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**REPORT OF THE**

**INTEGRATED SAFETY ASSESSMENT OF  
RESEARCH REACTORS  
(INSARR) MISSION**

**TO THE**

**High Flux Reactor (HFR)**

**Petten, The Netherlands  
4 - 11 October 2016**

**INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (INSARR)**

**DEPARTMENT OF NUCLEAR SAFETY  
AND SECURITY**

**DIVISION OF NUCLEAR INSTALLATION  
SAFETY**

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## INTERNATIONAL ATOMIC ENERGY AGENCY

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**Mission date:** 4-11 October 2016

**Location:** Petten, the Netherlands

**Facility:** High Flux Reactor

**Organized by:** IAEA, at the request of the Inspectorate of the Authority for Nuclear Safety and Radiation Protection (Dutch regulatory body - ANVS) and Nuclear Research and consultancy Group (NRG)

**Conducted by:**

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## EXECUTIVE SUMMARY

Following a request from the Inspectorate of the Ministry of Infrastructure and the Environment, which is the Dutch regulatory authority (AVNS), the IAEA conducted an INSARR mission at the High Flux Reactor (HFR) located in Petten. The reactor is mainly used for the production of medical isotopes and research in the field of nuclear fuels and materials. The reactor is owned by the Joint Research Centre, European Commission, and operated by the Nuclear Research and consultancy Group (NRG). The reactor is owned by the Joint Research Centre (JRC)

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

The mission team led by Mr A. Shokr (Head, Research Reactor Safety Section (RRSS)) was composed of three IAEA staff members and six external experts. Mr G. Rzentkowski, Director, IAEA Division of Nuclear Installation Safety (NSNI) participated in the last two days of the mission, and led the mission exit meeting.

The conduct of the mission included examination and assessment of the reactor safety and technical documentation, walkthrough of the reactor facility, discussions with the HFR reactor management and operating personnel, and NRG technical staff. The mission also included interviews with NRG and HFR staff for review of the safety culture programme. The IAEA team provided an executive summary report in the exit meeting, which was discussed and agreed upon.

Within the framework of the mission, a review of the implementation status of the 2011 INSARR mission to HFR was also conducted.

The IAEA team appreciated the competence of the NRG staff and noted the implementation of a mature management system, and good practices in the areas of training and qualification of personnel, periodic safety review, and addressing the relevant lessons learned from the Fukushima accident. The team also noted that maintenance and aging management programmes, as well as safety provisions of experiments and modifications are generally in line with the IAEA safety standards.

Good progress was also noted concerning the implementation of the recommendations of the 2011 INSARR mission. All the recommendations and suggestions of the mission were considered, and about 60 % of these have been fully implemented. Significant progress has been achieved in the implementation of another 25 %. Remaining actions are mainly related to leakage from the pool liner, installation of seismic instrumentation, identification of the root cause of Argon-41 release, and update of the SAR in accordance with the IAEA safety standards to contain all the necessary technical information demonstrating the safety of the facility.

The activities of the INSARR mission resulted in recommendations and suggestions for further safety enhancement. These covered the need to ensure the effectiveness in managing reactor operational safety, and to improve the independence of radiation protection function, effectiveness of the reactor safety committee and the coordination between JRC and NRG on decommissioning planning. The recommendations also covered updating safety analysis and safety documents (including the operational limits and conditions), seismic safety, and completing the ongoing work on revision of the reactor operating documents. Recommendations were also provided on identification of water leakage rate and paths from the reactor pool, and implementing accordingly the necessary corrective actions, upgrade of measures against seismic hazard, implementation of engineering measures to protect the reactor pool floor against accidental heavy load drops, and on further improvement of the operational radiation protection programme.

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## **1. INTRODUCTION**

### **1.1 BACKGROUND**

#### **1.1.1 Short description and history of the facility**

The High Flux Reactor (HFR) Petten, situated 50 kilometres north of Amsterdam, is a light water, cooled and moderated, 50 MW, tank-in-pool, multi-purpose materials testing reactor; 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). The reactor 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.

The HFR was constructed by the Government of the Netherlands and transferred to the European Commission in 1962; it was extensively used by the Netherlands and Germany, focusing on beam tubes research, new materials and material ageing. Currently the use of beam tubes is limited to the use of two positions.

In 1984 the aluminium reactor vessel was replaced; this made available new irradiation facilities, which allowed for a substantial increase in the production of radioisotopes, and thus converting the HFR into one of the major radioisotopes producers. The HFR facility is expected to continue its service until its replacement by the new planned research reactor (Pallas).

Following the Fukushima Daiichi nuclear power plant accident, HFR has conducted a safety reassessment ("stress test" or complementary safety margin assessment) to examine the robustness of the facility in case of extreme external events.

#### **1.1.2 Utilization programme**

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.

The HFR personnel are active in providing support to the IAEA activities on safety of research reactors, including providing opportunities for fellowships and expert services.

### **1.1.3 Summary of the previous IAEA assessments**

Full scope INSARR Missions were performed in 2005 and 2011 which identified good practices and provided recommendations and suggestions for safety improvements. 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.

## **1.2 OBJECTIVES AND SCOPE OF THE MISSION**

The 2016 mission was conducted following a request from the Dutch regulatory body (ANVS). The objectives of the mission were to conduct an integrated safety assessment (INSARR) of the HFR research reactor, and to provide recommendations and suggestions for safety improvements. The mission also served as a follow-up on the implementation of the recommendations of the 2011 IAEA INSARR mission.

### **1.2.1 Scope of the mission**

During the Pre-INSARR mission, which was conducted from 10-12 May 2016, it was agreed to review during the INSARR mission the following areas listed in the IAEA Services Series No.25:

- Operating organization and reactor management;
- Safety committee(s);
- Training and qualification;
- Safety analysis;
- Site evaluation and protection against external hazards;
- Operational limits and conditions;
- Management system for the operation phase;
- Conduct of operations;
- Maintenance, periodic testing and inspection, including ageing management activities;
- Major modifications;
- Utilization and experiments;
- Radiation protection;
- Radioactive waste management;
- Emergency planning;
- Decommissioning plan;
- Safety culture.



### 1.3 BASIS FOR THE ASSESSMENT

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

- IAEA Services Series No. 25: Guidelines for the Review of Research Reactor Safety (INSARR Guidelines), 2013;
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016;
- IAEA Safety Standards GSR Part 2: Leadership and Management for Safety, 2016;
- IAEA Safety Standards Series No. GS-G-3.5: The Management System for Nuclear Installations, 2006;
- IAEA Safety Standards Series No. SSG 20: Safety Assessment and Preparation of the Safety Analysis Report for Research Reactors, 2012;
- IAEA Safety Standards Series No. SSG 24: Safety in the Utilization and Modification for Research Reactors, 2012;
- IAEA Safety Guide NS-G-4.2: Maintenance, Periodic Testing and Inspection for Research Reactors, 2007;
- IAEA Safety Standards NS-G-4.4: Operational Limits and Conditions and Operating Procedures for Research Reactors, 2008;
- IAEA Safety Guide NS-G-4.5: The Operating Organization and Recruitment, Training and Qualification for Research Reactor Personnel, 2008;
- IAEA Safety Guide NS-G-4.6: Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, 2008;
- IAEA Safety Standards SSG-10: Ageing Management for Research Reactors, 2010;
- IAEA, Safety Reports Series, No.41: Safety of New and Existing Research Reactor Facilities in Relation to External Events, 2005;
- IAEA Safety Standards GSR Part 6: Decommissioning of Nuclear Facilities, 2014;
- IAEA Safety Standards Series No. SSG 37: Instrumentation & Control Systems and Software important to Safety of Research Reactors, 2014;
- IAEA Safety Standards Series No NS-R-3 (Rev.1), Site Evaluation of Nuclear Installations, 2016;
- IAEA Safety Standards No. GS-G-3.1 Application of the Management System for Facilities and Activities, 2008.

### 1.4 DOCUMENTS RECEIVED FROM THE COUNTERPART PRIOR AND DURING THE MISSION

The list of documents is incorporated in ANNEX I – LIST OF DOCUMENTS FOR THE HFR 2016 INSARR MISSION

### 1.5 CONDUCT OF THE MISSION

#### 1.5.1 INSARR Team

The mission was conducted during the period from 4-11 October 2016 according to the Agenda provided in Annex III. The mission team was composed of three IAEA staff members: Mr Amgad Shokr (Team Leader), Mr Deshraj Rao (Deputy Team Leader), and Ms Diana

Engstroem (IAEA/OSS); and six external experts: Mr Hassan Abou Yehia (IRSN, France), Mr Tibor Hargitai (Consultant, Hungary); Mr Koos Du Bruyn (Senior Manager: SAFARI-1 Research Reactor, South Africa), Mr Néstor De Lorenzo (INVAP, Argentina), Mr Steven Lynch (Nuclear Regulatory Commission, USA), and Mr Prabir Basu (Consultant, India). Mr Greg Rzentkowski, Director, NSNI, IAEA participated in the last two days of the mission. Representatives of the Dutch regulatory body ANVS (Mr Ronald Schipper, Ms Margreet Steenhuisen, Mark van Bourgondiën, Gert-Jan Auwerda, Sigrid de Koff, Anneke van Limborgh, Yvonne Dubbers, and Cees Janssen) attended the different technical sessions and presentations during the mission. Mr Jelmer Offerein, Reactor Manager, HFR was the main counterpart. The agenda of the mission is provided in Annex II.

The list of the participants of the mission, including the technical counterparts from NRG and HFR, and the representatives of the ANVS and JRC who participated in the mission, is provided in Annex III.

### **Entry meeting**

An entry meeting was held on Tuesday, 4 October 2016 for the mutual introduction of local technical counterparts and team members, and for the welcome address from the host organizations. In this meeting the IAEA team leader reviewed the objectives of the mission, expected results of the mission. The NRG Managing Director, Mr N. Unger, expressed his appreciation of the IAEA missions in particular INSARR missions which have helped HFR to improve safety. The HFR Reactor Manager provided an overview presentation of the HFR reactor and its current status.

During the first day of the mission, the IAEA team and the counterparts made a detailed walkthrough to the reactor and associated facilities. During the visit, the reactor was in operation at a power level of 45 MW for radioisotope production and three experiment irradiations. The team visited the reactor control room, reactor pool top area, reactor hall and the second floor. The technical visit familiarized the team with the reactor systems and components and their technical status.

During the visit, the team observed the excellent housekeeping of the reactor building and noted the installation of new security fences in the perimeter of HFR and the relocation of the truck entry for ensuring better access and handling conditions. The team also noted the installation outside the vital area of a new change room for the operating staff. The team discussed various aspects regarding the operational safety of the reactor facilities with the reactor operating personnel, and made recommendations and suggestions for further improvements. The details of the team observations and the associated comments and suggestions are provided in Appendix 1 (Issue Page: COP 01 – Observations during the walkthrough).

Five and a half out of six days of the mission time were dedicated to a series of technical meetings and plenary discussions with the technical counterparts, walk-through the facility, preliminary drafting of the mission report and final discussion with the main counterparts about the main findings and conclusions of the mission, with a general agreement on the IAEA recommendations. A follow-up on the implementation of the recommendations of the previous IAEA safety review missions, including the 2011 INSARR, was performed. Appendix 2 provides the details of this follow-up.

On 10 October, the NSNI Director and IAEA Team Leader held a meeting with the NRG Managing Director and the HFR management to brief them on the results of the mission.

The exit meeting was held on Tuesday, 11 October 2016 with the participation of the Director of NSNI/IAEA, NRG Managing Director, representatives of the ANVS and HFR main involved counterparts.

### **1.5.2 Short description of the assessment (way and methods)**

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

- a) Examination and assessment of the reactor safety and technical documentation;
- b) Walkthrough of the reactor facility;
- c) Discussions with the HFR reactor management and operating personnel, and NRG technical staff;
- d) Interviews with NRG and HFR staff for review of the safety culture programme;
- e) Discussions among the IAEA team members;
- f) Preparation of the mission report.

The mission report is based on the Issue Pages (see [APPENDIX 1: ISSUE PAGES](#)), a document which is developed during the mission by the IAEA team members and the technical counterparts. It was designed taking into account the following elements:

- Should reflect the transparency of the process;
- Should facilitate the retrieval of information;
- Should facilitate follow-up actions;
- Should be a document easily understood in the multicultural environment of the IAEA missions in order to facilitate the exchange of information between the IAEA team members and the technical counterparts.

In the first part of the Issue Pages (Issue Clarification/Observations) the experts and the counterparts are requested to isolate the facts that may be considered as a Safety Issue. These are the points in which there should be agreements between both counterparts, avoiding if needed to make judgments or giving any recommendation (just the facts). It follows possible safety consequences in which there may not be agreement between the team member and the counterpart. In case of disagreement the counterpart is requested to write his/her own comments in the section identified as Counterpart Views. The issue is further discussed in the team meetings; Recommendations and Good Practices (see below) are team advices and should be accepted with the consensus of the IAEA Team.

### **1.5.3 Review criteria**

The INSARR review compares the observations and finding with the IAEA Safety Standards and practices found at other research reactors worldwide. The comparison may result in

recommendations, suggestions, comments and good practices presented to the operating organization by the team as a whole, in accordance to the following definitions:

### **Recommendation**

Recommendations are review team advices for improving safety based on IAEA Safety Standards and recognized good practices. The recommendations focus on WHAT is recommended to be done. The ‘Suggestions’ section described below may mention approaches on HOW to implement the recommendations. The recommendations are designated with the letter “R” in the mission report.

The recommendations are numbered in the respective issue page as **R#**

### **Suggestion**

Suggestions are review team proposals in conjunction with a recommendation, or they may stand on their own. They may indirectly contribute to improvements in safety, but they are primarily intended to enhance performance. The suggestions are designated with the letter “S” in the mission report.

The suggestions are numbered in the respective issue page as **S#**

### **Good Practice**

Good practices are outstanding and proven performance, programmes, activities or uses of equipment that contribute directly or indirectly to operational safety and sustained good performance. A good practice is markedly superior to that observed elsewhere, not just the fulfilment of current requirements or expectations. It should be superior enough and have broad application to be brought to the attention of other research reactor operators and be worthy of their consideration in the general drive for excellence. The good practices are designated with the letters “GP” in the mission report.

## **2. SUMMARY OF MAIN CONCLUSIONS AND RECOMMENDATIONS**

The IAEA team appreciated the competence of the NRG staff and noted the implementation of a mature management system, and good practices in the areas of training and qualification of personnel, periodic safety review, and addressing the relevant lessons learned from the Fukushima accident. The team also noted that maintenance and aging management programmes, as well as safety provisions of experiments and modifications are generally in line with the IAEA safety standards.

Good progress was also noted concerning the implementation of the recommendations of the 2011 INSARR mission. All the recommendations and suggestions of the mission were considered, and about 60 % of these have been fully implemented. These were mainly in the areas of reactor management, maintenance and ageing management, training and qualification, environmental monitoring, experiments and modifications. Significant progress has been achieved in the implementation of another 25 %. Efforts still need to be exerted by NRG to finalize the implementation of these recommendations. Efforts also need to be taken on the remaining recommendations, in which no actions were taken. Remaining actions are mainly related to leakage from the pool liner, installation of seismic instrumentation, identification of the root cause of Argon-41 release, and update of the SAR in accordance with the IAEA safety standards to contain all the necessary technical information demonstrating the safety of the facility.

The activities of the INSARR mission resulted in recommendations and suggestions for further safety enhancement. These covered the organizational aspects, safety analysis and safety documents, and technical modifications to the facility, and are mainly provided as follows. The detailed discussions of the team observations and the associated recommendations and suggestions are provided in the Appendix 1 – Issue pages.

### **Organizational aspects**

- Concerted efforts have been taken by NRG to promote and further develop a strong safety culture. To supplement these efforts, the NRG senior management should ensure that self-assessments and independent assessments of leadership for safety and safety culture are conducted on regular basis. The planned IAEA Safety Culture Assessment peer review is a positive step towards this goal. The requirements of such assessments should be documented in the management system along with information on communication (to all staff) and use of the results.
- 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.
- For enhancing the effectiveness of the reactor safety committee, it is recommended that the committee is informed by the NRG management on the implementation of the actions associated with its recommendations.
- 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. Training on application of the management system should be conducted for HFR staff.
- 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.

### **Safety analysis and safety documents**

- 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;
  - Include periodic monitoring of the radioactivity contents of the underground water using the existing sampling wells near the facility.
- 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.
- The contents of the operation cycle reports should be improved to include the necessary information that allows the reactor management to verify the reactor operational safety and to perform trending of the reactor safety performance.

- 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.
- 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.

### **Technical modifications of the facility**

- The leakage rate and paths from the reactor pool should be determined, and consequently adequate corrective actions should be implemented to limit the water leakage.
- To complement the safety reassessment performed following the lessons from the Fukushima accident, it is recommended to define and implement measures aimed 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.
- 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 No NS-R-3, should be developed and implemented. This should be oriented to evaluate possible impacts on the safe operation of the reactor
- Engineering measures should be implemented to protect the pool floor from possible damaging effects of accidental conditions that may occur during handling the heavy loads, such as transfer casks.
- Adequate radiation monitors for neutron dose should be installed at the beam tube area. It is suggested to install on-line stack monitor for aerosols, iodine, and particulates.

Additionally, the IAEA team encourages ANVS to follow-up on the implementation of the results of this INSARR mission in a timely manner, and to request a follow-up mission in accordance with the IAEA INSARR Guidelines.

The IAEA team is pleased to note the commitment of the NRG senior management to further enhance safety and to promote safety culture, and appreciated the openness and transparency of the NRG staff during the mission and their motivation for safety enhancement.

## APPENDIX 1: ISSUE PAGES

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

#### 1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines
- IAEA Safety Requirement No. SSR-3: Safety of Research Reactors
- IAEA Safety Standards No. NS-G-4.5: The Operating Organization, and Recruitment, training and Qualification of Research Reactor Operating Personnel
- IAEA Safety Guide NS-G-4.6: Radiation Protection and Radioactive waste Management in the Design and Operation of Research Reactors
- Organogram HFR Organisation – PowerPoint Presentation, NRG, October 2016
- HFR Safety Analysis Report, Chapter 13

#### 2. ISSUE CLARIFICATION

The current organization structure for the HFR operation is provided in the figure below.

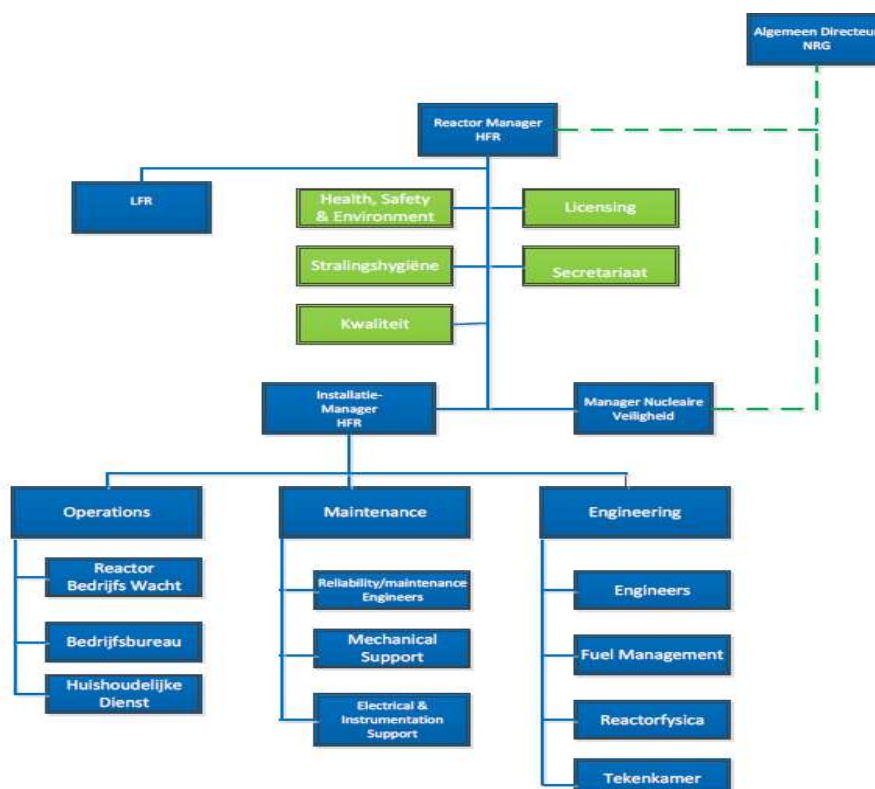


Figure: Organization structure of HFR operation

The Figure above shows several improvements compared to the situation observed during the INSARR mission conducted in 2011. This includes inclusion of positions on nuclear safety and on licensing. The organization structure also included dedicated groups for reactor operation



and for maintenance. In accordance with the organization structure, the HFR Reactor Manager reports to the Unit Manager – Nuclear Operations. The HFR Reactor manager also carries out the function of the Low Flux Reactor (LFR) reactor manager, which is at present under decommissioning. The team discussed this situation with the Counterpart, and is of the opinion that such a situation need to be evaluated from safety point of view to ensure that the safety of both facilities (HFR and LFR) are not compromised.

The discussions with the HFR operating personnel showed that the position of the Maintenance Manager has been vacant since 2014, and the relevant functions are being carried out by the Operation Manager. The team raised concern about potential conflict of interest due to this situation. The HFR operating personnel mentioned that NRG is in a process to fill this position.

Following the recommendations of the 2011 INSARR mission, some actions have been implemented to improve the independence of the radiation protection function from the control of the reactor manager. This includes appointment of a radiation protection officer for HFR (reporting to the HFR Reactor Manager) with direct access to the Chief Radiation Protection Officer of NRG and NRG Managing Director. There is also appointment of a radiation protection expert who reports to the local radiation protection officer. This radiation expert supports Operations during the daytime. However, during the operation shift, one of the shift-operators carries out the functions of radiation protection expert (e.g. radiation and contamination surveys).

The team also discussed with the reactor operating personnel the functions, duties, responsibilities and authorities of the HFR Installation Manager and possible overlaps or conflicts of authorities with the HFR Reactor Manager. Since establishment of this position within the organization structure, the positions of the Installation Manager and the Reactor Manager are occupied by the same person.

### 3. POSSIBLE SAFETY CONSEQUENCES

The overlap of functions, duties, and authorities of the Installation Manager and Reactor Manager could lead to conflicting situations with impact on operation safety if the two positions are occupied by different personnel. On the other hand, it has no added value if these two positions are to be kept always occupied by the same person.

The lack of adequate independence of the radiation protection functions could lead to a conflict of interest for the health physicist assigned to the HFR and reactor operation. This could lead to a situation of radiation safety concern.

The situation of having the same person carrying out the functions of the operation management and maintenance management could lead to a potential conflict of interest.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

HFR management highlighted the fact that there is no conflict of interest related to the responsibility of safety, which remains with the Reactor Manager, and that the mentioned situation will be analysed and actions to be taken accordingly.

NRG agrees that the current situation with no dedicated maintenance manager is not ideal and should be remedied as soon as possible.

## 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**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.

## **ISSUE SCL 01: Need for enhancement related to safety culture and management system**

### **1. BASIS AND REFERENCES**

- IAEA Safety Standards No. GSR Part 2 - Leadership and Management for Safety, 2016
- IAEA Safety Standards No. GS-G-3.1 Application of the Management System for Facilities and Activities, 2008
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Services Series No. 25: INSARR Guidelines, 2013

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

It is important to understand that the results presented below are not an assessment of the safety culture itself; they are an assessment of some of the important frameworks that have to be in place to sustain and improve leadership, management for safety and safety culture. Therefore, the discussions and the associated recommendations are also only focused on the framework.

There are several activities within NRG, implemented or ongoing, to establish, sustain and improve leadership and management for safety. The actions described below are expected, if fully implemented, to support the organization to sustain and improve safety. However, sustaining and improving safety is a never-ending task and there are some identified areas for improvement. An overall theme is that some of the processes seem to be informal and will only live on as long as there is an enthusiast driving the issues forward.

A vision of safety has been established by NRG which emphasizes safety as the overriding priority to prevent harm to people and the surroundings.

A procedure for critical functions identification and management has been implemented to ensure the in-house competence and the resources necessary. It is, according to managers, an important tool when it comes to resource management and succession planning. There is, for example, a new competence matrix implemented that describes all skills and training requirements linked to each and every position within NRG to achieve and sustain the required levels of competence. There is also a “point system” that ensures a high level of competence within each operation shift team within operations. Before an experienced operator retires a successor is recruited or chosen from the existing team to train with the retiring operator for a year or two.

The management system has been modified to clarify roles, responsibilities and accountabilities. The aim has also been to make it more user-friendly and to ensure the quality of documentation and procedures is good. There is, for example, a new free text search tool. However, despite the efforts and the explicit requirement to revise, and, if necessary update, documents in the management system every three to five years, there is a backlog according to the interviewees. At the moment 152 of 2158 documents within the NRG management system have not been revised according to the internal requirements. An additional 100 documents are not dated. Within HFR, 57 documents of 599 are not revised. Within both engineering and maintenance at HFR there is a dedicated document controller who tracks the unrevised documents and makes sure managers and document owners revise them as required. Within the

rest of NRG, it is usually the document owner's responsibility to make sure documents are revised and updated. However, there is no automatic reminder in the system. The interviews indicate that the knowledge on use of the management system is limited within the workforce. Some employees find it hard to search for procedures within the management system and prefer to ask colleagues how to do things rather than to search for information in the management system. None of the employees can remember whether they received any management system training.

In 2014 a management system baseline measurement and a baseline assessment of safety culture was conducted by an external company. The proposed actions based upon the identified gaps in the assessments were included in a larger "recovery plan" for 2014-2016. These actions were linked to an increased number of incidents and a shutdown in 2013. Several of the proposed actions were included in the yearly plan and formed the basis for the development a safety culture programme with two different processes. Process number 1 focused on safety leadership improvement (e.g. safety contacts, understanding and influencing behaviour and task briefings). Process number 2 focused on employee engagement (identifying critical behaviour in personal and nuclear safety, collecting data on critical behaviour by observation and giving feedback on observed behaviour). Using the data collected - action plans are set up to remove barriers to working safely. The safety culture assessments and the safety culture programme is a step in the right direction but there are no requirements in the management system that ensures regularly self-assessments of leadership for safety and/or safety culture within the organization. Nor are there any requirements in the management system related to independent assessments of leadership for safety and safety culture for the enhancement of the organizational culture for safety.

The current safety culture programme will be closed when processes 1 and 2 are fulfilled. According to interviewees there will be a new programme when the organization gets the result from the next assessment but there are no requirements that describe the safety culture continuous improvement strategy in the management system. The safety culture programme is now mainly focusing on behavioural safety and industrial safety (i.e. how to act safely and help/coach others to act safe in the everyday work) but lack a more systemic approach to safety. There was some H-T-O (Human-Technology-Organization) training included in process number 1 in the safety culture programme but there are no requirements in the management system that ensure managers' knowledge about safety encompasses interactions between human, technology and the organization.

There is a fairly new process for learning of events. The process is described in a procedure (Leren van gebeurtenissen) in the management system. The procedure describes how incidents, accidents and unsafe acts should be reported, investigated, corrective actions decided and followed up. Statistics provided during interviews shows that the number of reported incidents and accidents has increased with approximately 50 % the last two years but the process for learning from events is not fully implemented. Employees are aware of the process but do not always know how to use the MARS system to report an event. The need for improvements and minor incidents seem to mainly be discussed within the teams and the manager of the team. Interviewees agrees on the importance of reporting and continuous improvements but expressed that the process to get things done in practice often takes too long and that it affects the motivation to report negatively. Managers are aware of the backlog in MARS and that there were more open than closed safety notifications in 2015. However, there were also more notifications closed in 2015 than previous years.

There are three different levels of event (or root cause) analysis but the levels and the competence requirements of the analysis team are not described in the management system. The two low-level analyses are performed by internal resources while the in depth root cause analysis is (informally) required to be led by a root cause analysis specialist. A random sample shows that the last in-depth analysis was performed by internal staff members. It is unclear if any of the team members were a root cause analysis specialist but in earlier interviews it was stated that in-depth analysis is performed by an external company because of the lack of in-house competence within the area and to make use of the benefits of an outside view.

### 3. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations, recommendations and suggestions.

### 4. POSSIBLE SAFETY CONSEQUENCES

Declining safety culture could have significant negative impact on safety. Inadequate programmes to foster a learning attitude and a strong safety culture result in declining safety of the facility. Inadequate training on application management system and leaders not taking into account the human, technology and organizational factors adversely affects the safety of the facility.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**R2)** Concerted efforts have been taken by NRG to promote and further develop a strong safety culture. To supplement these efforts, the NRG senior management should ensure that self-assessments and independent assessments of leadership for safety and safety culture are conducted on regular basis. The planned IAEA Safety Culture Assessment peer review is a positive step towards this goal. The results of such assessments should be documented in the management system along with information on communication (to all staff) and use of the results.

**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.

**S1)** 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.

**S2)** Continue to implement the process for learning of events. Ensure personnel know how to bring up and act upon safety observations and concerns.

## **ISSUE SC 01: Inadequate follow-up by the RSC on the actions associated with its recommendations**

### **1. BASIS AND REFERENCES**

- IAEA Services Series No. 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- Rules and regulations of the Petten Reactor Safety Committee, April 2007
- Charter of the International Safety Experts Team (ISET)
- Terms of reference for the radiation safety committee, K5004/02.47911/I/I
- Minutes of meetings – RSC (four meetings held in July and August 2016)
- HFR Safety Committee, PowerPoint Presentation, NRG, October 2016

### **2. ISSUE CLARIFICATION**

At the NRG there are four safety committees: two committees for the reactor safety (RSC and HSC), one for radiation safety (SVC) and one international safety expert team (ISET) for reviewing the operation of the reactor and monitoring of safety culture. These committees have advisory roles; the RSC, SVC and ISET report to the NRG Managing Director, whereas the HSC reports to the HFR Reactor Manager. The figure below shows the interrelation between the committees, the HFR Reactor Manager and the Managing Director.

#### *HFR Safety Committee (HSC)*

The scope of the HSC is to review and approve all experiments, experimental facilities, foreseen modifications of the installation as well as the review of malfunctioning (root cause analyses), operational disturbances, external experience and Safety Performance Indicators. The HSC advises the HFR Reactor Manager.

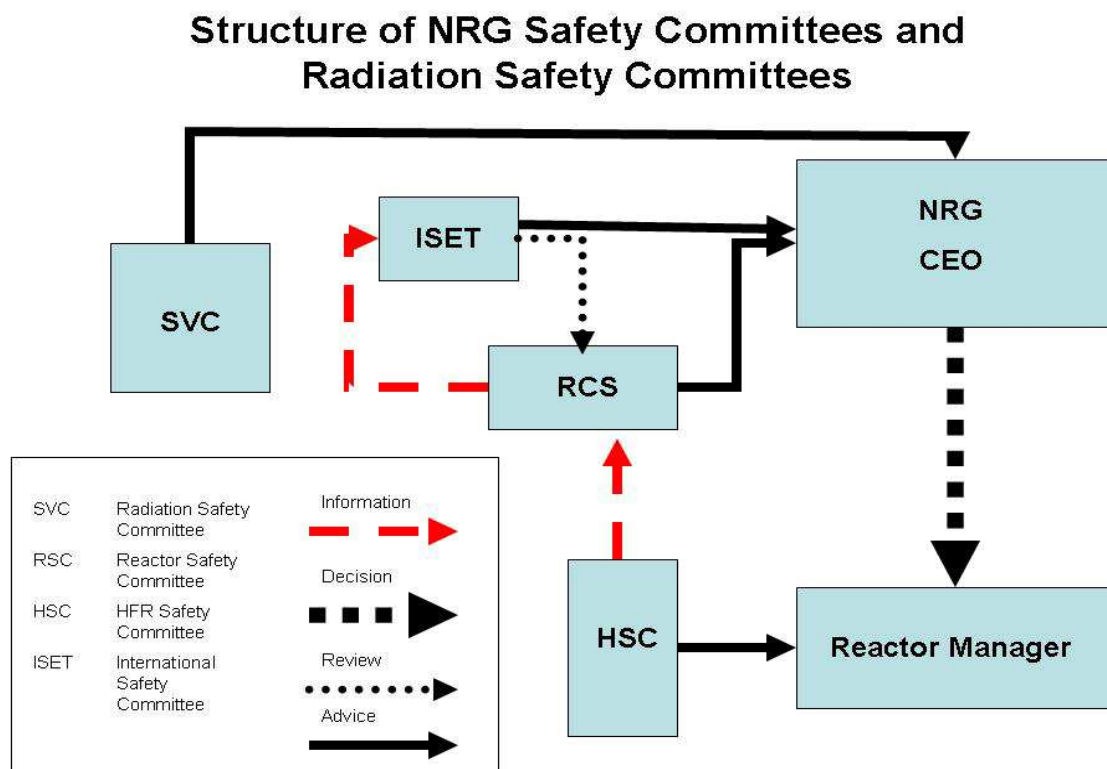
The HSC members are recruited from NRG (including HFR specialists), to ensure adequate competences in the committee. The members have competence in: irradiation experiment engineering, instrumentation and control, reactor physics, thermal hydraulics, mechanical stress analyses, reactor and experimental facilities, maintenance, radiation protection, waste handling, handling of irradiation rigs and QA/QC.

The HSC reviews are based on the received documents, e.g. irradiation proposal report or design and safety report.

The IAEA team discussed with the Chairman of the HSC, the methodology used for its safety review of proposals. The IAEA team commented on the need to clarify that the “Hazards” item indicated in the “Bow-Tie Diagram” does not have the same meaning as defined in the IAEA safety standards.

### *Petten Reactor Safety Committee( RSC)*

The RSC reports to the JRC, NRG and ECN Directors. There are at least 6 members in the RSC. Chairperson and 4 members must attend the meeting as a minimum quorum for a formal meeting. The HFR Reactor Manager, HFR technical experts, and the experiment project manager attend the meetings as observers or for giving presentations. RSC has in average, 11 meetings yearly.



The task of the RSC is to advise on all nuclear safety aspects related to nuclear facilities on the Petten site. This includes all work with experiments in nuclear research reactors and other nuclear facilities as well as their operations, modification and testing. All documents being sent to the regulatory body, including licensing documents are reviewed by the RSC. The RSC is authorised to investigate, request additional information and give advice on matters the committee itself believes to be relevant for nuclear safety.

The competence of the RSC includes familiarity with operation of nuclear facilities, reactor technology and heat transfer, reactor materials, reactor physics and criticality, chemistry, human factors, mechanics and thermal hydraulics, and health physics.

The chairperson of the SVC is a member of the RSC which facilitates an informal flow of information between the two committees. Following the recommendations of the 2011 INSARR mission, the terms of reference of the RSC were revised to include review of the radiological safety issues and proposed changes to the safety documentation.

The procedures for addressing difference in opinion between the RSC and NRG managing Director were also discussed and the team of the opinion that these procedures are in line with the international practice. The HFR management mentioned that it was never the case that a recommendation of the RSC was rejected. The RSC terms of reference states that if a disagreement occurred, the NRG Managing Director should communicate the RSC in writing with the reasons of rejection. Such a case should be also reported to the regulatory body.

As a follow-up to the recommendations of the 2011 INSARR mission, the IAEA team discussed the issue related to follow-up by the RSC on the implementation of the actions associated with its recommendations. The RSC Vice Chairman mentioned that this issue was discussed by the RSC and a conclusion was reached that this is not necessary. The IAEA team explained the importance of the recommended action in relation to enhancing the effectiveness of the RSC, and stressed on the need to implement this recommendations. Further, the IAEA team explained that implementation of this action does not make the RSC responsible for enforcement of the actions associated with its recommendations.

#### *International Safety Experts Team (ISET)*

As a follow-up on the implementation of the suggestion of the 2011 INSARR mission, the terms of reference of the ISET were revised to include review of the SVC operation.

### 3. POSSIBLE SAFETY CONSEQUENCES

Lack of a follow-up by the RSC on the implementation of actions associated with its recommendations will not ensure the effectiveness of the performance of this committee and may impact the effectiveness of safety management and verification.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendations.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

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

**GP1)** Establishment of an International Safety Expert Team to oversee the functioning of the Petten Reactor Safety Committee and Radiation Safety Committee is considered as a good practice.



## **ISSUE TRQ 01: Need for further enhancement of training and qualification programme**

### **1. BASIS AND REFERENCES**

- IAEA Safety Service No. 25: Guidelines for INSARR, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Guide NS-G-4.5: The Operating Organization, Recruitment, Training and Qualification for Research Reactor Personnel, 2009
- IAEA Safety Guide NS-G-4.2: Maintenance, Periodic Testing and Inspection for Research Reactors, 2007
- Training Programme for HFR Maintenance Staff, HFR document, 2013
- Set of Training Materials, documents, and records for the HFR Operators Training
- HFR INSARR: Training and Qualification, PowerPoint Presentation, NRG, October 2016

### **2. ISSUE CLARIFICATION**

A formal training programme is established for the different levels (6 levels) of the HFR reactor operators. The training programme is divided into two main parts: basic knowledge training and on-the-job training. The programme covers basic nuclear physics, reactor physics and engineering, heat transfer and thermal hydraulics, reactor types and designs, reactor materials, and radiation shielding. The new operators also take training on radiation protection. In accordance with the HFR Management, following the 2011 INSARR recommendations, basic knowledge training was expanded to cover topics on nuclear safety and safety culture. However, the HFR formal documents on the training of operators and maintenance staff (2013 version) do not include safety culture.

The on-the-job training lasts for an average duration of one year; it covers the HFR facility-specific knowledge, including HFR design, systems, operating procedures, and practical training. To become a senior reactor operator approximately 5 years of on-the-job experience is needed. This part of the training includes integration of the trainees in operational shifts under the supervision of licensed operators. A formal qualification process is established for the different levels of reactor operators. The trainers are from the NRG specialists, HFR shift supervisors, and lecturers from the national universities.

A formal training and qualification programme is established for the HFR reactor manager and reactor manager on-call duty officers. Following the recommendations of the 2011 INSARR mission, a formal training programme for the reactor maintenance staff was established.

The reactor operators and shift supervisors have a periodic retraining activity (called a 30 MW training session), which takes 5 operation shifts (every team trains one shift) and focuses mainly on retraining on abnormal situations. The IAEA team discussed the basis of selecting 30 MW power operations for training, and it is of the opinion that the selection of this power level needs to be justified with due consideration to minimize the risk. The retraining programme covers recent changes and modifications to the reactor systems and its safety documents, and on operating procedures which are not frequently executed, or selected topics from the initial training programmes.

Certification of the reactor operating personnel is performed, based on examinations, by NRG. The certificate (license) is valid for two years and participation in the retraining programme is a pre-requisite for re-certification. There is no requirement for recertification of certified personnel who are away for an extended period of time from the activities that they are licensed to perform. The IAEA team mentioned that international practices specify that an extended period of time away from licensed activities is considered to be between 3 and 6 months.

The IAEA team also noted with satisfaction that NRG has developed competency matrices for all functions within the HFR organization, which is a powerful tool for managing and enhancing the effectiveness of the training and qualification programme.

### 3. POSSIBLE SAFETY CONSEQUENCES

There is a potential risk to provide training at 30 MW, training at lower power level could meet the objective with lesser risk compared to that at 30 MW.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts indicated that a justification for the selected power level for training will be developed, including consideration of a lower power level training.

The counterparts indicated that the qualification programme could be further improved by requiring requalification of licensed personnel if they are away from their activities for an extended period of time.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**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.

**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 minimization of the overall potential risk of operating the reactor during the training process.

**GP2)** The establishment and use of a competency matrix management tool covering all functions within the HFR organization is considered to be a good practice.

## **ISSUE EVT 01: Need to establish natural hazards monitoring programme**

### **1. BASIS AND REFERENCES**

- IAEA Safety Services No 25, INSARR Guidelines, 2013
- IAEA, N-S-R-3 (Rev.1), Site Evaluation of Nuclear Installations, 2016
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA, 2011 INSARR Mission Report, Issue EVT-01: Siting and Protection against External Hazards

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

Protection of HFR against hazards due to events external to the reactor entails two distinct activities: 1) site evaluation and 2) design/qualification of structures, systems, and components (SSCs). Site evaluation has two major steps: 1) site characterization and 2) evaluation of design basis hazards for design/qualification of SSCs important to safety. Two issue sheets each containing four recommendations were prepared during the 2011 INSARR mission. The first one was on site characterization, including derivation from the design basis seismic hazard parameter (No. EVT-01). The second one was on improvement in seismic design/qualification of SSCs (No. EVT-02).

A programme was established by the operating organization for implementing these recommendations. Some of the recommendations were implemented and work for some is ongoing. The recommendations that have not been implemented are still valid. Work on their implementation should be continued.

The SAR does not contain information on site characterization or derivation of design basis parameter for different external hazards. (See also the Appendix on the follow-up of the 2011 INSARR mission). Reference to the documents in which site characterization and derivation of design basis values for external events are addressed in detail needs to be included.

Further, it was observed that the design/qualification of the SSCs for the facility, especially for seismic hazards, has yet to be completed. A plant walk down has been conducted, but subsequent evaluation has yet to be performed. No programme has been established for monitoring the external natural hazards during the reactor operation phase.

The HFR facility was not designed originally against seismic forces. The seismic qualification of SSCs important to safety was carried out using a ground motion response spectrum, which was not site specific. The IAEA team was informed that a conservative ground response spectrum was used for seismic safety analysis. All SSCs related to safe shutdown of the reactor and maintaining it in the safe condition is to be qualified against seismic and other external hazards following relevant IAEA safety standards. The reactor building is on pile foundation bored in the deep sand deposit. The sand has high liquefaction potential in the event of seismic excitation, which may reduce the load carrying capacity of piles. This aspect needs to be accounted for in the soil structure interaction modeling of the building for seismic response analysis.

### 3. POSSIBLE SAFETY CONSEQUENCES

Seismic, flooding and geotechnical are the important site issues. Behavior of loose saturated sandy soil and safety-related SSCs during an earthquake and associated internal flooding due to the unavailability of the storm drainage system can create critical safety issues.

### 4. COUNTERPARTS VIEWS AND MEASSURES ON THE FINDINGS

The counterparts agree with the observations, safety concerns as described above, and recommendations.

### 5. RECOMMENDATIONS/SUGGETIONS/GOOD-PRACTICES

**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.

**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.

## **ISSUE COP-01: Observations from the facility walkthrough**

### **1. BASIS AND REFERENCES**

- IAEA Services Series No 25: Guidelines for the review of research reactor safety, 2013
- IAEA Safety Standards SSR-3: Safety of Research Reactors, 2016
- Walk-through the reactor facility

### **2. ISSUE CLARIFICATION**

During the first day of the mission, the IAEA team and the counterparts made a detailed walkthrough to the reactor and associated facilities. During the visit, the reactor was in operation at a power level of 45 MW for radioisotope production and irradiation of experiments. The team visited the reactor control room, reactor pool top area, reactor hall, and the second floor. The technical visit familiarized the team with the reactor systems and components and their technical status.

During the visit, the team observed the very good housekeeping of the reactor building and noted the ongoing installation of a new security fence on the perimeter of the HFR site, as well as the relocation of the truck entry for ensuring better access and handling conditions. The team also noted the installation of a new changing room outside the vital area for the operating staff.

During the walkthrough, the team discussed various aspects regarding the operational safety of the reactor facilities with the reactor operating personnel and made recommendations and suggestions for further improving the operational safety concerning, in particular, the experimental areas and radiological safety.

The team noted the need to ensure that the operation bridge is clamped at its parking position to avoid de-railing in case of a horizontal vibration due to, for example, an earthquake.

In the reactor sub-pile (control rod drive mechanisms) room, the pipe penetration located in the top-left corner has a flange where four of the eight bolts are missing. It was not clear if the loss of leak tightness at this location could result in draining water through the pipe penetration.

The improvements recommended or suggested during the 2011 INSARR mission concerning the leak tightness of the door closing the control rod drive mechanisms room and the warning indications of the hazards (e.g., electrical, chemical, radiological, etc.) associated with each experimental area around the neutron beam tubes are not yet implemented.

The platform surrounding the reactor pool is not equipped completely with a barrier to prevent persons from falling into the contaminated water of the reactor pool. In addition, the two seats used by operating staff during handling operations in the pool are not equipped with security belts to prevent such an accident.

Radiations protection signs are missing in external areas with radiation hazards, including the roof of the Swan Lake and the newly installed tanks to store slightly contaminated water. During the walkthrough, the team also observed in several places drums containing contaminated material without adequate demarcation and physical barriers.

During the walkthrough, the team also observed non-used items (mostly from experiments that are no longer in use) located in the floor of different levels of the reactor building. The operating

personnel mentioned that these items belong to the reactor owner. These items need to be removed for further enhancing the house keeping within the reactor facility.

### 3. POSSIBLE SAFETY CONSEQUENCES

The above mentioned findings may have significant consequences on the safety of the reactor and personnel.

Lack of posting of warning signs for radiation, chemical, and electrical risks and incomplete protection barriers at the platform surrounding the reactor pool may affect the safety of personnel.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendations. Comments on the need of a leak-tight door for the control rod drive mechanism is discussed in the Appendix on the follow-up of the recommendations of the 2011 INSARR mission.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**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.

**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.

## **ISSUE COP-02: Need for improving the quality of the cycle reports and operation shift checklists**

### **1. BASIS AND REFERENCES**

- IAEA Services Series No 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards NS-G-4.4: Operational Limits and Conditions and Operating Procedures for Research Reactors, 2008
- Set of HFR operation documents and logs

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

Reports on operation cycles are issued and contain data useful for assessing the operating experience. These reports also provide feedback to reactor management and other technical groups within the HFR on events or occurrences, operational difficulties experienced, core management, behavior of structures, systems and components important to safety, and compliance with the OLCs. However, the data recorded in these reports are not supported by an analysis of deviations or significant variations of parameters important to safety. Additionally, these reports contain non-significant data concerning periods of time that are not related to the specific cycle.

Operation shift checklists for verifying operational parameters important to safety do not include the relevant acceptance criteria on these parameters, posing difficulties and additional efforts to achieve effective implementation of the procedures. Additionally, the records of these checklists do not show formal signature of the persons that performed them. These checks are necessary to verify compliance with the OLCs.

### **3. POSSIBLE SAFETY CONSEQUENCES**

Lack of quality in the contents and verification of operation checklists could have a significant negative impact on the safety of the reactor and personnel.

### **4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS**

The counterparts agree with the observation and recommendation.

### **5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES**

**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.

## **ISSUE MPT 01: Need for improvements of the Maintenance, Periodic Testing and Inspection Programme**

### **1. BASIS AND REFERENCES**

- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards No NS-G-4.2: Maintenance, Periodic Testing and Inspection for Research Reactors
- Report of the IAEA INSARR Mission Report, April 2011 – Issue MPT 01

### **2. ISSUE CLARIFICATION AND OBSERVATION**

A maintenance programme for HFR is established. The programme covers the organization of maintenance, SSCs that are subject to maintenance, maintenance activities, and schedule. The IAEA team examined the preventive maintenance schedule for 2016. It was found to be complete and include daily, weekly, monthly, semi-annually, and annual maintenance activities. Maintenance is conducted through work orders that combines maintenance procedure and work permit systems. The reactor documentation also includes adequate maintenance procedures.

The maintenance activities are performed by the maintenance department within HFR, or by external organizations under the control of this department. A minimum contingent of staff is available for day-to-day maintenance work and many of the maintenance activities including calibration of instruments and radiation monitors by accredited laboratory, annual testing of cranes, and maintenance of diesel generator sets. Special works, such as aluminium welding, are outsourced.

During the discussions with the HFR operating personnel, the IAEA team explained that the SSCs included in the maintenance schedule could not be verified against a master list of SSCs for completeness (for example flange joints are not included in the list). The team was informed that this will be confirmed against process and instrumentation diagrams as part of the recently established computerized management system tool (called SAP). The team also observed that the civil structures are not covered by the maintenance programme (however, algae formation was noticed on the support structure of stack).

Due to the fact that SAP is currently being implemented, electrical and instrumentation & control maintenance activities are still being managed outside the SAP.

Recently the HFR had faced outages due to maintenance issues including improper rivet joints of the control rods' cadmium absorber section and fuel follower. This was corrected by improved tool design for riveting and quality assurance checks of rivets. Another important issue faced by HFR was noise signals in nuclear channels for which the reactor was shut down for investigation. The reactor was restarted after necessary checks and the noise issue did not reappear. However, a conclusive root cause for this event was not established.

Before initiating a maintenance activity, necessary clearances (e.g., the shift supervisor's clearance, radiation protection officer's clearance, or electrical isolation) are obtained and signed on the work order. However, while handing over the equipment after completion of



maintenance activity, the shift supervisor is informed, but a formal signature is not obtained on the work order.

Sample checks were made by the IAEA team, which confirmed that the spare parts inventory for items important to safety is maintained. However, there is a need to establish re-order levels for spare parts based on consumption rate and procurement time.

### 3. POSSIBLE SAFETY CONSEQUENCES

Non-inclusion of items important to safety in the maintenance and inspection plan could result in their deterioration and unanticipated failures.

Non establishment of root cause for abnormal behaviour of safety significant SSCs such as nuclear channels could lead to hidden deficiencies remaining unnoticed and impact safety.

Non availability of spare parts for items important to safety could have an impact on reactor safety and availability

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterpart agrees that while the conversion of preventive maintenance plans to the electronic system is not complete, checking if all SSC's relevant to safety are covered by these maintenance plans is a time consuming effort. Therefore, it is not possible to take full credit for this. Completing the project of digitalizing the maintenance plans will make this an easy task, correcting this issue. The same holds for formalising the check performed by the shift supervisor. A process for performing the check is already in place in the electronic system, but as long as the project of digitalizing the maintenance plans is not complete, this process is not fully working.

The counterparts also agree that a process for determining stock strategies will increase the reliability of production.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES/COMMENTS

**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 organizations are covered. Additionally, the work order form should be revised to include quality checks concerning completion of maintenance and return to service checkouts.

**S4)** To further enhance management of spare parts, it is suggested to define "re-order" levels of items important to safety based on the consumption rate and lead time for procurement.

## **ISSUE MPT 02: Need to determine leakage rates and paths of the reactor pool and implement adequate corrective actions**

### **1. BASIS AND REFERENCES**

- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- Report of the IAEA INSARR Mission Report, April 2011 – Issue MPT 01
- HFR operating documents and records

### **2. ISSUE CLARIFICATION AND OBSERVATION**

Water leakage from the reactor pool has been observed from early operation of the HFR and regular repairs in the pool liner have been performed in the past. The pool liner has a leak collection system wherein the water leaking from the liner weld joints is collected in this system. The IAEA team was informed by the Counterparts that the present leak rate is around 90 l/day. Based on visual observations of the liner from the water side (pool), leakage was suspected from a joint where the storage pool isolation door frame is connected to the pool liner. The suspected zone was repaired by welding an aluminium plate over the existing liner. The water leakage was reduced for some time but increased again, indicating presence of other leakage paths that have not yet been identified. The work of identifying leakage paths and subsequent corrective actions will be followed up in a dedicated project.

The 2011 INSARR mission recommended actions for improvement of the leak tightness of the reactor pool and also to make the door of the control rod drive mechanism room, which is located under the reactor pool, water leak-tight. Further discussions have been held during 2016 mission and actions were agreed to implement the objective of the recommendation (see Issue Page SA 01).

### **3. POSSIBLE SAFETY CONSEQUENCES**

Leak tightness of the reactor pool is a design requirement as barrier against radioactive release to the environment. Leakage of pool water into concrete could result in corrosion of re-bars resulting into swelling of re-bars. This could subsequently lead to bulging and damage of pool liner or cracks and spalling of the concrete. The leakage of water may also lead to the corrosion of coolant system piping embedded in the concrete.

### **4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS**

The Counterpart indicated that a detailed plan is being worked out for locating leaking points in the pool and subsequent corrective actions. The Counterpart agreed that confining a leak of primary or pool water to the sub-pile room could be useful.

### **5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES**

**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.

## **ISSUE MPT 03: Good Practice – Establishment of a periodic safety review process**

### **1. BASIS AND REFERENCES**

- IAEA Safety Standards SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards SSG-10: Ageing Management for Research Reactors, 2010
- Discussion during presentation on “General description of the HFR” by Reactor Manager of HFR on 4 October 2016;
- Discussion on Ageing Management Programme on 5-6 October 2016
- Ageing Management Review HFR, Methodology
- Ageing Management Review HFR: Primary system
- Ageing management Review: Combination of materials, conditions and environment

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

The HFR has initiated an Ageing Management Programme in 2014 following the IAEA Safety Standards No SSG-10 “Ageing Management for Research Reactors”. The HFR maintenance group is responsible for the ageing management programme. The methodology for the ageing management programme covers the scoping and screening of SSCs with respect to safety, applicable ageing degradation mechanisms, grouping of SSCs based on similarity of material, and environment. The programme includes analysis of the current maintenance, periodic testing and inspection programmes to identify the gaps in the minimization and mitigation of the ageing effects on SSCs.

During the mission, the IAEA team examined the ageing management programme of the primary cooling system. The team found that the programme covers the inspection methods to detect and monitor ageing degradation of SSCs such as visual inspection and ultrasonic testing for reactor vessel, decay tank, and primary piping, as well as the frequency of these inspections. For monitoring the irradiation effects on reactor vessel material, coupons are irradiated in the reactor and these coupons are examined for their mechanical properties at the different fluence levels. The team was informed that for the current fluence level of the order of 1022 n/cm<sup>2</sup>, the fracture toughness of the reactor vessel material is acceptable. Silicon content in the reactor vessel material is estimated to be around 3%.

The results of the ageing management programme are used to adjust the maintenance and in-service inspection programme, for example the frequency of replacement of electrical relays and thermocouple inspections have been increased to prevent their failure.

The HFR has planned an IAEA safety review mission on ageing management for continued safe operation of the HFR.

The HFR conducted a periodic safety review (PSR) in 2012-14 and submitted the report to the regulatory review. This process is required to be conducted every ten years. Review of the activities performed with the PSR showed that it was conducted in accordance with the IAEA safety standards for nuclear power plants (SSG-25) with use of a graded approach. The review included fifteen safety factors and global assessment based on findings from the safety factors review. The implementation plan for safety improvements is being finalized.

### 3. POSSIBLE SAFETY CONSEQUENCES

Effective implementation of an adequate ageing management programme and performing periodic safety reviews have positive impacts on safety and will support continued safe operation of the reactor.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts mentioned that the existing practice will continue to be improved for further enhancement.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**GP3)** Conduct of periodic safety reviews every ten years, their regulatory review, and implementation of the resulting corrective actions and safety improvement plan is considered as a good practice.

## **ISSUE SA 01: Need for improving the safety analysis**

### **1. BASIS AND REFERENCES**

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards No SSG-20: Safety Assessment and Preparation of Safety Analysis Report for Research Reactors, 2012
- Safety Analysis Report of HFR, 2003

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

The HFR performed immediately after the accident at the Fukushima nuclear power plant, a complementary safety margins assessment (“stress-test”) to examine the robustness of the HFR facility in the case of extreme external events. The assessment was peer-reviewed by international experts and was submitted to the regulatory body for review. Most of the actions resulting from this assessment were implemented.

In the section above the reactor core, the reactor vessel is equipped with two (redundant) valves, through which the pool water can flow into the reactor vessel to cool the core when the forced cooling is not possible. In addition, the reactor vessel is equipped with two convection valves positioned above and below the core. In this configuration, the core can be passively cooled with pool water by natural convection. These valves are operated manually and ensure core cooling by natural convection. During reactor normal operation in the forced cooling regime, these valves must be fully closed in order to avoid core flow by-pass. Inadvertent opening of the convection valve at the core inlet will cause a bypass of the core in the forced cooling regime. This scenario was subjected to discussions during the 2011 INSARR mission. Following these discussions, an analysis was performed and instrumentation was installed to monitor the status of the natural convection valves.

Additionally, the 2011 INSARR mission provided recommendations to:

- Display in the control room the status (closed condition) of the convection valve. In this regard, the Counterpart mentioned that modifications were made following the Fukushima accident to ensure monitoring of the status of convection valves.
- Install, based on a detailed safety analysis, an isolation valve on the primary cooling piping before its crossing the reactor building and to consider the installation of isolation valves at the inlet and outlet of the primary coolant circuit close to the pool wall to minimize the quantity of water drainage in case of rupture of the primary cooling pipes. The counterparts indicated that this recommendation will not be implemented to avoid the risk of an inadvertent closure of such valves during the operation of the reactor. In this context and in the opinion of the IAEA team, the need for defining and implementing provisions to minimize the quantity of water drainage and to avoid uncovering of the core in case of rupture of pipes, remains valid and needs to be assessed.
- Ensure the leak tightness of the door of the room containing the control drive mechanisms (sub-pile room), which is located under the reactor pool. The objective of this recommendation was to confine a possible leak of primary or pool water to the sub-pile

room and to avoid the risk of uncovering of the core. The counterparts indicated that this recommendation will not be implemented because any possible water leakage in the sub-pile room will be collected in the effluent reservoir and will be returned back to the pool (circulation pump). In this context, the IAEA team indicated the need to demonstrate that the existing provisions are adequate to avoid the risk of uncovering of the core in case of rupture of the pipes connected to the bottom of the pool in the sub-pile room. Such analysis needs to consider, in the frame of the lessons learned from the Fukushima accident, the case of an earthquake leading to the rupture of the pipes and combined with a loss of electrical power supply.

### 3. POSSIBLE SAFETY CONSEQUENCES

A bypass of the primary coolant flow during the reactor operation may have a significant impact on the integrity of the fuel.

Leak tightness of the reactor pool (physical barrier) and avoiding the uncovering of the core are design requirements important to safety.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the above elements and with the positions of the IAEA team.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**R13)** To complement the safety reassessment performed following the lessons from the Fukushima accident, it is recommended to define and implement measures aimed 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.

**GP4)** Performing safety reassessment following the lessons from the Fukushima accident, its review by independent groups and by the national regulatory body and implementation of the resulting corrective actions is considered as a good practice.

## **ISSUE SA 02: Need for improvement to PSA**

### **1. BASIS AND REFERENCES**

- IAEA Safety Service No 25: Guidelines for INSARR, 2013
- Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants Specific Safety Guide - IAEA Safety Standards Series No. SSG-3
- HFR PSA – NRG-2.3446/15.131236 – Final
- SA for HFR, PowerPoint presentation, NRG, October 2016

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

In accordance with the IAEA safety standards for research reactors, probabilistic safety assessment (PSA) methods could be used as a complementary tool in the safety analysis. The ANVS requires complete level 1, 2 and 3 PSA for the HFR. The NRG initiated preparation of the PSA in 2013 and finalized a Level 1 PSA by December 2015. Although the IAEA team assessment was focused on the deterministic safety analyses included in the “Safety Report of the High Flux Reactor (HFR) at Petten” (25147/03.52449) and the “Complementary Safety Margin Assessment Onderzoekslocatie Petten” (25192/12.113089), some discussions were held in order to provide information for improving the content, clarity and completeness of the PSA being developed.

The potential radiation sources identified in the PSA are the core, the experiments, and the spent fuel. However, no reference is given to the irradiated targets, which could present significant radiological hazards during handling within the facility.

The identification of postulated initiating events (PIE) has been developed following the IAEA recommendations and decisions within HFR (e.g., inclusion of “Normal Shutdown” as a PIE) resulted in a different list than the one described in other documents. In addition, the definition of some PIE such as aircraft crash is defined inconsistently in different analysis (for instance, the reference plane is, sometimes defined as a military jet while in other documents is listed as a commercial airliner).

In the PSA, the “core damage” condition is reached if the fuel cladding temperature reaches 425°C. Other phenomenon, apart from the loss of the mechanical properties of the aluminium associated with this temperature, are not being considered for determining potential core damages, such as the flow redistribution.

The IAEA team noted also that the analyses of the plant evolution after occurrence of a PIE, credit some systems (referred to as “front-end-systems”) that are not classified as safety systems (see: Table 6-2 of the HFR PSA).

Models, data, and criteria used to determine the failure rate of “front-end systems” are not clearly described. In particular, in page 29/43 of the HFR PSA document, it is stated that “the insertion of one control rod will stop the fission reaction” thus indicating that the failure of the shutdown system involves the simultaneous failure of all the six control rods.

### 3. POSSIBLE SAFETY CONSEQUENCES

An incomplete identification of the radiation sources may impair the PSA conclusions, especially if transit sources being manually managed are not included. Inadequate identification of the processes leading to core damage as well as the values of the relevant safety parameters significantly affects the accuracy of the results. Erroneous definition of the successful actuation of the safety system may impact the probability associated with the final accidental scenarios.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and suggestion.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**S5)** To improve the quality of the probabilistic safety analysis, the following has to be considered:

- Mo irradiation targets as possible source of radiation, which will lead to consideration of new postulated initiating events (e.g., removal of irradiated targets before the specified cooling time);
- Clear identification and definition of the parameters involved in accidental scenarios, including core damage;
- Better description of the models used for analysis of the safety system, as well as the success criteria of the safety systems and components;
- Better documentation of the data used for assessing the reliability of components.



## **ISSUE OLC 01:Need for improvement to the OLCs**

### **1. BASIS AND REFERENCES**

- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards SSR-3: Safety of Research Reactors, 2016
- IAEA NS-G4.4 Operating limits and conditions and operating procedures for Research reactors, 2008
- OLCs for HFR , PowerPoint presentation, NRG, October 2016

### **2. ISSUE CLARIFICATION AND OBSERVATION**

Discussion related to the operating Limits and Conditions was made with the experts present following a presentation made by the HFR personnel. It was presented to the INSARR mission team that HFR follows the guidelines of the IAEA safety standards series No NSG-4.4 and SSG 24. The latest revision of the OLC's document is dated 13 November 2015. The discussions with the HFR operating personnel led to the observation that the following items are not described in the OLCs:

- Locations and alarm setting values of the radiation protection equipment and radiation fixed area monitors;
- Measures to be taken during the prolonged shutdown periods of the reactor including, unloading of the reactor core from fuel, operational and maintenance checks, operation of the over-head crane, availability of electrical power supply, minimum staffing requirements, etc.;
- Periodic monitoring of the radioactivity contents of the underground water near the facility.

### **3. POSSIBLE SAFETY CONSEQUENCES**

Inadequate inclusion of the above mentioned items in the OLCs may have a negative impact on safety.

### **4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS**

The Counterparts agree with the observation and the recommendation.

### **5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES**

**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.

## **ISSUE RPR 01: Improvements to the operational radiological protection programme**

### **1. BASIS AND REFERENCES**

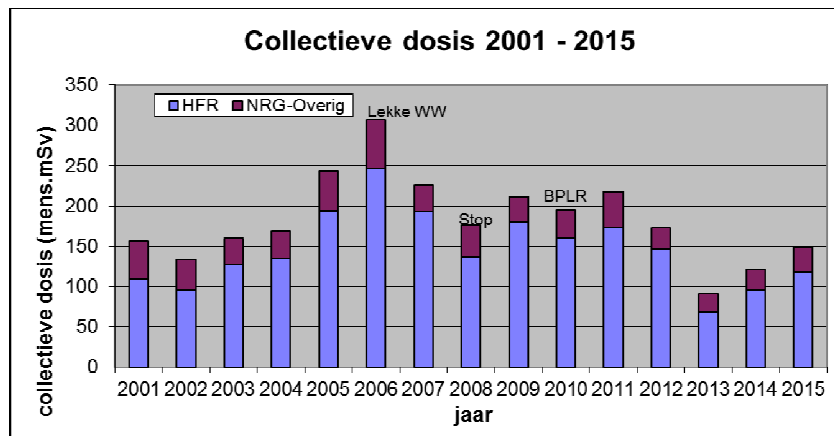
- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards Document No. SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards NS-G-4.6: Radiation Protection and Waste Management in the Design and Operation of Research Reactors, 2009
- HFR Radiation Protection, PowerPoint Presentation, NRG, October 2016
- NRF-SB-OD-0008,” Afhandeling van radioactieve besmettingen”

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

The operational radiological protection programme is established at the NRG site and covers all facilities presenting radiological hazards, including the HFR reactor. The documentation of the programme includes the organization of the radiation protection group, the radiological protection objectives, and adherence to application of the radiological protection principles, including the optimization principle. The operating procedures include a monitoring programme of the external dose and contamination at different working places inside the reactor building. The radiological protection equipment is calibrated and well maintained. The limits on radioactivity discharge to the environments are established and controlled by dedicated operating procedures.

The organization of radiation protection was discussed including during reactor operation shifts (see also the ISSUE Page on Reactor Management). The functional, operational, advisory, and reporting relationships between the different positions of the radiation protection organization are well defined within NRG. However, the IAEA team observed the need to enhance the communication between the QHSE (including the local radiation protection officers) and the other groups within the HFR. In this regard, it is worth mentioning that the QHSE was not aware of the recommendations of the 2011 INSARR in the area of operational radiation protection.

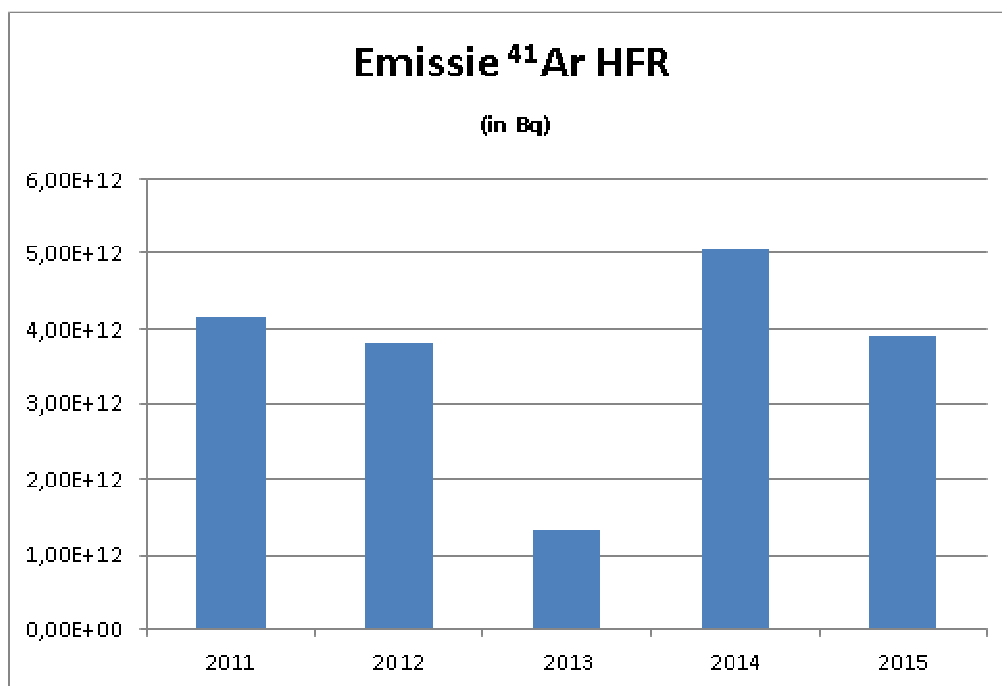
The discussions with the HFR operating personnel showed that a dose limitation system exists and applied, and it is in line with the IAEA safety standards. The personal dosimetry records for 2015 were reviewed during the mission: There was no individual dose exceeding the value of the dose constraints (5 mSv); and 87% of individuals received less than 1 mSv. The most exposed individual received dose of 4.11 mSv, and the HFR personnel received a collective dose of 111.26 mSv (or an average of 1.20 mSv per individual). However, as shown in the figure below, an increasing trend in the collective dose has been observed since 2013. This trend was explained by HFR as the additional maintenance and repair activities as well training of new staff.



**Figure: Collective dose for HFR (2001-2015)**

The IAEA team also made discussions with the counterparts concerning the implementation of the recommendations of the 2011 INSARR mission on radiation protection. These were mainly related to the adequacy of radiation fixed area monitors, minimization of releases of Ar-41 to the environment, and the step-by-step instructions on decontamination procedures.

The IAEA team also examined and discussed the records of the release of Ar-41 during the past five years, where it can be observed that there is no significant decrease of releases compared to 2011 observation (as shown in the Figure below).



**Figure: Records of Ar-41 release to environment from HFR (2011-2015)**

The IAEA team also noted that radioactive releases to the atmosphere are well below the authorized limits. However, measurements of radioactive releases are not in accordance with

the international practice (see also Issue Page on Waste Management). Radioactive liquid releases are appropriately transferred to the Site Central Decontamination Plant (DWT) after measurement and authorization. It was also observed that number of reported potential unsafe situations and the reports to the regulatory body has been increased in the last few years motivated by the positive attitude of the staff for documenting these situations.

During the discussions, the IAEA team noted that as many of the beam tubes are no longer in use, monitoring of neutron dose at beam ports has been disregarded. Nevertheless, the foreseen decommissioning of non-used beam tubes will require an update of the area monitoring system.

See also the observation from the walkthrough concerning the dose rate values at different areas and need for posting warning indications with different types of hazards, and for mapping different areas with respect to dose rate values.

### 3. POSSIBLE SAFETY CONSEQUENCES

Inadequate monitoring of neutron radiation, particularly at beam tubes area, could have significant impact on radiation protection of personnel. This is particularly important in view of the foreseen decommissioning of the non-used beam tubes.

Ineffective communication between the operating staff (including operators and maintenance personnel) and radiation protection officers could have a significant impact on the protection of personnel and affects the possibility for continuous improvements and optimization of radiation protection.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The Counterparts agree with the observations and recommendations of the mission.

### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**R15)** Adequate radiation monitors for neutron dose should be installed at the beam tube 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 optimization of radiation protection.

## **ISSUE RWMP-01: Radioactive waste management programme**

### **1. BASIS AND REFERENCES**

- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards No SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards NS-G-4.6: Radiation Protection and Waste Management in the Design and Operation of Research Reactors, 2009
- PowerPoint presentations on HFR and TWT Waste Management Programme, HFR, October 2016
- HFR Safety Analysis Report, 2003

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

The operational waste management activities for the HFR are covered by the established radioactive waste management programme for the NRG site. Arrangements for the operational radioactive waste management exist within HFR. These include, (preliminary) segregation and classification based on waste type (solid, liquid) and its radioactivity contents, temporary storage, control, and transport to another on-site organization (DWT) for further processing.

Limits on radioactivity discharge from the HFR to the environment are established and controlled by the operating procedures. With respect to gaseous releases, the reactor is equipped with three stack monitors measuring the activity of noble gases, while the measurement of aerosols, iodine and particulates is performed (by sampling) on weekly basis.

After its segregation, the radioactive solid waste is put in 30-liter drums. Following surface dose rate measurements, these drums are transferred to DWT for further processing. Liquid waste, based on its radioactivity contents, is pumped to DWT using one of two different pipelines. Currently there are 17 m<sup>3</sup> of stored ion-exchange resin waste at the DWT, with no additional storage capacity. If this additional storage capacity is not made available within the next two years, the HFR availability for operation would be significantly affected.

The spent fuel is stored temporarily in the reactor building (in storage pool or canisters), and is transferred to the national storage facility. Exotic radioactive waste (e.g. beryllium, tritium, sodium, potassium and fissile materials) is stored at the DWT without further processing at the moment.

The discussion with the reactor operating personnel showed that aspects of minimizing the generation of radioactive waste and the final destination of waste generated from experiments as well as their decommissioning plan are pre-requisites for approval of proposed experiments.

### **3. POSSIBLE SAFETY CONSEQUENCES**

The continuous measurement of aerosols, iodine, and solid particles would enhance the radiation monitoring of the reactor facility and would help to detect irregularities in timely manner.

Potentially long outages that could be caused by the shortage of resin storing capacity is mainly an operational and financial issue. However, any longterm shutdown has a relatively strong influence on the morality of the operating personnel.

#### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observaion and suggestion.

#### 5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

**S7)** 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.

## **ISSUE MOD 01: Insufficient procedures for documenting and restarting incomplete or postponed modifications**

### **1. BASIS AND REFERENCES**

- IAEA Safety Standards No SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards SSG-24, Safety in the Utilization and Modification for Research Reactors, 1996
- Set of HFR documents on modification projects
- HFR Modification, PowerPoint presentation, NRG, October 2016

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

Modification proposals are prepared by engineering teams within the NRG Business Unit. Proposals include a description of the safety case, and a preliminary categorization of the modification with respect to safety. Modifications are categorized based on their safety significance in accordance with the IAEA safety standards SSG-24: category I (major modifications); Category II (Significant modifications), category III (minor modification), and Category IV (Modification with no safety effect). The HFR Manager of Nuclear Safety reviews, approves, and assigns a category to proposed modifications with the advice of the HFR safety committee and the Radiation Safety Committees. Modification proposals of Category I have to be approved by the regulatory body and require detailed safety analysis and procedures for design, fabrication, installation, and commissioning similar to those applied for the reactor itself. Category II modification proposals are sent to the regulatory body for approval, but don't require regulatory approval on its commissioning. All modification proposals with safety significance (category I, II, and III) are subject to review by the HSC and RSC.

In some cases, initiation or completion of approved modification proposals may be postponed for an indefinite period of time. In the event that these projects are continued in the future, the HFR management team determines whether the approval process for the modification should be reinitiated. However, there is no procedure to establish guidelines for determining when a postponed modification should receive re-approval before re-initiating work on the project. Further, there is no procedure to inform the regulator of the status of postponed Category I and Category II modification proposals.

Samples of modification projects were examined during the mission, and found to be implemented in accordance with the established procedures. The review made by the team showed that review of the reactor safety committee of proposed modifications is adequate.

### **3. POSSIBLE SAFETY CONSEQUENCES**

Without consistent procedures for re-initiating work on postponed modifications, the basis for the safety case of the proposed modification could be impacted by subsequent initiation and/or commissioning of other modifications or experiments. This could lead to miss-categorization of



postponed modifications, which could challenge safety, underestimate radiological consequences, and expose staff to unnecessary radiation levels.

#### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

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

#### 5. RECCOMENDATIONS/SUGGESTIONS/GOOD PRACTICES

**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.

**S8)** It is suggested that the regulatory body be informed of changes in status of postponed Category I and II modifications and experiments.

## **ISSUE MOD 02: Safety improvements for the ongoing modification projects on spent fuel storage casks and over-head crane modernization**

### **1. BASIS AND REFERENCES**

- IAEA Safety Service No 25: Guidelines for the Review of Research Reactor Safety, 2013
- IAEA Safety Standards SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Standards SSG-24: Safety in the Utilization and Modification of Research Reactors, 2012
- NRG, Presentation made on the modification proposals of storage spent fuel cask in the pool and modernization of the overhead polar crane, 2016

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

With respect to the modification project for spent fuel storage cask, there is a possibility of damaging the aluminium liner on the pool floor if the casks drop accidentally. The damage can cause pool water leakage through the liner. The leaked water may further get passage through the concrete mat of the pool floor, potentially increasing radiation levels in the reactor hall and pose risk for uncovering of spent fuel.

With respect to the ongoing crane modernization project, replacement of the lifting mechanism is necessary because the present crane is not fulfilling the relevant national standard (KTA 3902). The IAEA team was informed that proposed modernization would fulfil the single failure proof criteria for the crane. Moreover the crane bridge may derail due to horizontal excitation and fall down if it is not protected.

### **3. POSSIBLE SAFETY CONSEQUENCES**

There is potential of damage to the pool floor liner under accidental heavy load drops such as transfer casks. This may lead to concrete damage and also potentially increasing radiation levels in the reactor hall (see also Issue Page MPT 02).

The possibility of the crane falling down due to derailment caused by horizontal movement by seismic excitation should be assessed. Precautions need to be taken in order to prevent this event. The team also explained that during modernization of the over-head crane, precautions need to be taken to park the crane and clamp it in a secure position, ensure placement of fuel elements in the pool in a position that minimize the possibility of being hit by incidental fall of heavy loads, and protect the pool water surface against dust, oil, and other possible spills.

### **4. COUNTERPARTS VIEWS AND MEASURES ON THE FINDINGS**

The counterparts recognize the fact that the pool floor (concrete and liner) need to be protected against heavy load drop. A shock-absorbing floor is designed and currently under assessment for its adequacy. The counterparts agree with the observations and the recommendations.

## 5. RECOMMENDATIONS/SUGGETIONS/GOOD-PRACTICES

**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.

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

## **ISSUE EXP 01: Need to establish requirements for qualification of staff to be recruited in the Irradiation Services and Research and Development Units**

### **1. BASIS AND REFERENCES**

- IAEA Safety Standards No SSR-3: Safety of Research Reactors, 2016
- IAEA Safety Service No 25: INSARR Guidelines, 2013
- IAEA Safety Standards SSG-24, Safety in the Utilization and Modification for Research Reactors, 2012
- Set of HFR documents on experiments projects

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

Experiment proposals are received by the Irradiation Solutions, or Research and Development Units within the NRG. These two units also initiate experiment proposals, which include a description of the safety case, and a preliminary categorization of the modification with respect to safety. At present, these two units include specialists who had working experience in HFR and they are aware of the safety features of the reactor and its OLCs. However, there is a need to ensure that the qualification of employees to be recruited in these units require knowledge on HFR design, safety features and OLCs.

Requests for experiments, including the irradiation request and design safety report, are submitted to the HFR Nuclear Safety Manager, who is responsible for review of the proposal from the safety point of view with the support from other groups within HFR, including the safety committees. The process for review, approval, regulatory review, and implementation of experiments are the same as for modification proposals (see Issue Page MOD 01). Like modifications, experiments at HFR are categorized in accordance with the IAEA safety standards SSG-24.

The recommendation provided in the Issue Page MOD 01 of this report also applies to experiments.

### **3. POSSIBLE SAFETY CONSEQUENCES**

See the same Section on Issue page MOD 01.

### **4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS**

The counterparts agree with the observation and recommendations.

### **5. RECCOMENDATIONS/SUGGESTIONS/GOOD PRACTICES**

**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.

## **ISSUE EMR 01: Improvements of the emergency planning and preparedness**

### **1. BASIS AND REFERENCES**

- IAEA Safety Service No 1: INSARR Guidelines, 2013
- IAEA Safety Standards No SSR-3: Safety of Research Reactors, 2016
- HFR presentation on the emergency planning, NRG, October 2016

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

Recently, an extensive reorganization of the emergency response structure has been implemented, which is aimed at clearly defining roles and responsibilities of the four organizations involved in the work within the site. In line with this reorganization, the HFR is modifying the HFR emergency plan, ensuring compatibility with the site emergency arrangements. This action is expected to provide enhancement for the HFR emergency plan.

Arrangements with external organizations are being coordinated, thus facilitating the access through the security control points and guiding the support vehicles (ambulance for instance) up to the proper access point to the facility.

The HFR emergency plan incorporates a classification of emergencies into 15 categories, providing criteria for classifying scenarios with the appropriate category as well as correlations with levels defined in the site emergency plan. Procedures are being developed for each of the above-mentioned categories including step-by-step instructions to be performed by the different responsible persons, as well as reporting and communications aspects. Training and drills aspects are also being included in these updated procedures.

The document is available in Dutch, but the discussions with the HFR responsible staff indicated that the revised HFR emergency plan is rather complete and it is expected to contribute to enhancing the effectiveness of emergency preparedness.

The IAEA team discussed the need for training and drills on the revised emergency plan as soon as possible, and the necessity of consideration of the aircraft crash scenario, in a consistent manner with that identified in the SAR.

### **3. POSSIBLE SAFETY CONSEQUENCES**

Delay in implementing the revised emergency plan, including performance of emergency drills, prevents receiving the benefits of the already developed plan.

### **4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS**

The Counterparts agree with the observations and suggestions.

### **5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES**

**S9)** 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.

## **ISSUE DEC 01: Improvement in coordination of decommissioning plan updates and maintenance of HFR staff during decommissioning**

### **1. BASIS AND REFERENCES**

- IAEA Safety Standards GSR Part 6, Decommissioning of Facilities, 2014
- IAEA Safety Guide WS-G-2.1, Decommissioning of Nuclear Power Plants and Research Reactors, 1999
- IAEA Safety Service No 25, Guidelines for the Review of Research Reactor Safety: Revised Edition 2013
- Decommissioning plan of HFR-2010
- HFR Safety Report - Chapter 19 - Decommissioning
- JRC presentation on decommissioning planning

### **2. ISSUE CLARIFICATION AND OBSERVATIONS**

The 2011 INSARR mission provided a recommendation to clearly define the responsible organization for decommissioning of the HFR. In addition to the HFR operating personnel, two representatives from Joint Research Centre (JRC), the HFR owner, participated in the discussions of the present mission. The outcome of the discussions can be summarized as follows.

The JRC is the owner of the HFR and has ultimate responsibility for decommissioning the HFR, including site remediation. The NRG (the licensee) prepared a preliminary decommissioning plan in 2010, which included description of the facility, decommissioning strategy, and organizational considerations. This version of the plan was reviewed and approved by ANVS. The JRC independently developed a detailed decommissioning plan in 2012 through a specialist company (Siempelkamp), which covered technical details, cost, and final site use considerations. This decommissioning plan was not submitted to ANVS. The JRC is currently preparing an updated decommissioning plan with another company (Gas Natural Fenosa) and expects to complete the update in 2017. The updated plan will be sent for ANVS review and approval. The content of the 2012 and proposed 2017 decommissioning plans, as presented to the INSARR team, include the relevant information as per the IAEA Safety Standards for the preliminary decommissioning plan of the HFR. A separate, high-level decommissioning plan is also included in the HFR SAR. There is a need to improve the coordination between JRC and NRG on decommissioning planning. The HFR documents, such as the SAR, must contain or reference the latest version of the decommissioning plan. Future updates to the decommissioning plan will be made every five years and submitted to the ANVS for review and approval.

Preliminary cost estimates were made in the plan prepared by JRC. The updated 2017 decommissioning plan will additionally include the time and cost for the transition period between operation and decommissioning following permanent shutdown. The update will also analyze organizational options. The NRG is providing technical input to JRC in support of this update. While decommissioning is not anticipated in the near-term, a portion of the budget is currently available. The current decommissioning plan envisions immediate decommissioning. It is estimated that the transition period, which includes fuel cool-down, fuel removal, operational waste removal, and decommissioning license approval will take approximately four years.

After the transition period, decommissioning will occur over a four-year period. A decision has yet to be made whether the HFR site will be returned to a restricted use or unrestricted use condition. For an unrestricted use state, site remediation activities will be conducted over a 15-month period. The JRC and NRG are having ongoing discussions on the responsibilities of each organization during the transition period and decommissioning. The IAEA team emphasized that even if the decommissioning is carried out by an external specialist organization under the JRC control, it is necessary to involve appropriate level of HFR staff during each phase of decommissioning, as they possess the knowledge and information required for the safe decommissioning of the facility.

### 3. POSSIBLE SAFETY CONSEQUENCES

Lack of coordination and clear delineation of responsibilities in the preparation of the decommissioning plan between JRC and NRG could result in inadequate updates of the decommissioning plan during the lifetime of the HFR. Lack of staff with up-to-date facility knowledge could adversely impact the decommissioning with associated consequences such as delays and increased risks of radiological and industrial hazards.

### 4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observation and recommendation.

### 5. RECOMMENDATIONS/SUGGESTIONS/GOOD PRACTICES/COMMENTS

**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.

## APPENDIX 2: FOLLOW UP OF THE RECOMMENDATIONS OF THE 2011 INSARR



: The recommendation is not implemented, remains valid and should be implemented (Open)



: Adequate actions has been taken and the recommendation is implemented and considered as (Closed)

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
SCL 01	Management system and safety culture	S1	It is suggested that a strategy be developed to utilise the positive sides of the existing safety cultural basic assumptions and avoid the negative effects. The relevant actions could be deployed to highlight the advantages and the negative effects that the basic assumptions may cause. These actions need to be implemented at different staffing levels, including top management, in order to develop and maintain vigilance in the everyday work.	The intent of the suggestion was not adequately clear to the counterpart, see Issue Page SCL01 which provides detailed information.	Suggestion is considered as closed See Issue Page SCL 01
RMG 01	Need to improve the organization chart for HFR operation	R1	All the functions of the radiation protection group must be independent of the reactor operation. The health physicist assigned to the facility should be independent of the reactor operation organisation and the Business Unit. It is therefore suggested that the radiation protection officer assigned to the facility reports to the head of radiation protection at NRG.	Several improvements have been introduced. However, there are actions still to be finalized to improve safety supervision of the reactor operation (see Issue Page RMG 01)	Partially implemented



Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
RMG 01		S1	It is suggested that a formal procedure is established to define the internal flow of safety related documents before sending to the regulatory body.	Procedure has been established for internal flow of documents including quality checks before submission to the regulatory body.	Closed
RMG 01		S2	It is suggested that the Reactor Manager issues an annual report on the operation of the reactor. This report needs to be submitted to the reactor safety committee for review and to the regulatory body for information.	Reactor operating cycle reports are sent to the safety committees and regulatory body which meets the objective of the recommendation.	Closed
SC 01	Terms of Reference of the Safety Committees	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.	A draft adaption of the terms of reference (TOR) of the RSC has been made. Rules and regulations of the RSC have been updated. It is not yet formally issued.	Partially implemented, Open
SC 01		S1	It is suggested to modify the terms of reference for the ISET so that it also includes review of the SVC operation.	Terms of Reference for ISET have been modified to include review of SVC.	Closed
TRQ 01	Need for establishing a formal training programme for the maintenance staff and improving the retraining programme	R1	A formal training programme, following the IAEA Safety Standards (NS-G-4.2 and NS-G-4.5) should be established and implemented for the reactor maintenance staff.	Training programme for maintenance staff has been established and implemented.	Closed

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
		S1	For further enhancement of the initial training programme of the reactor operators, it is suggested that nuclear safety and safety culture topics be included in the syllabus. It is also suggested to extend the retraining programme to cover the operating experience feedback from the reactor and other reactor facilities, procedures that are not frequently performed, changes to the reactor systems and documents, and selected topics from the initial training programme.	Training programme for reactor operators has been revised and includes recommended topics of nuclear safety and safety culture in the syllabus, as well as other suggestions.	Closed
RSV 01	Need for improvement of the regulatory inspection	R1	The regulatory inspection process should be improved. The content of the regulatory inspection reports should be improved to include recommendations with associated schedule for their implementation. A follow-up on the implementation of the inspection recommendations should be performed. The regulatory body should also verify the implementation of the recommendations of the IAEA safety review missions	Counterpart response: Changes in the regulatory oversight processes are an area of continuous development in recent years. A major development was the founding of an independent comprehensive nuclear regulator (ANVS).	Recommendation is not relevant to the present INSARR as regulatory supervision was not covered.
RSV 02	Need for establishing criteria for safety categorization for experiments	R2	Criteria for safety categorization of experiments, and for regulatory review and assessment of experiments with safety significance (including those involve irradiation of fissile material) should be established by the regulatory body based on discussions with the operating organization.	Counterparts response: Categorization process based on the IAEA Safety Standards Series: SSG-24 ‘Safety in the modification and utilization for research reactors’ has been established and implemented.	Closed

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
SAR 01	Inadequate analysis of accidents involving reactor core fuel with radiological consequences, and improvement to the technical content of the SAR	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	The counterparts mentioned that: A project on upgrading the HFR Safety Analysis Report addresses issue of SAR-01 R1. This project needs input from the PSA Level 1, 2 and 3 and will be started after completion of those projects. Project delivery is due for end of 2017.	Open The recommendation is valid and should be implemented.
		R2	The HFR should establish a list of the SSCs important to safety with the associated seismic and quality requirements.	Counterparts mentioned that the issue is addressed in the project HFR Design Rules. The project scope is split into two parts: setting up a consistent classification of the safety relevant SSCs of the HFR according to IAEA Safety Standards Series No. SSG-30 (phase 1) and subsequently setting up a comprehensive system of design rules (including codes and standards) (phase 2). The draft reports of Phase 1 have been completed by the (internal) supplier and submitted for review to the HFR. The work on Phase 2 has not yet been started. Project delivery is due for end of end of Q1 2017.	On-going, Open

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
SAR 02	Conduct of the HFR Periodic Safety Review (PSR)	R3	The scope of the planned PSR should include, inter alia, assessment of the physical status of the SSCs important to safety and definition of their remaining service life, analysis of the external events and implementation of the relevant IAEA recommendations, updating of the SAR and safety documents, and analysis of the abnormal events and operating experience feedback. The results of the PSR should form the basis for the continuation of the operation of the reactor and for its upgrading.	PSR has been completed based on the IAEA Safety Standards Series No. SSG-25 “Periodic Safety Review for Nuclear power Plants” using a graded approach and the recommended items were covered.	Closed
OLC 01	Improvements to the OLCs	R1	The OLCs should clearly state that the shift supervisor has the authority to shut down the reactor for any safety reason without contacting the Reactor Manager. The OLCs should also clearly require reporting of violation of the OLCs to the regulatory body.	OLCs have been modified to include recommended actions.	Closed

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
EVT 01	Siting and Protection against external hazards	R1	There is an urgent need to complete the site characterisation work in compliance with the latest requirements and recommendations established in IAEA safety related standards. It is therefore recommended to systematically consider all external hazards, screen and evaluate the remaining external events for determining the design bases parameters by considering updated database, applicable methods, new requirements and annual probability of exceedance values established for different external hazards	Site characterisation work is completed	Closed
		R2	Coastal flooding (considering different phenomenon/sources of tsunamis, combination of extreme flooding events with ambient conditions), presence of unconfirmed active faults in the near regional area, liquefaction of loose saturated sandy soil, behaviour of safety related SSCs in case of an earthquake and internal flooding in case of intense precipitation are the critical issues for the site and should be addressed as priority.	Necessary assessment for recommended hazards including coastal flooding has been completed.	Closed

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
		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.	The meteorological data collection is in progress.	The implementation of this recommendation is of an ongoing nature, Open
		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	Data collection is in progress.	The implementation of this recommendation is of an ongoing nature, Open
EVT 02	Improvement to the seismic design	R5	There is an urgent need to complete the site characterisation work in compliance with the latest requirements and recommendations established in IAEA safety related standards. It is therefore recommended to perform the seismo-tectonic studies by following the guidelines of the IAEA Safety Guide SSG-9 and using the generated seismic input for the analysis of safety related SSCs.	Site specific response spectra have been generated following the IAEA Safety Standards Series No. SSG-9, and submitted to the regulatory body.	Closed

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
		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.	Soil structure interaction effects have been considered, Floor response spectra will be used for seismic qualification of the SSCs. Alternate method to address the issue of shear modulus and damping is being considered.	Partially completed. Work is continuing to fulfil the recommendation, Open
		R7	A detailed walk down all safety structures should be conducted to evaluate all anchorages and potential interactions effects; many non-safety items were found to be unanchored and could thus damage a safety system/component during a seismic event.	Walk down has been completed and resulting actions have not yet started.	Partially implemented, actions on-going See also Issue Page EVT:01
		R8	Seismic instrumentation should be installed to receive a notification in the control room and scram the reactor at 0.05g.	Upon further discussions during the INSARR mission, the Counterparts agreed to implement the recommendation.	Open

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
COP 01	Inadequate procedures for the operator's response to the anticipated operational occurrences and incident conditions	R1	Procedures should be established for the operator's response to the anticipated operational occurrences and incident situation. The procedures should cover all the anticipated operational occurrences and incidents postulated by the design, including the loss of off-site power supply, fire inside the reactor building, and external events. The procedures should be simple, clear and include step-by-step instructions aimed at achieving the basic safety functions in all conditions.	Operating procedures have been reviewed and the recommended procedures have been established and implemented.	Closed
COP 02	Improvements of protection against LOCA and natural convection valves	R2	The status of the natural convection valves should be monitored and displayed in the reactor control room	System of natural convection valves has been modified to operate the valves remotely and monitor the status of the valves.	Closed



Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
		R3	In order to maintain the function of second barrier for the primary coolant system, it is recommended to install, based on a detailed safety analysis, an isolation valve on the primary cooling piping before its crossing of the wall of the reactor building. It is also recommended to consider the installation of isolation valves at the inlet and outlet of the primary cooling circuit close to the pool walls (outside the concrete shielding) in order to minimize the quantity of water drainage in case of rupture of the primary cooling pipes.	The Counterparts stated that installation of additional valves could introduce additional risks. Further discussions were held on this recommendation to explain the objective of the recommendation (to prevent uncovering of the core). The counterparts were encouraged to explore alternate means to meet the objective of the recommendation (See also the recommendations of this INSARR mission).	The issue is considered closed in view of the discussions held in the current INSARR mission.

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
COP 03	Observations from the facility walk-through	R4	The fire hazard analysis should be updated and, accordingly, the different areas within the reactor building should be equipped with fire detectors. The results of the updated fire hazard analysis should define the actions to be taken concerning the operation of the reactor ventilation system in case of fire with the associated justification.	<p>Fire hazard analysis is completed.</p> <p>The counterparts stated that project HFR PSA Level 1 addresses the issue. The project scope concerns upgrading of the existing Risk Scoping Study HFR to a full-scope PSA Level 1 including fire. The PSA Level 1 model of the HFR has been completed by the (internal) supplier. The reports documenting the model are now in their final review by the HFR. After completion of the review, the PSA model will be submitted to the internal safety committees (HSC, RSC) and subsequently will be discussed with the ANVS.</p>	Closed

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
		S1	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.	<p>Action in progress.</p> <p>The feasibility of a plan for posting warnings indicating the types of risk have been established. A new posting format for every room has been drafted and is currently in the implementation phase. Next to that a dedicated radiation map of the HFR has been drafted so that average radiation levels for every area are known. In this way deviations can easily be detected and appropriate measures can be taken. The issue will be formally closed in Q4 2016 when all postings have been renewed.</p>	The implementation of this recommendation is of an ongoing nature. Partially implemented - Open
		S2	It is suggested to remove from service all the non-used alarm indications.	<p>As follow-up to this issue, an inventory of all alarm indications in the control room was made and alarm indications not in use were subsequently removed.</p> <p>Moreover, instructions for removing not-used alarm indications were included in modification and maintenance plans.</p>	Closed

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
		S3	It is suggested to install leakage detectors for the pumps at the valve station, and to cover by a layer of epoxy the channel draining leaked water in this area.	Leak detectors at the valve station have been installed and epoxy coating on the channel for drainage of leaked water has been completed.	Closed
MPT 01	Need to ensure the leak tightness of reactor pool	R1	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.	A system for continuous monitoring of reactor pool leakage rate has been made operational and was subsequently transferred to the HFR organisation. Measures to limit the water leakage rate have not been successful to date, as demonstrated by an unexpected increase of the leakage rate of pool 1 recently. This is currently under investigation.	Open - See also Issue Page MPT 02
		R2	The door of the control rod drive mechanisms should be made water leak-tight.	Further discussions have been held during 2016 mission and actions were agreed to implement the objective of the recommendations See Issue Page SA 01	Closed - see also Issue Page SA 01

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
		S1	With respect to the determination of the leakage rate of the reactor pool it is suggested to block the water evaporation from the pool by using the existing plastic cover and by monitoring the change of the water level during an adequate period of time. The determination of the leakage rate will allow better detection of possible evolution of the leakage. In a second step, it is suggested to cover, at the occasion of a long shutdown period for maintenance, the suspected singular zones in the pool liner by a resin epoxy	Further discussions have been held during 2016 mission and actions were agreed to implement the objective of the recommendations See Issue Page MPT01	Open - see also Issue Page MPT02
MOD 01	HFR modification projects	R1	A safety assessment should be performed for the uncompleted projects tacking into consideration the effect of the completed ones in order to prioritize the implementation of the projects with respect to their contribution to enhance the reactor safety.	The recommendation was made in the light of several uncompleted modifications projects at the time of INSARR 2011 mission. Subsequently projects have been prioritized and completed to the possible extent.	In view of the actions taken, the issue is considered closed.
		S1	It is suggested to consider the use of a dry transfer system and lighter transfer container inside the reactor hall as an alternative to the existing design concerning the handling of heavy loads inside the reactor hall.	Heavy load drop assessment has been completed to address the issue. Modifications to install a protection cover for spent fuel storage and a shock absorber in the cask handling area are being implemented	The objectives of the suggestion have been met and the issue is considered closed.

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
BPL 01	Successful repair of the BPL	R1	Considering the results of the radioactivity measurements of samples from the wells which showed the presence of traces from tritium in the underground water, it is recommended to drill another well as close as possible to the reactor building. It is also recommended to improve the validity of activity measurements and check that it is not due to water pool leakage to the environment.	Recommendations are implemented. 200 wells were drilled on the reactor site to monitor tritium in the ground water.	Closed
RPR 01	Improvements to the operational radiological protection programme	R1	The adequacy of the radiation fixed area monitors should be checked with the aim to cover all the reactor areas with potential radiation hazards	The recommendation was considered and an analysis was made to check the adequacy and coverage of the fixed area radiation monitors. The analysis concluded that present area radiation monitors are adequate but additional temporary area monitors are needed during reactor stop periods.	Closed- See also Issue Page RPR 01
		R2	Procedures for decontamination of the personnel, surfaces and areas should be established and implemented	Procedures have been implemented	Closed
		S1	It is suggested to explore the possibility of reducing the Ar-41 releases through the reactor stack.	No action has been taken and the suggestion remains valid	Open

Ref.	Review Area		Description of recommendation/suggestion	Follow-up	Progress/Status
EMR 01	Improvements of the emergency planning and preparedness	R1	The emergency classification system should include HFR building emergency. The conditions (e.g. dose rate, contamination values) for declaring different classes of emergency (building, site, and off-site emergency) should be established. The required radiological measurements at different phases of an emergency should be established.	Significant actions have been taken and the recommendation is in the final implementation stage and expected to be completed by 2016.	Closed
DEC 01	Non-clear responsibility for decommissioning of the HFR	R1	VROM-KFD should decide as soon as possible which organization is responsible for the HFR decommissioning. According to the IAEA Safety Standards, the operating organization should continue updating the decommissioning plan even if the decision by VROM-KFD is not yet taken	It was decided that JRC is responsible for decommissioning of the HFR.	Closed - See also Issue Page DEC 01

## **ANNEX I: LIST OF DOCUMENTS FOR THE HFR 2016 INSARR MISSION**

- a. Policy statement - Vision of Safety
- b. Policy on Nuclear Safety – 2015
- c. Policy statement - Occupational Safety and Health-2015
- d. Policy statement - Quality policy statement
- e. Policy statement on preparedness for emergency situations – 2015
- f. NRG management processes – 2015
- g. NRG Risk Matrix
- h. NRG Asset Management policy – 2013
- i. Table of Content- Risk Management Modifications Nuclear Facilities
- j. Education and training manual Maintenance staff – Version 1, 2016
- k. Rules and Regulations of the Petten Reactor Safety Committee, 2007
- l. Safety Culture Programme Overview, 2016
- m. Safety Performance Indicator – HFR Dashboard, 2016
- n. Function Restoration Procedures -2014
- o. HFR Safety Report – 2003
- p. Deterministic Safety Analyses HFR – 2003
- q. Complementary Safety Margin Assessment – 2012
- r. HFR PSA - 2016
- s. Overview operating instructions
- t. HFR Pre operation check-out procedures 2016
- u. Table of content of Technical Specifications HFR – 2015
- v. Ageing Management review summary report
- w. Table of content - HFR Periodic Safety review 2014
- x. Preventive Maintenance Program (E.I.S.) - Index of E.I.S.- Maintenance Documents, 2014
- y. Maintenance Program - Index of M.S.-Maintenance Documents – 2015
- z. Education and training manual operator staff-2016
- aa. Table of content of HFR Emergency Procedures
- bb. Decommissioning plan for HFR-2010

### **Presentations:**

- i. General presentation HFR
- ii. HFR deterministic safety analyses
- iii. HFR Safety Committee
- iv. HFR: Training & Qualification
- v. HFR: Conduct of operations
- vi. HFR: Maintenance, periodic testing and inspection, ageing management
- vii. NRG: Safety Culture



- viii. HFR: Siting & protection against external hazards
- ix. HFR: Radioactive waste management programme
- x. Modifications within nuclear operations
- xi. Major modifications HFR
- xii. PSA HFR
- xiii. HFR Deterministic safety analyses
- xiv. Operational Limits and Conditions HFR
- xv. Emergency planning
- xvi. Future Decommissioning of the HFR Petten

## ANNEX II: AGENDA

*Note: Some sessions started with a presentation from the Counterparts on the relevant review area. This presentation was also considered for the review process.*

Additional remarks: NRG counterparts in **red**, NRG key responsible marked with (kr)

MONDAY 3 October 2016 – IAEA Team at the Hotel		
18:30-19:00	INSARR Methodology: Structure, Reporting, General Guidance on the conduct of the mission (Shokr)	
19:00-20:30	Preliminary comments from available documents (10 minutes for each review team member)	
TUESDAY 4 October 2016		
09:00-10:00	Entry meeting: Opening address: NRG, IAEA and ANVS ANVS participants: S. de Koff, A. van Limborgh and R. Schipper. NRG: N. Unger, H. Buurlage, M. Janssen, R. Huiskamp, J. Offerein, O. Wouters, R. Ruiterman, J. Best, S. Kamer, R. van der Stad	
10:00-10:30	Presentation - General description of the HFR (JF Offerein)	
10:30-10:45	Coffee break, INSARR 4440, Joke Licht.	
10:45-13:00	<ul style="list-style-type: none"><li>Operating organization and reactor management IAEA: All (led by Shokr) NRG: J. Offerein (kr), R. Ruiterman, O. Wouters, S. Kamer</li><li>Safety committee(s) IAEA: All (led by Shokr) NRG: Klaas Bakker en/of Y. Stockmann (kr)(RSC), S. Kamer (kr)(HSC), J. Offerein, O. Wouters</li><li>Training and qualification IAEA (led by Shokr) NRG: J. Offerein (kr), R. Ruiterman, D. Vonk,</li></ul>	
13:00-14:00	Lunch break	
14:00-14:15	Preparation for the walkthrough 2-3 Groups led by: O. Wouters, J. Offerein and R. Ruiterman. 9 IAEA, 3 ANVS, 12, 2 group of 6.	
14:15-16:30	HFR plant walk down	
16:30 – 17:00	IAEA Team meeting	Evaluation meeting (HFR core team)

WEDNESDAY 5 October 2016				
09:00-09:30	Briefing the main counterpart (Shokr), Participant ANVS <a href="#">R. Schipper</a>			
09:30-12:30	<b>Conduct of operations (1)</b> Presentation NRG  IAEA: Koos + Abou Yehia  NRG: <a href="#">R. Ruiterman</a> (kr), <a href="#">D. Vonk</a> , <a href="#">E. Hartsink</a>	<b>Maintenance, periodic testing and inspection, including ageing management activities (1)</b> Presentation NRG IAEA: Rao + Tibor + Basu <a href="#">ANVS: R. Schipper</a> NRG: ( <a href="#">R. Ruiterman</a> (kr)), <a href="#">B. Pronk</a> , <a href="#">M.J. Janssen</a> , <a href="#">M. van Dijke</a>	<b>Radiation protection (1)</b> Presentation NRG  IAEA: Nestor + Steven  NRG: <a href="#">F. Draaisma</a> , <a href="#">C. van Wijk</a> (kr).	<b>Safety culture (1)</b> 09:30-11:00 <i>Safety culture experts</i> Presentation NRG IAEA: <a href="#">Diana Engstrom</a> <a href="#">ANVS: M. Steenhuisen</a> NRG: <a href="#">J. Offerein</a> (kr), <a href="#">M. Janssen</a> , <a href="#">O. Wouters</a>
				11:15-12:30 <i>Management system expert</i> NRG: <a href="#">N. Jablonowski</a> , <a href="#">J. Offerein</a> , <a href="#">M. Koenen</a> , <a href="#">M. Janssen</a>
12:30-13:30	Lunch break			
13:30-16:30	<b>Siting and protection against external hazards (1)</b> Presentation NRG  IAEA: Basu + Abou Yehia <a href="#">ANVS: G. Delfini</a>  NRG: <a href="#">O. Wouters</a> (kr), <a href="#">H. Brinkman</a>	<b>Maintenance, periodic testing and inspection, including ageing management activities (2)</b>  IAEA: Rao + Koos <a href="#">ANVS: R. Schipper</a>  NRG: <a href="#">R. Ruiterman</a> (kr), <a href="#">B. Pronk</a> , <a href="#">M.J. Janssen</a> , <a href="#">M. van Dijke</a>	<b>Radioactive waste management (1)</b> Presentation  IAEA: Nestor + Tibor + Steven <a href="#">ANVS: M. van Bourgondiën</a>  NRG: <a href="#">C. van Wijk</a> (kr), <a href="#">A. Pater</a>	<b>Safety culture (2) 13.30-14.30</b> IAEA: <a href="#">Diana Engstrom</a> <a href="#">ANVS: M. Steenhuisen</a> <i>Resources, rewards and sanctions</i> NRG: (HR), <a href="#">M Janssen</a> , <a href="#">J. Offerein</a>
				14.45-15.30 NRG: <i>In/external safety- and/or safety culture assessment</i> <a href="#">M. Jansen</a> , <a href="#">J. Offerein</a> , <a href="#">M. Koenen</a> ,
				15.30-16.30 NRG: <i>Leadership development</i> <a href="#">J. Offerein</a> , <a href="#">M. Janssen</a> , <a href="#">L. du Rieu</a> , <a href="#">B. Dolle</a> ( <a href="#">D. Reus</a> ),
16:30-17:30	IAEA Team meeting		Evaluation meeting (HFR core team)	
THURSDAY 6 October 2016				

<b>09:00-09:30</b>	Briefing the main counterpart (Shokr), Participants ANVS: <a href="#">G. Auwerda</a> , <a href="#">M. Steenhuisen</a>	
<b>09:30-11:00</b>	<b>Utilization and experiments (1)</b> Presentation NRG MOC (pr) IAEA All (led by Tibor) ANVS: <a href="#">G. Auwerda</a> NRG: <a href="#">S. Kamer (kr)</a> , <a href="#">J. Best</a> , <a href="#">D. Boomstra en/of A. de Koning</a> , <a href="#">H van Koningsbruggen</a> , <a href="#">R. Telling</a>	<b>Safety culture (3)</b> 9:30-10:30 IAEA: Diana Engstrom ANVS: <a href="#">M. Steenhuisen</a> <i>Training and Qualification expert</i> NRG: <a href="#">R. Ruiterman</a> , <a href="#">D. Vonk</a> , <a href="#">A. van der Zanden</a>
<b>11:15-13:00</b>	<b>Major modifications (1)</b> <ul style="list-style-type: none"> <li>- Presentation Hall Crane</li> <li>- Presentation Ventilation Control Room</li> <li>- Presentation on shock absorbing floor</li> </ul> NRG: <a href="#">J. Offerein</a> , <a href="#">O. Wouters (kr)</a> , <a href="#">J. Best</a> , <a href="#">V. Wichers</a> , <a href="#">H. Bouwhuis</a> , <a href="#">R. van Duijn</a> , <a href="#">N. Bosker</a>	10:45-12:30 <i>The person(s) in charge of observations, reporting...</i>  NRG: <a href="#">M. Koenen</a> , <a href="#">M. Janssen (MARS)</a> , <a href="#">J. Biesheuvel</a> , ( <a href="#">M. Droog</a> )
<b>13:00-14:00</b>	Lunch break	
<b>14:00- 17:00</b>	<b>Safety analysis (1)</b> Presentation on PSA HFR  IAEA: All (led by Abou Yehia) ANVS: <a href="#">G. Auwerda</a>  NRG: <a href="#">O. Wouters (kr)</a> , <a href="#">M. Sloodman (pr)</a> , <a href="#">R. van der Stad</a> , <a href="#">J. Offerein</a> , <a href="#">H. Brinkman</a>	<b>Safety culture (4)</b> 13:30-14:30 IAEA: Diana Engstrom ANVS: <a href="#">M. Steenhuisen</a> <i>Operation or maintenance</i> NRG: <a href="#">R. Ruiterman (kr)</a> Randomly chosen staff, Ploeg(en) op. 14:30-15:15 Third party NRG: Randomly chosen contractor. <a href="#">J. Bol</a> , Project hekwerk. <a href="#">T. Maas</a> 15:30-16:30 <i>Major project staff member</i> NRG: Randomly chosen staff member ( <a href="#">Hans Bouwhuis</a> , <a href="#">Niels Bosker</a> , <a href="#">René van Duijn</a> , <a href="#">Victor Wichers</a> )
<b>17:00</b>	Transfer to the Hotel	Evaluation meeting (HFR core team)
<b>FRIDAY 7 October 2016</b>		

09:00-09:30	Briefing the main counterpart (Shokr), Participants ANVS: <a href="#">G. Auwerda</a>		
09:30-11:00	<b>Operational Limits and Conditions (1)</b> IAEA: All (led by Abou Yehia) <a href="#">ANVS: G. Auwerda</a> NRG: <a href="#">O. Wouters (kr)</a> , <a href="#">J. Best</a> , <a href="#">J. Offerein</a> , <a href="#">R. Ruiterman</a> ,		<b>Safety Culture</b> IAEA: Diana Engstrom <a href="#">ANVS: tbd</a>
11:00-12:30	<b>Emergency Planning (1)</b> Presentation NRG  IAEA: Nestor + Tibor + Abou Yehia + Basu  <a href="#">NRG: O. Wouters (kr)</a> , <a href="#">N. Jablonowski</a> , <a href="#">T. van Zanten</a> , <a href="#">J. van Dongen</a>	<b>Decommissioning plan (1)</b> Presentation (?)  IAEA: Rao + Koos+ Steven <a href="#">ANVS: G. Auwerda</a> <a href="#">NRG: M. Fuetterer (JRC)</a> , <a href="#">J. Offerein (kr)</a> , <a href="#">R. van der Stad</a>	NRG: tbd
12:30-13:30	Lunch break		
13:30-16:30	<b>Follow-up on the status of the implementation of the 2011 INSARR mission</b> IAEA: All (led by Rao) <a href="#">ANVS: R. Schipper</a>  NRG: <a href="#">V. Wichers</a> , <a href="#">O. Wouters (pr)</a> <a href="#">J. Offerein (kr)</a> , <a href="#">R. Ruiterman</a>		<b>Safety Culture</b> IAEA: Diana Engström <a href="#">ANVS: tbd</a> NRG: tbd
16:30-17:00	IAEA Team meeting		Evaluation meeting (HFR core team)
SATURDAY 8 October 2016– IAEA Team at the Hotel			
09:30-12:30	Development of issue pages (Team members)		
12:30-14:00	Lunch		
14:00-16:00	Discussion on issue pages (Team members)		
SUNDAY 9 October 2016 –Free day			

MONDAY 10 October 2016	
09:00-09:30	Meeting with DIR NSNI, IAEA team and counterparts (All)
09:30-10:30	<b>Management system for the operation phase(1)</b> Presentation NRG IAEA: All (led by Rao) ANVS: M. Steenhuisen or Y. Dubbers NRG: R. Ruiterman (kr), E. Hartsink , N. Jablonowski, M. Koenen
10:30-11:30	<b>Siting and protection against external hazards (2)</b> Presentation NRG IAEA: All (led by Basu) ANVS: G. Delfini (optional) NRG: O. Wouters(kr), S. van den Boogaart, H. Brinkman
11:30-12:30	<b>Safety Culture (5)</b> IAEA: All (led by Diana) ANVS: Margreet Steenhuisen of Yvonne Dubbers NRG: program/interviews tbd
12:30-13:30	Lunch
13:30-15:00	<b>General comments on the safety analysis report (2)</b> IAEA: All (led by Shokr) ANVS: G. Auwerda NRG: O. Wouters (kr), M. Sloodman, R. van der Stad, J. Offerein, R. Ruiterman, H. Brinkman
15:00-17:00	Drafting of the mission executive summary report (IAEA Team)
TUESDAY 11 October 2016	
09:00- 11:00	Finalization of the mission executive summary report (IAEA Team)
11:00- 13:00	Exit Meeting: Mission conclusions and main recommendations (All) ANVS: S. de Koff, A. van Limborgh, R. Schipper NRG: J. Offerein, O. Wouters, R. Ruiterman, R. van der Stad, R. Huiskamp, M. Janssen, J. Best, S. Kamer, L. du Rieu, N. Unger

### **ANNEX III: LIST OF PARTICIPANTS OF THE 2016 INSARR**

#### **NRG**

N. Unger, Managing Director (NRG)  
H. Buurlage, Operational Director (NRG)  
L. du Rieu, Business Unit Manager Nuclear Operations  
J. Offerein, Reactor Manager HFR  
O. Wouters, Manager Nuclear Safety  
R. van der Stad, Manager Licensing Nuclear Operations (NO)  
R. Ruiterman, Manager Operations  
J. Best, Team leader Engineering  
S. Kamer, Manager Engineering, Chairman HSC  
M. Janssen, Manager Quality Health Safety and Environment (QHSE)  
R. Huiskamp, Policy Expert Nuclear Safety (QHSE)  
F. Draaisma, Chief Radiation Protection Expert (NRG)  
B. Pronk, Section Head Electrical and Instrumentation Support  
M. Janssen, Section Head Mechanical Support  
M. van Dijke, Section Head Electronical Support  
E. Hartsink, Supervisor, Operational support office  
D. Vonk, Shift Supervisor  
C. van Wijk, Local Radiation Protection Officer  
A. Pater, Shift Supervisor  
J. Biesheuvel, Health Safety and Environment  
M. Koenen, Quality Assurance HFR, Leader VIP Safety Culture Surveillance Project  
N. Jablonowski, Quality insurance HFR, Coordinator Site Emergency Program  
K. Bakker, Vice Chairman, RSC  
D. Boomstra, Engineer (Experiment)  
A. de Koning, Engineer (Experiment)  
H van Koningsbruggen, Experiment Coordinator  
R. Tellinga, Engineer (Coordinator, Management of Change)  
H. Bouwhuis, Engineer from Business Unit Consultancy and Services  
R. van Duijn, Engineer from Business Unit Consultancy and Services  
N. Bosker, Engineer from Business Unit Consultancy and Services  
H. Brinkman, Nuclear Consultant from Business Unit Safety and Power  
M. Sloodman, Nuclear Consultant from Business Unit Safety and Power  
E. Brinkman, Former Manager Human Resources

## **JRC**

L. Debarberis, Senior Expert Nuclear Energy and Technologies  
M. Fütterer, HFR Liaison Officer  
M. Noël, Nuclear Programme Coordinator  
Y. Stockmann, Chairman Reactor Safety Committee (RSC)

## **ANVS Counterparts**

R. Schipper, Inspector ANVS  
M. van Bourgondiën, Expert ANVS  
G. Auwerda, Expert ANVS  
M. Steenhuisen, Expert ANVS  
Y. Dubbers, Expert ANVS  
S. de Koff, Section Leader ANVS  
A. van Limborgh, Director ANVS  
C. Janssen, Inspector ANVS

## **IAEA**

Greg Rzentkowski	DIR-NSNI/IAEA (10 - 11 October 2016)
Amgad M. Shokr	(NSNI/IAEA - Team leader)
Deshraju Rao	(NSNI/IAEA - Deputy Team Leader)
Diana Engstrom	(NSNI/IAEA)
Hassan Abou Yehia	(France)
Tibor Hargitai	(Hungary)
Prabir Basu	(India)
Nestor De Lorenzo	(Argentina)
Koos DuBruyn	(South Africa)
Steven Lynch	(United States of America)