded, and acceptance criteria are displayed on the form. Parameters that have a direct relationship with the OLCs are colour highlighted. The Day Status Form is signed by the shift supervisors.

The team considered that the implementation of this recommendation as complete and the issue as closed.

The team also noted that actions have been taken by NRG to implement the suggestion INSARR2011 COP-03 S1), which was provided by INSARR 2011***:"****It is suggested to post warning indications at different working places showing the types of risk (radiological, chemical, and electrical) with the values of dose rate."*. In this regard, the IAEA team noted examples of the warning signs that are now installed in all areas around the reactor facility. The warning signs contain a combination of symbols and text that cover radiological safety, occupational health & safety hazards, required personal protective equipment for the area and text that assists the worker in carrying out operational tasks, and instructions for emergency situations. The signs were developed co-operatively by operational, maintenance and safety staff.

3.2.11 Management System

"R3) *Training on application of the management system should be conducted for HFR staff. Actions should be taken to reduce the accumulation of the reactor safety documents pending revision. The relevant management system process should be revised to make it easier for the document owners to revise them timely."*

Implementation

The training requirements for staff with respect to use of the management system have been revised, and a compulsory training courses have been established on the management system including, introductory training for newly hired staff (Ref: NRG-HR-OD-0024) and refresher training once every two years for existing staff (Ref: NO-IB-HFR-OD-0013). Staff attendance at these courses is checked by managers of the staff that attend and is recorded in the management system.

The process for revising documents in the management systems was revised, and as of the dates of the follow-up INSARR mission, there were no documents that were due for revision. The process owners for documents have a software tool available, that notifies them of when a document is approaching its required revision date. The time period of the first reminder is enough for process owners to put into effect a work-flow and the necessary resources to have documents revised, reviewed and approved before the expiry date. The tool also allows a global overview of all the documents in the management system. Document registration was also displayed and the process for archiving described, where archived documents are available if there is a need, but they are not displayed in the management system as normal practice.

The team considers the implementation of this recommendation as complete and the issue as closed.

A suggestion was also provided by the INSARR 2016 mission (S1)on the interaction between human, technical and organizational factors***: "****Ensure adequate arrangements are made to consider the interactions between human, technical and organizational factors according to requirements in IAEA safety standards series No. GSR Part 2"*. The IAEA team noted that actions have been taken by HFR to address this suggestion. Two examples were given to the team during discussions on this suggestion. The first was on leadership profiles, and the second on personnel performance assessment.

For leadership development, there is a dedicated training programme which lists the leadership and management positions within HFR, and the people within the organization, who may be able to perform the role in the future. The requirements for the position, and the skills and abilities of the potential future people in the role are compared and training, experience and development opportunities are identified for each of the people listed.

For personnel performance assessment, a 9-point grid process for assessing performance and capability was described. An example of how the process was applied to development of future shift supervisors was provided to the team. The reactor operator cohort have the personal assessment undertaken and management review the assessments and identify operators that may be suitable for a future shift supervisor role using the 9-point grid process. Those people who make the grade go through a two-step process for promotion, where they first become a deputy shift supervisor for a definite and known period of time, and then are appointed to shift supervisor, again using the 9-point grid process.

3.2.12 Emergency Planning

The INSARR 2016 mission did not provide recommendations in this area. A suggestion (**S9**) was provided: "*It is suggested to proceed with the implementation of the revised emergency plan as soon as possible, including the conduct of emergency drills involving the participation of internal and external emergency teams."*. In this regard, the team noted that NRG has addressed the suggestions and achieved improvements in several aspects in emergency planning, including:

- A clear distinction between NRG corporate responsibilities and the responsibilities and activities of the local HFR emergency response teams. The roles and responsibilities for individual positions are articulated in the emergency plan (EMP), and the relationships between positions and lines of command during emergencies are defined and documented in the EMP;
- The local HFR emergency team has immediate responsibility for reactor safety if an emergency occurs, and that team comprises the people on the current operational shift, led by the shift supervisor;
- The EMP states there must be a person on-call every day of the year in the role of “on-call reactor manager”. This duty is performed by a number of HFR managers, specified in a roster. If an emergency occurs, it is the responsibility of the on-call reactor manager” to go to the site and assume leadership responsibility for the emergency. The people on the roster have sufficient experience and training to assume that responsibility, and they live close enough to the site that they can get to the site inside of an hour;
- The emergency room has been upgraded, including modernising communications systems;
- Arrangements with external parties/services, such as the fire brigade and ambulance are in place. The external services have approvals to enter the site during emergencies;
- Monthly emergency exercises are conducted within NRG, and when HFR is involved in the chosen scenario, the local emergency organization at HFR joins the exercise. The exercise runs for a one-week period with repetitions of the same scenario every day to train all the relevant staff;
- Deficiencies noted in the exercises are recorded and then used as feedback to modify and improve the procedures for emergencies.

3.2.13 Utilization and Experiments

“R19) *As they are responsible for safety evaluation of proposed experiments (and modifications), the requirements on qualifications of the staff to be recruited at the Research and Development and Irradiation Solution Units should include knowledge on HFR design, safety features, and OLCs.”*

Implementation

A revised training and qualification plan for engineering has been written (Ref: NO-EN-OD-0026). This plan applies to the HFR Engineers but also to the engineers at the Research and Development and at the Irradiation Solutions Units. However, a detailed and systematic training programme has not been developed and the training records that have been verified during the mission did not show that such training has been implemented.

The team concluded that no adequate actions have been taken to implement this recommendation; the recommendation remains valid and the issue remains open.

3.2.14 Modifications

“R16) *A procedure should be developed to evaluate postponed modifications before re-initiating work, taking into consideration the impact of subsequent modifications and experiments and need for re-approval. Similar considerations are valid for postponed experiments.”*

Implementation

The procedures governing modifications to the installations, which were recently developed during the INSARR 2016 mission, have been in use for about three years and have been evaluated by all users. This evaluation led to a revision of the process documents. This revision was input for a fruitful discussion between HFR and ANVS and resulting in regulatory approval of the process.

A re-evaluation of a postponed or delayed project is not explicitly addressed in the policy document but by the nature of the consecutive modification documents (e.g. user requirements, project initiation document, modification proposal, detailed design, and commissioning). In addition, every gate passage requires a discussion and approval by the HFR management (in a dedicated modification session). This ensures that re-evaluation of assumptions are performed. This also ensures that the postponed modifications are subjected to evaluation of the impact of the sub-sequent modifications and to reapproval before initiation of the relevant work.

In view of the above-mentioned, the team considered the implementation of this recommendation as complete, and the issue as closed.

A suggestion (**S8**) was also provided by the INSARR 2016 mission: "*It is suggested that the regulatory body be informed of changes in status of postponed Category I and II modifications and experiments.*". NRG has considered this suggestion and kept ANVS periodically updated on experimental programme, including expected start date for new experiments and production facilities; and status of projects that require regulatory review (e.g. category I and II modifications). Approximately four times a year a meeting is organized between NRG and ANVS to discuss all running and upcoming cases (reported deviations, investigations, inspections, pending approvals, etc.)

***"R17)** Engineering measures should be implemented to protect the pool floor from possible damaging effects of accidental conditions that may arise during handling the heavy loads, such as transfer casks."*

Implementation

HFR has considered the design for a shock absorbing construction to be placed on the floor of the spent fuel pool underneath the container loading position. This programme was finally terminated in 2018 since it turned out impossible to prove that such a construction would be fit for purpose for all possible heavy load drops and the confidence was lacking that such a construction could be implemented without damage to the pool liner, especially after longer period of time. Instead, in addition to existing measures (e.g. limit crane movement above the spent fuel pool, installation of a new polar crane), HFR has identified the following two main actions to achieve the intent of the recommendation:

- Engineer a protecting construction to be placed around the spent fuel racks to mitigate the effects of a falling pool door on top of the spent fuel racks (planned to be implemented in 2019);
- Modify the room beneath the spent fuel pool in order to make it watertight. If as a result of a falling load cracks occur in the concrete floor and water is lost, this will prevent the spent fuel from being uncovered and cooling can be guaranteed. This project has recently been initiated and planned to be completed in 2020.

In view of the above mentioned, the team assessed that this recommendation has not been yet fully implemented. The identified measures have to be fully implemented before the issue could be treated as closed.

***"R18)** The over-head crane should be clamped in parking conditions while not in use to provide protection of the crane against accidental derailment."*

Implementation

The team observed during the INSARR follow-up mission the replacement of the trolley of the polar crane in the reactor building. The new crane is designed following nuclear standards. (Norm KTA3902). The crane has protection against derailment caused by both earthquakes and component failure. The team was informed that the new trolley of the polar crane is single failure proof and the analysis showed that the crane cannot be derailed. The crane was designed, tested, and installed by a qualified company. The team verified that adequate modification process was followed in different stages of the project of installation of the new crane, including ANVS regulatory review and assessment.

The IAEA team assessed that in view of the replacement of the trolley of the polar crane and the analysis performed, the recommendation is considered as implemented and the issue as closed.

3.2.15 Siting and Protection against External Hazards

***"R6)** The corrective actions resulting from the facility seismic walk down and subsequent evaluation should be implemented in a timely manner. A programme for monitoring site characteristics during the operation phase, in accordance with the IAEA Safety Standards Series No NS-R-3, should be developed and implemented. This should be oriented to evaluate possible impacts on the safe operation of the reactor."*

Implementation

A seismic walk down was performed by a specialist company (ABS consulting company, UK). The findings from the seismic walk down have been added as corrective actions to the plant maintenance programme and will be implemented over the coming period.

A list of input data for the external hazard assessment of the HFR has been drafted, which includes all hazards mentioned in the IAEA safety standards No NS-R-3 (Rev.1). All external hazards were compiled and screening of hazards (in/out) was performed based on the probability of occurrence and its consequence on the reactor safety. The team has verified the database (in excel sheet) for all applicable external hazards (HFR Natural Hazard Database). This database is used as a reference basis for the PSA and will be added to the management system. This list of applicable hazard characteristics for the HFR site will be reviewed every ten years and updated as part of periodic safety reviews. Large changes in hazard characteristics may warrant revision of safety analyses.

The team noted that programme for monitoring site characteristics and its updating has been developed and implemented. The team also assessed that the corrective actions resulting from the seismic walk downs have not been yet implemented and considered that the issue is still open.

***"R7)** Seismic safety analysis of HFR was performed using a conservative ground response spectrum. To confirm that sufficient safety margins exist, the piping and other service lines important to safety should be checked for adequate seismic capacity."*

Implementation

A site-specific design basis earthquake was determined for the Petten site for a return frequency of 10^{-4} /year by Rosenhauer & Meidow company in 2015. As historical data was not available, additional sensitivity analysis was performed. In 1998, data from a German site was used to qualify all SSCs in the safe shutdown path. The German data used to qualify the SSCs in the safe shutdown path is highly conservative compared to the site-specific data.

Based on this information, the ANVS agreed with HFR that all SSCs already qualified against a much more conservative non site-specific seismic response spectrum need not be requalified against the new design base earthquake (DBE). A safe shutdown path was determined for the HFR and all SSCs part of the shutdown path (including primary piping) have been evaluated in the past against the conservative spectrum. This analysis was re-evaluated in 2016. The results of the analysis were presented to the team and for all SSCs, part of the safe shutdown path, including piping, adequate safety margins to the allowable stresses exist. Since the site-specific response spectrum has much lower accelerations (PGA: 0.1g) than the spectrum used in the analyses (PGA: 0.4g), the safety margins are large and the piping in the safe shutdown path have adequate seismic capacity.

The team assessed that the implementation of this recommendation is complete and the issue as closed.

"INSARR2011 EVT-01 R3) *The meteorological data should be compiled in a systematic manner and design bases for winds and precipitation should be established. For radiological dispersion, site specific data should be used."*

Implementation

A management system-controlled document has been created that lists all hazards as used in the external events analyses for the PSA. The list contains all (screened-in) hazards mentioned in IAEA safety standards No NS-R-3 (Rev 1) including site specific characteristics for wind and precipitation. The meteorological data has been compiled by the Royal Netherlands Meteorological Institute (KNMI). Critical flooding level and critical wind speed for reactor building and stack have been established. The IAEA team was informed that the HFR is located at a higher elevation than the surroundings and the reactor cannot be flooded under the critical flood level. The team was also informed that as part of emergency plan, the HFR safety is ensured for 72 hours if the access to the reactor site is not available due to flooding in the surrounding area or any other reasons.

For radiological dispersion, the site specific meteorological data is used as prescribed in the Dutch guidelines for Level 3 PSAs for radiological dispersion. After the release of radioactive water to the ground in 2012 a thorough geohydrological study of the soil structure beneath and surrounding the HFR has been performed to be able to predict the dispersion of tritium containing ground water. Quarterly measurements of ground water samples at several dozens of sampling points all over the Petten site are used to validate and correct the model.

In view of the above mentioned actions taken by NRG, the team assessed that the recommendation is implemented and considered the issue as closed.

"INSARR2011 EVT-01 R4) *It is recommended to immediately create an inventory of the existing data and reports and compiled in a reliable and qualified data base system."*

Implementation

The PSA has been delivered with a full library of sources used and the input data for the external event analysis has been captured in a management system controlled document (See Issue INSARR2011 EVT-01 R3). The IAEA team observed that the site-specific data and various analysis performed for external events have been included in the management system, including updating of data every ten years (see follow up on the implementation of R6). This information has been used for performing PSA Level 1, 2, and 3.

The team considers the recommendation as implemented and the issue as closed.

"INSARR2011 EVT-01 R6) *The seismic analysis of the reactor building should consider the Soil-Structure Interaction (SSI) effects, and floor response spectra for the qualification of the SSCs. A cross hole seismic survey should be performed, and curves to account for soil strain versus shear modulus and damping should be developed. Other safety buildings and SSCs should also be analysed against the generated seismic input, and floor response spectra be used for qualification. The behaviour of subsurface soil needs to be checked against this seismic ground motion, especially as the facility is located on soft soil."*

Implementation

The site investigation for HFR, HCL and Pallas site was performed by a specialist company 'Fugro'. A site-specific design basis earthquake was determined for the Petten site for a return frequency of 10^{-4} /year. The site investigation was performed using cone penetration method to obtain shear wave velocity, velocity profile and dynamic shear modulus. The shear wave velocities at the NRG site were 210 to 221 m/s. Based on the site-specific data, the NRG site at Petten is categorized as type C (deep deposits of dense or medium dense sand, gravel or stiff clay with thickness of several tens to many hundreds of metres).

During the mission, the IAEA team was provided with the results of the various site investigation results including site response spectra (see the implementation of R7) and shear modulus vs depth. The team was informed that other buildings on the site that could have effect on reactor safety have also been analysed. Probabilistic seismic hazard analysis has been performed. Safe shutdown path (two trains) was determined for the HFR and all SSCs part of the shutdown path have been evaluated in the past against the conservative spectrum. These analyses have been re-evaluated in 2016. For the PSA an analysis has been performed to extrapolate the new site-specific spectrum to a return frequency of 10^{-6} /year and it was established that the 10^{-6} spectrum is fully enclosed by the conservative spectrum. The site-specific DBE and the extrapolation to 10^{-6} have been reviewed by the ANVS (and its technical support organizations) in 2018 and approved.

The team assessed that all elements of the recommendation have been addressed and implemented, and that the issues is considered as closed.

"INSARR2011 EVT-01 R8) *Seismic instrumentation should be installed to receive a notification in the control room and scram the reactor at 0.05g."*

Implementation

A free field seismic detector (consisting of a 3D-seismometer and 3D-accelerometer) has been installed near the secondary pump building. The system alarms the control room of low-level seismic activity (0.01 g for the accelerometer and 0.05 g for the seismometer). A software has been developed that is able to compare the earthquake with the design basis earthquake for the HFR. If an earthquake is confirmed, the shift supervisor has to consult the reactor management for further instructions.

The installation of seismic detectors in the reactor hall, that in the future may be coupled to the reactor protection system has been added to the list of modification proposals but has not been yet implemented.

The team consider that the recommendation is partly implemented and cannot be treated as closed before implementation of the part related installation of an automatic signal on high seismic vent.

3.2.16 Safety Culture

The INSARR 2016 mission also provided a recommendation on safety culture. The recommendation was related to conduct of periodical self and independent assessments of leadership for safety and safety culture and documentation of the results (and communication to all staff) in the management system. The implementation of this recommendation was followed up in detail in the Follow-up ISCA mission, which was conducted in parallel to the Follow-up INSARR mission. In this regard, the team noted the implementation of the recommendation and that for the purpose of the INSARR follow-up mission the issue is closed. The team also highlighted the ongoing nature of this recommendation, and the need for a continuous improvement of a strong culture for safety.

3.2.17 Scoping and screening of SSCs for Ageing Management for Continued safe Operation

The IAEA team discussed with the counterparts the proposed methodology for scoping and screening of SSCs for Ageing Management for the Continued Safe Operation (CSO) Programme of HFR. The team observed that generally the approach to establishing the scope of CSO is in line with the IAEA safety standards.

HFR has established an asset register and mentioned that this includes all reactor SSCs. The process of scoping the CSO programme is underway. HFR staff mentioned that the CSO will include items important to safety, and those items not important to safety but that would affect the functioning of items important to safety. The asset register is being used as a primary input for this process and the output will be a Master List of SSCs for the CSO. The HFR team is also in the process of developing the safety classification of SSCs. The team highlighted the need to use this classification consistently across all programmes and activities within HFR.

The team also observed that HFR needs to review and revise the scoping methodology in the light of following:

- The criteria used for safety classification does not explicitly mention the safety functions to be performed by structures and components or their support of the others which are performing a safety function;
- The list of systems does not explicitly show some important safety systems, e.g. the reactor protection system, although those systems not explicitly shown are included in the detail of other systems in the list;
- Structures and components that are periodically replaced or refurbished are excluded from the Master List of structures and components for CSO;
- Structures and components that are removed but may be installed (e.g. a spare equipment under servicing) are excluded;
- Example of some SSCs that are excluded but support the safety functions are radiological monitoring system, electrical grounding system, and communication system.

ANNEX I: AGENDA

Monday 8 April 2019			
09:00-10:30	Entry meeting: - Review of mission objectives, expected results, and adoption of agenda - Overview of status of the implementation of the INSARR and ISCA mission recommendations Directie, MT HCL , MT HFR, J. van Gent, R. van Touw, M. Droog , M. Janssen, R. Huiskamp, F. Draaisma, J. Minkema, D. Reus, A. van der Zanden, P. Romano, C. de Koning, J. van den Broek, A. Vreeling, Y. Stockmann		NRG, ANVS (Jansen, Schipper, Boom and Dubbers) and IAEA Location: Grote vergaderzaal
10:30-11:00	Coffee break		
11:00-13:00	Walkthrough the HFR reactor and associated facilities		IAEA and NRG
13:00-14:00	Lunch break		
14:00-17:00	Follow-up of implementation of the recommendations of INSARR mission on: - Operating organization and reactor management (R1) - Safety committee (R4, 2011-SC- R1) - Training and qualification (R5, S3) IAEA: Shokr, Knutsson, Abou Yehia, Storr NRG: Offerein, Ruiterman, Huiskamp, Y. Stockmann ANVS: Schipper and Dubbers	Discussions on scoping and screening of SSCs for ageing management - General overview with plant manager and the continuous improvement coordinator IAEA Team: Storr, Rao NRG: Wouters, Stefanini, F. Blom/C. de Haan, Anink ANVS: Van Vliet and Boom Location: Printerruimte HFR 102.023	

<table>
<tr><td></td><td colspan="2">Location: Cursusruimte 102.115</td><td colspan="2"></td></tr>
<tr><td>18:00-19:00</td><td colspan="4">Team meeting (Hotel)</td></tr>
<tr><td colspan="5">Tuesday 9 April 2019</td></tr>
<tr><td>09:00-12:30</td><td colspan="2">Follow-up of implementation of the recommendations of INSARR mission on:
- Safety analysis (R13, S5, 2011-SAR-R1, 2011-SAR-R2)
- Operational Limits and Conditions (R14)
IAEA: Abou Yehia, Shokr, Storr, Rao,
NRG: Wouters, Best, Bosker, Brinkman , Slootman
ANVS: Schipper and Kuriene
Location: Cursusruimte 102.115</td><td colspan="2">Follow-up of implementation of the recommendations of ISCA mission
IAEA: Knutsson + External expert
NRG: Offerein, Bogert, Janssen, Cuijpers, Van Gent, Koenen
ANVS: Tolud and Dijkman
Location: PMC ruimte 034.201</td></tr>
<tr><td>12:30-13:30</td><td colspan="4">Lunch break</td></tr>
<tr><td>13:30-16:30</td><td>Follow-up of implementation of the recommendations of INSARR mission on:
- Operational radiation protection programme (R15, S6, INSARR 2011 S1)
- Radioactive waste management (S7)
- Decommissioning planning (R20)
IAEA team: Shokr, Storr,
NRG: Ruiterman, Draaisma, Huiskamp, Van Wijk, Van der Stad</td><td colspan="2">Follow-up of implementation of the recommendations of INSARR mission on:
- Maintenance, periodic testing and inspection (R11, S4, R12, 2011 INSARR MPT01R1)
Discussions on scoping and screening of SSCs for ageing management (cont.)
IAEA team: Abou Yehia, Rao
NRG: Anink, Wouters, Drenth, Stefanini</td><td>Follow-up of implementation of the recommendations of ISCA mission:
- Management system
- Safety goals
- Safety Culture management
IAEA: Knutsson + External Expert
NRG: Offerein, Bogert, Janssen, Ruiterman, Koenen, van Touw, Droog, M. Smit
ANVS: Tolud and Dijkman</td></tr>
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	ANVS: Arends and Muller Location: Cursusruimte 102.115	ANVS: Van Vliet and Schipper Location: Printerruimte HFR 102.023	Location: PMC ruimte 034.201
16:30-17:00	Team meeting (on-site)		
Wednesday 10 April 2019			
09:00-12:30	Follow-up of implementation of the recommendations of INSARR mission on: - Conduct of operations (R8, R9, R10, COP -03 INSARR 2011 S1) - Management system for the operation phase (R3, S1) - Emergency plan (S9) IAEA team: Storr, Rao NRG: Ruiterman, Wouters, Jablonowski ANVS: Dubbers and Boxman Location: Cocon Oost 34	Follow-up of implementation of the recommendations of INSARR mission on: - Utilization and experiments (R19) - Modifications (R16, S8, R17, R18) IAEA Team: Abou Yehia, Shokr NRG: Kamer, Best, Waard ANVS: Schipper and Matteoli Location: Printerruimte HFR 102.023	Follow-up of implementation of the recommendations of ISCA mission on: **(INSARR R2, S2)** - Leadership for safety IAEA: Knutsson + External Expert NRG: Offerein, Bogert, Janssen, Cuijpers, Van Gent, Koenen, Ruiterman, van Touw, Droog, M. Smit, Dolle. ANVS: Tolud and Dijkman. Location: Cursusruimte 102.115
12:30-13:30	Lunch break		
13:30-16:30	Follow-up of implementation of the recommendations of INSARR mission on: - Siting and protection against	Development of the mission summary report IAEA: Shokr and Storr	Follow-up of implementation of the recommendations of ISCA mission - ANVS

	external hazards (R6, R7, INSARR EVT R3, R4, R6, R8) IAEA team: Abou Yehia, Rao NRG: Wouters, Brinkman, de Haan ANVS: Schipper and Matteoli Location: Cocon Oost		IAEA: Knutsson + External expert NRG: Offerein, Bogert, Janssen, Cuijpers, Van Gent, Koenen ANVS: Tolud and Dubbers Location: Cursusruimte 102.115
15:00-16:30	Meeting with ANVS – Briefing on the mission progress and results IAEA team: Shokr and Knutsson ANVS: Schipper, Dubbers and Boom Location: Cursusruimte 102.115		
Thursday 11 April 2019			
09:00-10:30	Finalization of the mission summary report (IAEA team)		
10:30-11:00	Coffee break		
11:00-	Exit meeting: Conclusions and recommendations of the mission (NRG, ANVS, and IAEA) ANVS: Vrolijk, Verweij, Schipper and Dijkman Location: Grote vergaderzaal Directie, MT HCL , MT HFR, J. van Gent, R. van Touw, M. Droog , M. Janssen, R. Huiskamp, F. Draaisma, J. Minkema, D. Reus, A. van der Zanden, P. Romano, C. de Koning, J. van den Broek, A. Vreeling, Y. Stockmann		

ANNEX II: LIST OF PARTICIPANTS

Name	Job title	Organization
Jelmer Offerein	Director Operations	NRG
Roland Ruiterman	Installation Manager HFR	NRG
Rene Huiskamp	Corporate Policy Advisor Nuclear Safety (QHSE), Vice Chairman RSC	NRG
Onne Wouters	Reactor Manager HFR	NRG
Johan Best	Manager Nuclear Safety HFR	NRG
Sander Anink	Maintenance Manager HFR	NRG
Niels Bosker	Nuclear Safety Consultant	NRG
Hans Brinkman	Risk Reliability Expert	NRG
Marcel Slootman	Nuclear Safety Consultant	NRG
Halbert Taekema	Safety and Reliability Consultant	NRG
Chris van Wijk	Radiation Protection Officer HFR	NRG
Rob van der Stad	Manager Nuclear Safety Hot Cell Laboratories (HCL)	NRG
Sander Anink	Manager Maintenance HFR	NRG
Jan Waard	Senior HFR Engineer	NRG
Lorenzo Stefanini	Project Leader CSO	NRG
Luca Ratti	Consultant on CSO project	NRG
Nancy Jablonowski	Safety Officer HFR	NRG
David de la Haye	Human Factor Engineer	NRG
Sander Kamer	Manager Engineering HFR	NRG
Ciska de Haan	Team Leader Asset Integrity Services	NRG
Yvonne Dubbers	Senior Inspector Nuclear Safety	ANVS
Patrick Arends	Senior Inspector Nuclear Safety	ANVS
Cees Jansen	Senior Consultant International Affairs	ANVS
Martijn van Vliet	Senior Inspector Nuclear Safety	ANVS
Camilla Matteoli	Senior Inspector Nuclear Safey	ANVS
Ronald Schipper	Plant Inspector HFR	ANVS
Hubert Boxman	Senior Inspector Nuclear Safety	ANVS
Rob Jansen	Senior Consultant International Affairs	ANVS
Bert Verweij	Teamleader Inspectorate Nuclear Safety	ANVS
Cassandra Vrolijk	Head of Department Nuclear Safety and Security	ANVS
Ynte Stockmann	Chairman Reactor Safety Committee	JRC

IAEA Team

Name	Job title	Organization
Amgad Shokr	Section Head, RRSS (Team leader)	IAEA
Deshraju Rao	Consultant	India
Greg Storr	Consultant	Australia
Hassan Abou Yehia	Consultant	France