IAEA-NSNI/INSARR
ORIGINAL: ENGLISH

IAEA
International Atomic Energy Agency

REPORT OF THE

INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (INSARR) MISSION

TO THE HOGER ONDERWIJS REACTOR (HOR)

Delft University of Technology

Delft, the Netherlands
7-14 September 2021

INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (INSARR)

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
Division of Nuclear Installation Safety

INTERNATIONAL ATOMIC ENERGY AGENCY

Mission Date:	7-14 September 2021	
Location:	Delft, the Netherlands	
Facility:	Hoger Onderwijs Reactor (HOR)	
Organized by:	IAEA at the request of the Authority for Nuclear Safety and Radiation Protection (ANVS), the Netherlands	
Conducted by:	Mr D. Sears	RRSS/NSNI – Team Leader
	Mr K. Sun	RRSS/NSNI – Deputy Team Leader
	Ms C. Pike	OSS/NSNI – Nuclear Safety Officer
	Mr N. De Lorenzo	Argentina
	Mr F. Joppen	Belgium
	Mr V. Juricek	Czech Republic
	Mr A. Stritar	Slovenia

EXECUTIVE SUMMARY

The objective of the INSARR mission was to review the safety of the Hoger Onderwijs Reactor (HOR), covering regulatory supervision, operating organization and reactor management, safety committee, training and qualification, safety analysis, operational limits and conditions, management system, conduct of operations, maintenance, periodic testing and inspection, safety of modifications, safety of utilization and experiments, radiation protection, radioactive waste management, emergency planning, planning of decommissioning, and safety culture. The review was performed following the methodology established by the IAEA Guidelines for Research Reactor Safety Review (INSARR Guidelines, 2013 Edition), which are based on the IAEA safety standards.

The mission team comprised three IAEA staff members: Mr D. Sears (IAEA Team Leader, Research Reactor Safety Section (RRSS), Mr K. Sun (Deputy Team Leader, IAEA RRSS), and Ms C. Pike (Safety Culture Specialist, IAEA OSS), and four international experts: Mr N. De Lorenzo (Argentina), Mr F. Joppen (Belgium), Mr V. Juricek (Czech Republic), and Mr A. Stritar (Slovenia). The main technical counterparts were Mr H. Th (Bert) Wolterbeek, Director of Reactor Institute Delft (RID) and HOR Reactor Manager, and Mr C. Kaaijk, Head of HOR Development. The conduct of the mission included the examination and assessment of the reactor safety and technical documentation, a walkthrough of the reactor facility and discussions with senior managers and technical personnel of the HOR reactor. The IAEA team provided an executive summary report in the exit meeting in the presence of Mr H.Th Wolterbeek, Director of RID with the participation of the RID and HOR management and technical staff, and the representatives of Authority for Nuclear Safety and Radiation Protection (ANVS), Mr J. Boom, Consultant International Affairs, Department of Strategy and Regulatory Affairs, Mr B. van der Heijdt, Department Head, Nuclear Installations and Transport, and Mr J. de Jong, Deputy Inspector RID-HOR. There was general agreement by the counterparts on the IAEA recommendations.

The team acknowledged the openness and transparency of the HOR management and technical staff and observed the significant work performed and the progress achieved in the modernization of the reactor's safety systems and components for continuous safety enhancement. The team also observed the establishment of a process for periodic safety review, which will further help with identification and implementation of safety upgrades of the reactor. The team noted the effectiveness of the interaction between ANVS and RID, including through formal and informal discussions aimed at explaining the basis for regulatory decisions concerning HOR reactor and at providing ANVS with opportunities to be timely informed on potential safety issues. Nevertheless, the team noted that there appeared to be a large amount of work remaining to be completed on the Oyster project, including completion of modifications, inspections, tests and other commissioning activities, and there may be a number of challenges to be overcome before the fuel is reloaded into the reactor core and the reactor operation is restarted. In this regard, the team highlighted the need to continue to follow good safety practices and promote a strong culture for safety so that safety is not compromised when meeting the currently planned project schedules and deadlines.

The team identified areas requiring improvement and provided recommendations and suggestions to address these areas for further safety improvements. These mainly covered safety management and organizational aspects, safety analysis and safety documents, and the operating programme and technical modifications to the facility.

The main recommendations and suggestions for improvements include:

- Strengthening the organizational structure for operation by clarifying roles and responsibilities for safety to avoid potential conflicts of roles and duties;
- Improving the programme for restart of the reactor operation after the prolonged shutdown period by retraining reactor operating personnel and updating reactor safety documents and operating procedures to reflect recent modifications;
- Enhancing ageing management by addressing obsolescence of systems and components and by using feedback from the reactor operation and safety assessment;
- Establishing a strong safety culture through an organizational approach to safety with effective communication of management expectations and by assigning a senior leadership role for the safety culture programme;
- Enhancing the functioning of the HOR safety committee by revising the safety documents to be submitted for review in accordance with the IAEA safety standards No. SSR-3, and by enhancing working procedures;
- Improving the reactor safety analysis by re-evaluating the fuel channel blockage event, and by identification (and inclusion of its description in the SAR) of the limiting event defining the maximum reactivity worth of fixed experiments, as well as updating, accordingly, the operating limits and conditions (OLCs);
- Establishing a formal process for safety categorization of new experiments, and subjecting those with major safety significance to routes of approval, safety assessment, and a process for design, installation, and testing in accordance with the IAEA safety standards No. SSG-24.
- Enhancing the operational radiation protection programme through improvements to work instructions and radiation monitoring practices.

The IAEA team recommended that the HOR management should establish a plan to implement the recommendations, which could be reviewed in a follow-up INSARR mission to be conducted in 2023.

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1. INTRODUCTION

1.1 BACKGROUND

Following a request from the Authority for Nuclear Safety and Radiation Protection (ANVS), the Dutch regulatory body, the IAEA conducted an Integrated Safety Assessment of Research Reactors (INSARR) mission to the Hoger Onderwijs Reactor (HOR) in the Delft University of Technology (TU Delft), the Netherlands, from 7 to 14 September 2021.

1.1.1 Short description and history of the facility

The HOR is an open pool-type research reactor, operated by the Reactor Institute Delft (RID) at TU Delft. The reactor uses low enriched MTR fuel. The core is composed of 16 fuel assemblies and 4 control assemblies, with 4 control rods. It is equipped on three sides with a row of beryllium reflector assemblies acting as neutron reflectors. The reactor provides neutron radiation to a variety of facilities for radioisotope production and neutron activation analysis. It is also equipped with six horizontal beam-tubes in two sets of three at opposite sides of the core, and a tangential beam tube, mainly used for neutron scattering experiments. The reactor is operated typically 4 to 5 days a week at 2.3 MW. The reactor achieved criticality for the first time in 1963 and went through several modifications and upgraded during its lifetime, including power upgrade to 3 MW (1967), conversion from highly enriched uranium to low enriched uranium fuel (2005), and refurbishment of the instrumentation and control system (2010).

In 2013, the RID started the Oyster project to design, construct and install a cold neutron source (CNS) in the HOR. The project includes the modification of the R1 and R2 beam tubes to accommodate a CNS. In 2020, the RID replaced the voting logic in the reactor protection system, the primary and secondary cooling system, and the cover plating on the reactor containment dome. The RID has applied for the approval of installation of the cold neutron source in two phases; phase 1 is the R2 extension tube installation and phase 2 is the in-pool assembly installation. This was approved by the ANVS. A revised commissioning plan for restart of the rector after the completion of phase 1 modifications was prepared in 2021. It was also approved by the ANVS. The following list contains the major modifications of the HOR reactor in recent years:

- Replacement of helium return isolation valve (2017);
- Construction of the CNS utility building (2017);
- Replacement of voting logic reactor protection system (2020);
- Installation of the CNS, including beam tube modification (2020);
- Modification of reactor hall penetration for installation of CNS (2020);
- Renovation of containment dome plating (2020);
- Replacement of the primary and secondary cooling systems (2020);
- Modification of feedthroughs for the reactor hall (2020);
- Installation of a seismic measure and registration system (2021);
- Installation of remote monitoring room (2021).

Periodic safety reviews (PSRs) were conducted in 1999 and in 2010; currently the third PSR is underway with expected completion by the end of 2021. The reactor operation license is valid for the facility lifetime and licensing conditions are subjected to review based on the results of PSRs. The licensing authority of the HOR is the ANVS.

1.1.2 Utilization programme

The HOR reactor is mainly utilized for:

- Neutron Physics (mainly use beam tubes for neutron scattering experiments);
- Radioisotope production (medical);
- Neutron activation analysis;
- Materials irradiation;
- Education and training.

The reactor is currently under a prolonged shutdown since May 2019, primarily due to the ongoing major modifications.

1.1.3 Previous IAEA missions

An INSARR mission to the HOR reactor was conducted in 2000. This mission resulted in five recommendations, such as on topics of SAR references and experimental approval process, and five suggestions, such as on topics of work permit system and QA programme.

A pre-INSARR Mission was conducted to the HOR reactor at the RID site during the period of 25-26 September 2018. The technical and organizational arrangements for the INSARR mission were agreed between the IAEA representatives and the HOR management during this mission.

1.2 OBJECTIVES AND SCOPE OF THE MISSION

The objective of the mission was to conduct a review of the safety of the HOR reactor against the IAEA safety standards, and to provide recommendations and suggestions for safety improvements.

1.2.1 Scope of the mission

During the Pre-INSARR meeting, it was agreed that the scope of the INSARR mission would cover the review of the following areas listed in the IAEA services series No.25:

- Regulatory supervision (REG);
- Operating organization and reactor management (RMG);
- Safety committee (SC);
- Training and qualification programme (TRQ);
- Safety analysis (SA);
- Operational limits and conditions (OLC);
- Management system (IMS);
- Conduct of operations (COP);
- Maintenance, periodic testing and inspection (MPTI);
- Safety of modifications (MOD);
- Safety of utilization and experiments (EXP);
- Radiation protection (RPR);
- Radioactive waste management (RWM);
- Emergency planning (EMR);
- Decommissioning (DECOM);
- Safety culture (SCL).

1.3 BASIS FOR THE ASSESSMENT

The basis for the safety review of HOR reactor is the IAEA Safety Standards. The following IAEA documents were used as the 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 Series No. GSR Part 2, Leadership and Management for Safety, (2016);
- IAEA Safety Standards Series No. GS-G-3.1, Application of the Management System for Facilities and Activities, (2006);
- IAEA Safety Standards Series No. GS-G-3.5, The Management System for Nuclear Installations, (2009);
- 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 Standards Series No. NS-G-4.2, Maintenance, Periodic Testing and Inspection for Research Reactors, (2006);
- IAEA Safety Standards Series No NS-G-4.3: Core Management and Fuel Handling for Research Reactors, (2008);
- IAEA Safety Standards Series No. NS-G-4.4, Operational Limits and Conditions and Operating Procedures for Research Reactors, (2008);
- IAEA Safety Standards Series No. NS-G-4.5, The Operating Organization and Recruitment, Training and Qualification for Research Reactor Personnel, (2008);
- IAEA Safety Standards Series No. NS-G-4.6, Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, (2008);
- IAEA Safety Standards Series No. SSG-10, Ageing Management for Research Reactors, (2010);
- IAEA Safety Standards Series No. SSG-37, Instrumentation and Control Systems and Software Important to Safety of Research Reactors, (2015);
- IAEA, Safety Reports Series No. 41, Safety of New and Existing Research Reactor Facilities in Relation to External Events, (2005);
- IAEA Safety Standards Series No. GSR Part 6: Decommissioning of Facilities, (2014);
- IAEA Safety Standards Series No. SSG-15: Storage of Spent Nuclear Fuel, (2012).

1.4 DOCUMENTS RECEIVED FROM THE COUNTERPARTS PRIOR TO AND DURING THE MISSION

The list of documents provided by the counterparts is included in ANNEX I.

1.5 CONDUCT OF THE MISSION

The mission was conducted during the period from 7-14 September 2021 in accordance with the Agenda provided in ANNEX II. During the mission, the reactor technical staff made several presentations which covered all review areas of the INSARR mission. These presentations provided an overview of the status of the reactor facility and its associated documentation and were followed by detailed discussions of the review areas. The IAEA team provided a summary report in the exit meeting with the Director of RID, the representatives of the ANVS, and the

HOR reactor management and technical staff. There was general agreement on the recommendations provided to the counterparts.

1.5.1 INSARR Team

The mission team comprised three IAEA staff members, Mr D. Sears (Senior Nuclear Safety Officer, Research Reactor Safety Section (RRSS) – Team Leader), Mr K. Sun (Nuclear Safety Officer, RRSS – Deputy Team Leader), and Ms C. Pike (Nuclear Safety Officer, Operational Safety Section (OSS)), and four international experts: Mr N. De Lorenzo (Argentina), Mr F. Joppen (Belgium), Mr V. Juricek (Czech Republic), and Mr A. Stritar (Slovenia). The main technical counterpart of the mission was Mr C. Kaaijk, Head of Development (HOR-O), RID). The list of participants is provided in ANNEX III.

1.5.2 Short description of the assessment method

The conduct of the mission included the following activities:

- Examination and assessment of the HOR reactor safety and operating documentation;
- Walkthrough of the HOR reactor and the associated facilities;
- Discussion with the HOR reactor management and operating personnel, and the RID managers and technical staff;
- Interviews with the RID and HOR staff for review of the safety culture programme;
- Discussion among the IAEA team members, and 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.

1.5.3 Review criteria

The INSARR review compares the observations and findings with the IAEA Safety Standards and practices found at other research reactors worldwide. The comparison may result in recommendations and suggestions presented to the operating organization by the team as a whole, in accordance with 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 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. They describe HOW to implement the recommendations. The suggestions are designated with the letter “S” in the mission report. The suggestions are numbered in the respective issue page as **S#**.

2. SUMMARY OF THE MAIN CONCLUSIONS AND RECOMMENDATIONS

The IAEA team appreciated the openness and transparency of the RID and HOR management and technical staff and their commitment for continuous safety improvements, as well as the competence of the staff and the quality of the discussions held during the mission.

The IAEA team noted the significant efforts exerted by the operating organization with respect to refurbishment and modernization of the reactor's safety systems and components for continuous safety enhancement. The team also observed the completion of safety reassessment following the lessons learned from the Fukushima-Daiichi accident and the establishment of a process for periodic safety review, which will further help identification and implementation of safety upgrades of the reactor.

The team noted the effectiveness of the interaction between ANVS and RID, including through formal and informal discussions aimed at explaining the basis for regulatory decisions concerning HOR reactor and at providing ANVS with opportunities to be timely informed on potential safety issues. This also provides RID with opportunities for identification and implementation of measures for continued safety improvements in accordance with the regulatory requirements. The team encouraged the continuation of this practice and highlighted its importance for safety during the process of restart of reactor operation after the prolonged shutdown.

The team observed the intensive work performed and the progress achieved in the implementation of the modification projects. Nevertheless, the team noted there appeared to be a large amount of work to be completed on the Oyster project, including completion of modifications, inspections, tests and other commissioning activities, and there may be a number of challenges to be overcome before the fuel is reloaded into the reactor core and the reactor operation is restarted. In this regard, the team highlighted the need to continue to follow good safety practices and promote a strong culture for safety so that safety is not compromised when meeting the currently planned project schedules and deadlines.

The IAEA team also identified areas requiring improvement. The activities of the mission resulted in recommendations and suggestions to address these areas for further safety improvements. These mainly covered safety management and organizational aspects, safety analysis and safety documents, and operating programmes and technical modifications of the facility, which are presented as follows.

Safety management and organizational aspects

- RID should establish, advocate, and adhere to an organizational approach to safety that establishes behavioural expectations, institutional and individual values, and the acceptance of personal accountability in relation to safety. In this regard, RID is recommended to:
  - o Develop a vision and strategy for defining, communicating, and monitoring safety culture;
  - o Assign a senior leadership role with defined responsibilities regarding safety culture programme, including communications of safety issues and continuous improvement.
- In view of the considered restructuring of the organization of HOR operation, adequate analysis should be performed (and measures taken accordingly), in accordance with approved procedures that supplement the existing TU Delft procedures on organizational changes, on safety implications of the proposed changes

including on roles and responsibilities for safety of positions in particular with respect to leadership and management for safety. The analysis should be subjected to review by the reactor safety committee and to ANVS review and assessment.

- The organization structure of the HOR operation should be improved by:
  - Establishing adequate measures and practical arrangements to ensure effective quality verification of the activities important to safety that are carried out by the reactor operators swapping their functions between operation and maintenance;
  - Ensuring the independence of the quality assurance function from the reactor management;
  - Formalizing the HOR safety committee position in the organizational structure, with a clear description of its role, function, and line of communications.
- The functioning of the HOR safety committee should be further improved by:
  - Revising the list of the safety documents to be submitted to the committee for review in accordance with the IAEA safety standards No. SSR-3;
  - Establishing working instructions for the committee, including procedures for dealing with situations where consensus is not achieved, and procedures to ensure effective follow-up on the implementation of the Committee's recommendations.

Safety analysis and safety documents

- The safety analysis should be further improved by re-evaluation of the fuel channel blockage event, particularly with respect to the validity of the computational tools and models used, and by identification (and inclusion of its description in SAR) of the limiting event defining the maximum reactivity worth of fixed experiments.
- Surveillance requirements and periodic testing (as part of the OLCs) that were waived during the reactor prolonged shutdown period should be re-established unless it is adequately justified based on a comprehensive safety analysis considering the status of the facility, documented, and subjected to review and approval of the regulatory body. New experiments and modifications as well as associated commissioning plans for restart of the reactor should be evaluated to reassess the need for improvements or changes to OLCs. The OLCs should constitute an envelope for which reactor safety parameters and SSCs conditions are demonstrated to be safe and that the site personnel and public are protected against radiation. These OLCs could be subjected to revision based on the commissioning of new experiments and modifications.
- The OLCs should be revised in accordance with the IAEA safety standards No. SSR-3 to include safety limits and safety system settings. As OLCs are included in a separate document, a summary of these OLCs should be included in the SAR with a reference to that separate document.
- Updating of the SAR, which is being performed by RID, should be taken as an opportunity to further improve its contents and comprehensive nature as the main document on the safety of the facility by including up-to-date information on modifications, integrating all necessary technical information (e.g., OLCs) and resolving any potential inconsistencies including with other facility's documentation. The SAR should be periodically updated to reflect modifications made to the facility and on the basis of experience and in accordance with regulatory requirements.

Operating programmes and technical modification of the facility

Training and qualification

- A training programme for the reactor operating personnel should be developed and implemented for restart HOR operation after the prolonged shutdown period. This programme should include items such as modifications and changes to the reactor systems and components, safety documents, procedures that are not frequently performed, selected topics from the initial training programme, and operating experience feedback from the reactor and other similar facilities.
- A formal re-qualification process should also be established, and implemented before restart of reactor operation, for operating personnel who have not performed their duties for long periods (suggested more than 6 months).

Operational radiation protection programme

- Assessment of the radiological hazards within the reactor building should be performed based on the facility's actual status. Adequate radiological protection measures (including workplace contamination monitoring) should be established accordingly. This includes assessment of the likelihood and magnitude of possible airborne releases, and investigation of the need for installation of charcoal filtering system for protection of reactor personnel as well as the environment.
- The system for area classification and zoning from radiological protection should be revised in accordance with the IAEA safety standards No. SSR-3 and NS-G-4.6, considering the requirements for research reactors and taking into consideration the laboratories within the reactor premises.

Conduct of operations

- RID should consider improving the process of information flow between all levels of management so that the reactor manager would be in position to fully carry out his responsibility for safety. In particular, the reactor manager should ensure adequate checks and verification during the refuelling process and that the safety parameters of the newly assembled core configurations are verified in accordance with the OLCs.
- Operating procedures and work instructions, including for radiological protection, should be revised to account for the modifications and to be consistent with the actual status of the facility.

Maintenance programme

- A work permit system should be established in accordance with the IAEA safety standards No. NS-G-4.2. This system should be used to improve record keeping in order to facilitate operating experience feedback and trending of maintenance, periodic testing, inspection, and ageing management.
- The results of the probabilistic safety assessment, including the risk importance factors of SSCs, should be utilized for further improvement of the maintenance, periodic testing and inspection programme as well as for ageing management.

Ageing management

- Ageing management programme should be further improved by covering obsolescence of SSCs, identification of degradation mitigatory measures, and establishment of a process for managing spare parts for systems and components important to safety.

Safety of utilization and experiments

- A formal process for safety categorisation of utilization and experiments should be established in accordance with the IAEA safety standards No. SSG-24. Utilization and experiments with major safety significance should be subjected to safety analysis, routes of approval, and procedures for design, quality, fabrication, and commissioning equivalent to those applied for the reactor itself.

Major modifications

- Criteria should be clearly defined, and documented, on what constitutes a routine replacement or a modification of SSCs important to safety. This should be supplemented by definition of the relevant safety requirements, including the need for safety analysis, routes for approval, and procedures for implementation.

Operational radioactive waste management

- RID should update the models and assumptions used for assessing the magnitude of the radionuclides released as gaseous effluents that cannot be measured by online methods, and submit the results to the safety committee and the ANVS for review and assessment.
- RID should establish a procedure for keeping record of unused experimental equipment in the reactor pool and improve the process for declaring unneeded equipment as radioactive waste.

Emergency planning

- RID should conduct an emergency drill before the planned return to normal operation for ensuring the awareness of the operating personnel, external response organizations and relevant authorities about the change in operational status after the prolonged shutdown of the reactor.

The IAEA team also recommended that HOR reactor management develops a plan to implement the recommendations of the mission, which could be reviewed in a follow-up INSARR mission to be conducted in 2023. The implementation of the recommendations of the mission could also be followed up during regulatory inspections.

The implementation of the mission was done in good conditions. The excellent preparation and organization of the mission by the RID should be highlighted.

APPENDIX 1: ISSUE PAGES

ISSUE REG01: Need for improved solution of licensing documentation

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, (2013)
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, (2016)
- HOR PowerPoint Presentation, Regulatory Supervision, September 2021

2. ISSUE CLARIFICATION

The Netherlands has legislative and regulatory environment for nuclear installations that is adequately in-line with the IAEA safety standards, European Union Directives and WENRA Reference Levels. The functions of the regulatory body are carried out by the Autoriteit Nucleaire Veiligheid en Stralingsbescherming (ANVS).

The HOR reactor has a valid license issued in 1996. There is no time limit in the license. The application for the license was based on the Safety Report (SR), which was prepared by the RID in 1993 and was based on the safety analysis performed by the German company Siemens. The content and format of the SR is prescribed by Dutch national legislation, which is applicable to different kinds of facilities and is not limited to nuclear facilities. In addition to the SR, the safety analysis report (SAR) was written in-line with the IAEA safety standards that were applicable at that time. Additional information can be found in the Issue Page on SAR (i.e. ISSUE SAR01) of this report.

Following the license issuance in 1996, the HOR license has been modified 13 times due to various reasons. Each modification has to follow a well-established process, where the operating organization has to submit, for review and assessment, to the ANVS an application with sufficient justifications. The ANVS can also request the opinion of an independent technical supporting organization (TSO) on the application. Before the modification is approved, the ANVS invites the public to comment on the first concept of the license. After expiration of prescribed consulting period, the licence approval of the modification is officially issued and is considered as an amendment of the original operating license.

Under the scope of the Oyster project, the RID has applied for approval of the proposed modifications, primarily the installation of a cold neutron source. Due to practical reasons for implementation, the application has been approved in two stages with two licenses. The first one was for the building and cooling systems of the cold neutron source, issued in 2017 and the second one was for the cold neutron source itself, issued in 2019.

A commissioning plan for restarting the HOR reactor after the completion of several major modifications, including the installation of the cold neutron source, was prepared by the RID in 2020. It was reviewed, assessed and approved by the ANVS. The ANVS inspectors have been visiting the HOR on average every second week. The ANVS inspectors have been following the implementation of the commissioning plan and have sufficient authorization to intervene or enforce corrective measures in case of any detected anomalies.

The implementation of modifications under the scope of the Oyster project have started in 2019 and the HOR reactor has not been operating since that time. Due to the delays in the delivery of some equipment for the cold neutron source, in particular the in-pile section, it has been decided by the RID not to wait any longer for the completion of the cold neutron source installation, but rather to restart the reactor without installation of the in-pile assembly, by the end of 2021. The approved commissioning plan has foreseen this above-mentioned situation, therefore from the licensing point of view, the HOR reactor is permitted to such a restart. Representatives of the RID and of the ANVS have explained that they will follow the well-established practice that they have regularly used for restart of the reactor after the summer breaks: The RID will send a letter to the ANVS announcing that the operating organization intends to restart the HOR reactor and the ANVS will, after its review and assessment, acknowledge the announcement by the confirmation letter.

In parallel to the Oyster project, a periodic safety review (PSR) of the HOR is being implemented. The RID plans to submit its results to ANVS by the end of 2021. The PSR will result in a list of proposed improvements, which will be reviewed and assessed by the ANVS.

The RID and the ANVS have agreed to prepare the renewed license after the final conclusion of the Oyster project and the PSR. The new license will merge and consolidate all the major modifications of the original license in the years after 1996 including the results of the ongoing PSR and remaining changes associated with the Oyster project. It will include also the reference to the up-to-date safety analyses, which has been prepared by the NRG in recent years. Based on those safety analyses and also on ongoing major modifications, a new SAR is being written. Several completed chapters of the new SAR have already been informally reviewed by the ANVS, though not yet approved. The RID and the ANVS have agreed to send the 2020 version of the new SAR (see also ISSUE SAR01) to the IAEA team as the basis for the review of safety aspects of the facility during this INSARR mission.

Before the RID will apply for the license amendment after the final conclusion of the Oyster project and the PSR, it will need to prepare also the SR as required by the Dutch national legislation. Such an SR will need to be submitted as the basis for the renewed license. It is expected that the content of the SR will directly reflect the content of the renewed SAR but will be organized in a different format as prescribed by the Dutch national legislation.

During the mission, the IAEA team noted the effectiveness of the interaction between ANVS and RID, including through formal and informal discussions aimed at explaining the basis for regulatory decisions concerning HOR reactor and at providing ANVS with opportunities to be timely informed on potential safety issues. The team encouraged the continuation of this practice and highlighted its importance for safety during the process of restart of reactor operation after the prolonged shutdown.

3. POSSIBLE SAFETY CONSEQUENCES

Having two safety documents (SR and SAR) to satisfy the legislation needs in the licensing process may result in functional conflict and confusion. Maintaining both documents imply additional administrative burden and the potential for inconsistency between them.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the suggestions.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

S1) The RID is suggested to communicate with the regulatory body for a practical solution to minimize the functional conflict and confusion between SAR and SR as well as the potential inconsistency due to each individual amendment in the licensing process.

ISSUE SCL01: Need to develop and communicate a more formalized organizational approach to safety culture

1. BASIS AND REFERENCES

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, (2016)
- IAEA Safety Standards Series 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, (2006)
- Safety Culture Survey report, RID-697, 8 July 2021
- Safety Culture, PowerPoint Presentation, RID, September 2021

2. ISSUE CLARIFICATION

Several indicators of strong safety culture are present within the RID. For example, safety focus, practices and norms are communicated frequently in personal interactions, training (or on-the-job training), and in-person communications. Safety is discussed during the pre-job briefings and in the context of troubleshooting and problem-solving situations. Such informal discussions of safety can be a powerful mechanism in establishing and reinforcing safety norms and expectations. In addition to such informal mechanisms, there should be a more formal and systematized organizational approach to ensuring and sustaining a strong culture for safety.

A safety culture survey was conducted by external experts in July 2021. The choice of survey consultant was appropriate, and the methodology of the survey was sound. The report has been reviewed by senior leaders, who generally acknowledge the findings of the report, and the organization has begun plans for following up on survey recommendations. The committee has been formed and will include an external expert for additional input and to add new perspectives. The committee will address the combined findings of the safety culture survey, the employee perception survey, and the risk inventory and evaluation, thereby integrating the work in disparate but related areas. This represents a first step to actively monitoring and influencing safety culture and supports a systemic approach to safety.

Organizationally, there is no specified role within the organization to focus on safety culture, nor is safety culture specified as a responsibility of any existing role within the organization. There is little in the way of formal training or organization wide communications regarding expectations related to building and maintaining a healthy culture for safety. Such communications are important and generally serve to establish a shared understanding of cultural expectations and prevent shifts or deterioration in culture.

There is a safety policy within the integrated management system. The content of this policy is predominantly focused on describing the role and responsibilities for safety that lie with Director of RID. The policy states that RID "operates an integrated management system to ensure safety", with no mention of the importance and management of the safety culture, and only one general reference to individual responsibilities and accountabilities for safety.

There is recognition of the importance of human and organization factors for effective operations, and some early efforts are being made to ensure these are considered. A new process for analysing non-conformances has been introduced and reviewed by the safety committee. It includes consideration of human and organization factors in both the analysis of causes and formulation of recommendations. Continued discussions about the best way to incorporate this information into the integrated management system are in progress. Still, at this time, the primary focus is on technical risks and technical safety. For example, "safety considerations" are incorporated in the template for procedure development, but "human and organization factors" are not.

3. POSSIBLE SAFETY CONSEQUENCES

The absence of formal leadership roles and documented statements, responsibilities, strategies, and policies regarding safety culture creates the possibility of undetected cultural shift and the informal reinforcement of any unsafe practices that develop. Formalization and explicit statements regarding safety culture will guide and reinforce the informal mechanisms which are in place. Without a formal, documented description of safety culture ambitions and expectations, the possibility of individual interpretations that are divergent in concept and practice may occur, unintentionally creating symptoms of declining safety culture. Formalizing an approach to safety culture creates and reinforces shared, common understanding essential for healthy safety culture.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R1) RID should establish, advocate, and adhere to an organizational approach to safety that establishes behavioural expectations, institutional and individual values, and the acceptance of personal accountability in relation to safety. In this regard, RID is recommended to:

- Develop a vision and strategy for defining, communicating, and monitoring safety culture;
- Assign a senior leadership role with defined responsibilities regarding safety culture programme, including communications of safety issues and continuous improvement.

S2) RID is suggested to:

- Formalize and continue efforts to follow up on the safety culture survey report;
- Continuously develop processes and tools that consider the interactions between human and organization factors in procedure development, event analysis, and proposed changes.

ISSUE SCL02: Need to ensure adequate attention to nuclear safety aspects

1. BASIS AND REFERENCES

- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, (2016)
- IAEA Safety Standards Series 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, (2006)
- Safety Culture Survey report, RID-697, 8 July 2021
- Safety Culture, PowerPoint Presentation, RID, September 2021

2. ISSUE CLARIFICATION

The current organization culture is adaptive and dynamic, supporting its academic, teaching and experimentation mission. There is open and free communication within and across levels. There is broad awareness of safety practices and procedures and focus on safety has been integrated into some processes within the RID. For example, safety related values and behaviours have recently been integrated into the recruiting and selection process for operators.

The radiation protection programme provides specific training on radiation hazards. However, several key human resource administration processes (employee survey, performance management system) and event analysis process (PRISM) are administered at the university (TU Delft) level and represent generic approaches and risks across all faculty departments. It will be important to maintain a balance between the university environment and experimentation and freedom of thought and the adherence to nuclear standards and procedural requirements to ensure nuclear and radiological safety.

3. POSSIBLE SAFETY CONSEQUENCES

If the aspects of radiation hazards are not emphasized in an academic driven university environment, operational safety of nuclear facilities may be compromised. In addition, students who move onto industrial organizations may not be fully prepared with sufficient awareness of safety culture.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the suggestion.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

S3) Formal training regarding the aspects of nuclear safety and safety culture (raising concerns across functions and levels, questioning attitude, and learning from external experience) should be made available.

ISSUE RMG01: Need to improve the organization structure for the HOR operation

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 Series No. NS-G-4.5: The Operating Organization, and Recruitment, Training and Qualification of Research Reactor Operating Personnel, (2008)
- IAEA Safety Standards Series No. NS-G-4.6: Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, (2008)
- Operating Organization and Reactor Management, PowerPoint Presentation, RID, September 2021
- Safety Committee, PowerPoint Presentation, RID, September 2021

2. ISSUE CLARIFICATION

The HOR reactor is operated by the Reactor Institute Delft (RID), Delft University of Technology (TU Delft). The reactor achieved criticality for the first time in 1963 and went through several modifications and upgrades during its lifetime, including power upgrade to 3 MW (1967), conversion from highly enriched uranium to low enriched uranium fuel (2005), and refurbishment of the instrumentation and control system (2010). Periodic safety reviews (PSR) were conducted in 1999 and in 2010; currently the third PSR is underway with expected completion by the end of 2021. The reactor operation license is valid for the facility lifetime and licensing conditions are subjected to review based on the results of PSRs. The licensing authority of the HOR is the ANVS.

The RID conducts research and development in a broad range of radiation science and nuclear technology. The RID includes about 60 employees, including management personnel (6), HOR-B operation (17), HOR-B maintenance (4) with additional TU Delft maintenance support (4), HOR-O (7), radiational protection (7), security (2), instrumentation group (7), and occupational education group (9). The Executive Board of TU Delft is the operating organization of the HOR reactor and thus has the prime responsibility for safety. The daily operation has been delegated to the reactor manager who is the Director of RID. This responsibility is defined by written procedures indicating that the reactor manager has the necessary resources to fulfil this responsibility. The reactor manager is appointed by the Executive Board of TU Delft.

The head of the department HOR-B (HOR Operations) is responsible for everyday operation of the reactor, including safe operation within the approved operational limits and conditions, operation shift management as well as specific reactor maintenance. The head of the department HOR-O (HOR Developments) is responsible for supporting operation of the reactor, including fuel management, development of safety documents including the SAR and OLCs, coordination with the other departments within the RID, and project management of major modifications and experiments.

The IAEA team discussed with the counterparts the overlap and potential conflict of duties and authorities between the heads of HOR-O, HOR-B and the reactor manager.

The RID has established an integrated management system (IMS) covering all the activities performed by the HOR. The documentation system, management processes, and procedures (including the working level instructions) are contained within this system. The quality management function is under the programme manager of IMS (who reports to the Reactor Manager/Director of RID, with no direct reporting line outside of the reactor management.

The radiation protection function of the reactor is carried out by the radiation expert and the radiation protection group. The radiation expert reports to the reactor manager but has an independent line of communication to the Executive Board of TU Delft.

The HOR has an established safety committee to advise the reactor manager (see also SC Issue Page). The safety committee is not included in the organization chart for HOR despite the committee having been established for many years and being prominent in the organization.

The Director of RID mentioned that a restructuring of the HOR organization chart is being considered with the possibility of adding the position of reactor manager reporting to the Director of RID (who is currently also the reactor manager). The IAEA team discussed the need to perform adequate analysis of proposed changes before implementing it to ensure that safety level at the reactor is not jeopardized. It should be clearly determined that the benefits of such a rearrangement would outweigh potential drawbacks. The RID management is aware that any restructuring of the operation organizational chart of the HOR reactor has to be approved by the national nuclear regulatory body before implementation.

3. POSSIBLE SAFETY CONSEQUENCES

The overlap of functions, duties, and authorities for the reactor manager and the manager of HOR-O and HOR-B could lead to conflicted situations with a resulting negative impact on operational safety. Additionally, if it is not adequately managed, the potential conflict of interest may have negative implications on the required independent verification of safety important activities.

The reactor safety can be jeopardized if restructuring of the organization has been made without ensuring the availability of adequate human resources, and training and qualification of personnel required for safety for a new organization structure.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R2) In view of the considered restructuring of the organization of HOR operation, adequate analysis should be performed (and measures taken accordingly), in accordance with approved procedures that supplement the existing TU Delft procedures on organizational changes, on safety implications of the proposed changes including on roles and responsibilities for safety of positions in particular with respect to leadership and management for safety. The analysis should be subjected to review by the reactor safety committee and to ANVS review and assessment.

R3) The organization structure of the HOR operation should be improved by:

- Establishing adequate measures and practical arrangements to ensure effective quality verification of the activities important to safety that are carried out by the reactor operators swapping their functions between operation and maintenance;
- Ensuring the independence of the quality assurance function from reactor management;
- Formalizing the HOR safety committee position in the organizational structure, with a clear description of its role, function, and line of communications.

ISSUE SC01: Need to improve the effectiveness of the HOR safety committee

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 Series No. NS-G-4.5: The Operating Organization, and Recruitment, training and Qualification of Research Reactor Operating Personnel, (2008)
- HOR PowerPoint Presentation, Safety Committee, September 2021
- HOR Safety Committee, Terms of Reference, DIR-010P, September 2020
- HOR Safety Committee, Taken, bevoegdheden en samenstelling van de RVC / RVC tasks, competency and composition, DIR-010B, September 2020

2. ISSUE CLARIFICATION

A safety committee is established at the RID level. The committee has an advisory role (to the Director of RID who is also the Reactor Manager) on the safety aspects of the operation and utilization of the reactor. It reviews the adequacy and safety of proposed experiments and modifications and provides the reactor manager with recommendations for action. The committee does not have a line of reporting to the Executive Board of TU Delft.

The HOR safety committee is composed of seven members from different organizational units within RID (four members) and from the Department of Radiation Science and Technology in TU Delft (three members), who have competence in nuclear reactor physics and technology, radiation protection, reactor operation, chemistry, radiochemistry and radiation chemistry, instrumentation, mechanical and electrical system, and knowledge of materials. The committee membership does not cover competence on management system and safety culture.

The HOR safety committee is currently chaired by the head of the Department of Radiation Science and Technology. The terms of reference of the committee are established in the integrated management system documents and includes competences, composition, and items to be reviewed by the committee. It also includes a description of the committee working procedures, number of members required for a quorum and number of meetings to be held per year.

The discussions on the functioning of the safety committee showed that there is no established process for the safety committee to follow-up on the implementation of its recommendations. The IAEA team noted that the practice of the safety committee is aimed at obtaining consensus on the conclusions of the committee. Although there is the possibility to record dissent if it occurs (e.g. by voting), there are no established procedures for dealing with such situations.

The list of items that the safety committee considers includes some but not all items required by the IAEA Safety Standard No. SSR-3. Among those items missing are: the design of structures, systems and components important to safety and in particular the design and qualification of nuclear fuel elements and reactivity control elements; violations of the operational limits and conditions, of the licence and of procedures that are significant to safety; periodic reviews of the operational performance and the safety performance of the research reactor facility; reports on regulatory inspections.

The IAEA team discussed the items to be covered by the scope of the safety committee considering the prolonged showdown period of the HOR reactor for refurbishment and major modifications.

3. POSSIBLE SAFETY CONSEQUENCES

Lack of systematic follow-up by the HOR safety committee on the implementation of the actions associated with its recommendations could impact verification and management of safety. Harmonization of the list of items to be reviewed by the safety committee in line with the IAEA safety standard No. SSR-3 could help ensure that important safety aspects are not missed. The review of items important to reactor operational safety including proposed changes to licensing documentation and review of retraining provision for personnel who have had (because of the prolonged shutdown) extended absences from their authorized duties, could impact verification and management of safety.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agreed with the observations and recommendations regarding improvement of the functioning of the safety committee.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R4) The functioning of the HOR safety committee should be further improved by:

- Revising the list of the safety documents to be submitted to the committee for review in accordance with the IAEA safety standards No. SSR-3;
- Establishing working instructions for the committee, including procedures for dealing with situations where consensus is not achieved, and procedures to ensure effective follow-up on the implementation of the Committee's recommendations.

ISSUE SA01: Need to further improve the reactor safety analysis

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 Series No. SSG-20: Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, (2012)
- HOR PowerPoint Presentation, Safety Analyses, September 2021
- Safety Analysis Report Hoger Onderwijsreactor Reactor, Chapter 16, February 2019

2. ISSUE CLARIFICATION

The current version of the safety analysis report (SAR) for the HOR reactor was developed in 1990s by Siemens and is based on outdated IAEA safety standards. A number of document updates have been performed over the past 20 years and the amendments were approved by the ANVS, but the basic structure and technical methodology of the current SAR remain unchanged. The RID recognized the necessity to develop an entirely new SAR, in order to be in line with the up-to-date IAEA safety standards and to better reflect the recent major modifications of the reactor. The development of the new SAR started in the 2010s and the IAEA team was provided for reference and review with a near-final version of this document (referred as 2020 Version herein), which has not yet been officially approved by the ANVS. This decision of providing this unofficial SAR was agreed as an outcome of the pre-INSARR mission and was to better reflect the up-to-date information of the HOR reactor.

The 2020 Version of HOR SAR summarized the results and conclusions of the deterministic safety analysis in Chapter 16. A list of postulated initiating events (PIEs), which were selected from the full PIE list provided in the IAEA safety standards No. SSR-3, were quantitatively analysed. The detailed process of the selection, which was performed by NRG, however, was not presented to the IAEA team. Overall, the scope of safety analysis presented in the 2020 Version of HOR SAR is considered comprehensive. The SAR also included a complementary probabilistic safety assessment (PSA), which is associated with a separate recommendation in ISSUE MPTI01.

One major inconsistency between the currently official Siemens analysis and the 2020 Version of NRG analysis is the consequence of the channel blockage accident. The Siemens analysis considered the channel blockage accident as the “worst possible accident” and the “covering hypothetical accident” with consequences of fuel plate melting and radiological release. This is the typical practice for the safety analysis of most plate fuel type research reactors. In 1980, the RID implemented a new reactor trip to the HOR based on excessively negative reactivity changing rate (or called “margin indicator exceeds 100%” in the HOR specific terminology). Such a measure aimed to detect the potential channel blockage via negative reactivity insertion caused by coolant temperature feedback and thus prevented fuel melting via a timely reactor scram.

In the 2020 Version of HOR SAR, the consequence of the channel blockage accident no longer involved fuel melting and the subsequent radiological release. The corresponding safety analysis was conducted using the RELAP5 code, which uses a point kinetics model. The IAEA team believed that the channel blockage accident involves highly heterogenous spatial effect, resulted by local blockage and coolant boiling. Such physical phenomenon is not suitable for the point kinetics based RELAP5 model to analysis. It is highly likely that the presented computational results over-estimated the negative reactivity feedback caused by the local coolant boiling, so that the HOR reactor will not receive the expected scram signal from "margin indicator exceed 100%" (or at least will not receive it in a timely manner) and the fuel melting thus cannot be prevented. The IAEA team recommended the RID to re-evaluate the safety assessment in the SAR for the channel blockage accident, via appropriate verification and validation of the point kinetics based RELAP5 model or alternatively using more suitable computational tools for the analysis of such physical phenomenon.

In the list of PIEs that have been analysed in the 2020 Version of HOR SAR, there are two reactivity insertion accidents included: 1) PIE R3a-10: Inadvertent withdrawal of the most effective control element or control element group with loss of limitation systems and 2) PIE R3b-01: Maximum reactivity insertion by withdrawal control elements on the basis of the operating conditions "full load". The former could be resulted by a single failure; whereas the latter considered the potential scenarios with multiple failures. The IAEA team noticed that both of the analysed events represented reactivity insertion with a slow rate, which was limited by the maximum speed of the control rod drives. Even though the reactivity worth of the analysed control rod withdrawal was greater than the maximum allowed value for a fixed experiment (1.5% dk/k), the latter could have occurred in a much faster manner. As a result, the selection of this particular OLC parameter for fixed experiment was not bounded by the safety analysis in the SAR. It is thus recommended to establish a bounding scenario and demonstrate the selected OLC for maximum reactivity worth of fixed experiment is justifiable.

In the list of PIEs that involve radiological release, there is one experimental failure analysed as PIE R3a-22: Damage of capsules of irradiation samples (loop experiment) and it represented the greatest radiological consequence caused by HOR operation. The IAEA team noticed that this loop experiment was based on a hypothetical design and had not yet been approved by the ANVS. Such an experiment was thus not suitable to be included in the SAR. It is suggested to perform safety analysis in the SAR using as-built experimental facilities. The results were to be used as the basis for selecting OLCs.

3. POSSIBLE SAFETY CONSEQUENCES

The fuel channel blockage accident can potentially be the "worst possible accident" resulting considerable amount of radiological release. The RID should provide adequate and valid justifications for concluding the reactor safety system settings will be able to prevent the fuel melting via credible reactor scram signal. Otherwise, the operating organization will become vulnerable in terms of emergency preparedness if such hypothetical accident may have occurred. Also, if the selection of certain OLCs is not supported by safety analysis, the reactor safety cannot be ensured in the corresponding operational regime. For this particular case, the maximum allowed reactivity for a fixed experiment in the OLCs is not bounded by the safety analysis. The reactor safety thus cannot be ensured if conducting such a permitted experiment.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R5) The safety analysis should be further improved by re-evaluation of the fuel channel blockage event, particularly with respect to the validity of the used computational tools and models, and by identification (and inclusion of its description in SAR) of the limiting event defining the maximum reactivity worth of fixed experiments.

S4) The safety analysis needs to be performed using the as-built experimental facilities, and the SAR needs to be revised accordingly.

ISSUE OLC01: Need to update OLCs in accordance with the status of the reactor

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 Series No. SSG-20: Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, (2012)
- HOR PowerPoint Presentation, Operational Limits and Conditions, September 2021
- Veiligheidstechnische specificaties van de HOR,Volgnummer 4, versie 5 - 1 juli 2020
- Safety Analysis Report Hoger Onderwijs Reactor (HOR-SAR), Chapter 17, Operational Limits and Conditions

2. ISSUE CLARIFICATION

The OLCs of the HOR reactor are described in two separate documents: Chapter 17 (OLCs) of the SAR (2020), which is high level summary of the information and the Veiligheidstechnische specificities (VTS), which is the comprehensive specification and is in Dutch. The IAEA team, however, observed that the summary version included in the SAR contains no technical information, but rather serves an extended table of content, referring to the full VTS document. It is noted that the SAR should have a summary of the OLCs, which reflect operational boundaries of the actual status of the reactor

The IAEA team observed that in the current OLC specifications of the operational boundaries for safety limits (or Veiligheidsgrenzen) in Section 3 of the VTS. Two tables (Tables 3-1 and 3-2) are currently presented in the VTS, representing the operating modes for forced convection and natural convection, respectively. However, these specified operational boundaries are identical to the safety system settings (or Instellingen beveiligingssysteem) in Section 4 of the VTS. This implies that the concept of no defense in depth is not taken into account during the OLC selection and no safety margin to critical phenomena are provided during operation. This issue must be appropriately addressed with a clearly specified operational boundaries for safety limits.

The IAEA team also observed that Chapter 16 (Safety Analysis) of the SAR (2020) was not yet used for selection of the OLCs presented in Chapter 17 (OLCs). Chapter 16 reflected the results of the most recent calculations (as it is clear from its references), while Chapter 17 still uses the former thermohydraulic calculations (in SAR 1996) as a basis for definition of the safety limits. The figures thereof are outdated, as they refer to core configurations which are no longer in use. The current set of OLCs does not include the up-to-date information of the new experiments and modification, The IAEA team discussed the need of taking into account the information collected during the utilization of the facility, including the coming restart, for updating the set of OLCs. The team also discussed the need of reviewing and updating as needed the OLCs after the approval of the SAR (2020).

As discussed in ISSUE MPTI01, some of the surveillance requirements, which are part of the OLCs, are waived due to the prolonged shutdown condition of the HOR reactor. Even though the justifications of the nonconformance provided by the counterpart are considered valid, in accordance with the IAEA safety standards No. SSR-3 any modifications of OLC must be subjected to review and approval of the regulatory body. The process of updating OLCs should be formalized and well documented for future reference.

The IAEA teams also observed that the current set of OLCs has not yet been updated with the new experiments and the major medications that are being implemented by the RID during the prolonged shutdown. In addition, the OLCs were found not being sufficiently prepared for the planned commissioning toward the end of 2021. For example, the staff from the HOR-O (department of development) mentioned that, during the (re-)commissioning stage, the HOR reactor plans to operate at a reduced power level, e.g. 1.5 MW instead of 2.3 MW, for a certain period of time, while conducting the physics measurements and the power calibration. Such an operational arrangement should not only be specified in the administrative procedures, but also by the OLC specifically developed for commissioning. In addition, the IAEA team clarified that the OLCs should constitute an envelope for which reactor safety parameters and SSCs conditions are demonstrated to be safe and that the site personnel and public are protected against radiation. These OLCs could also be subjected to revision according to the results of commissioning tests for the HOR restart.

3. POSSIBLE SAFETY CONSEQUENCES

With safety system settings and safety limits overlapping, no safety margin to critical phenomena is provided during operation of the facility with a significant safety implication. Regarding the absence of formal routes for approving certain surveillance requirements being waived, with OLCs involved or not, the decision-making process may be inconsistent on a case-by-case basis and may have a negative impact on the safety culture of the facility.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R6) Surveillance requirements and periodic testing (as part of the OLCs) that were waived during the reactor prolonged shutdown period should be re-established unless it is adequately justified based on a comprehensive safety analysis considering the status of the facility, documented, and subjected to review and approval of the regulatory body. New experiments and modifications as well as associated commissioning plans for restart of the reactor should be evaluated to reassess the need for improvements or changes to OLCs. The OLCs should constitute an envelope for which reactor safety parameters and SSCs conditions are demonstrated to be safe and that the site personnel and public are protected against radiation. These OLCs could be subjected to revision based on the commissioning of new experiments and modifications.

R7) The OLCs should be revised in accordance with the IAEA safety standards No. SSR-3 to include safety limits and safety system settings. As OLCs are included in a separate document, a summary of these OLCs should be included in the SAR with a reference to that separate document.

ISSUE SAR01: Need to improve the contents of the SAR

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 Series No. SSG-20: Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report, (2012)
- HOR PowerPoint Presentation, Regulatory Supervision, September 2021
- HOR PowerPoint Presentation, OLCs, September 2021

2. ISSUE CLARIFICATION

The application for the HOR license was based on the Safety Report (SR) prepared in 1993 by the German company Siemens. The content and format of the SR is prescribed by Dutch national legislation, which is applicable to different kinds of facilities, and is not limited to nuclear facilities. In addition to the SR, the Safety Analysis Report (SAR) was written in-line with the IAEA safety standards that were applicable at that time.

The preparation of a new SAR was initiated in 2010s to address the major modifications proposed for the facility under the Oyster project. At the time of the INSARR mission, the content of the new version was almost finished. The new SAR (referred herein as the 2020 Version) has been already presented to the ANVS, which has agreed in principle with its content, but it has not been formally approved yet. The IAEA team was informed that the intention is to approve the new SAR in the scope of issuing the renewed license, which is foreseen after finalization of the Oyster project and the currently ongoing periodic safety review (PSR). As the content of the new SAR better reflects the current state of the HOR reactor and its experimental facilities, the RID and the ANVS have agreed that the 2020 Version of the SAR would be provided to the IAEA team as the basis for the review of safety aspects of the facility during this INSARR mission.

During the mission, the IAEA team identified inconsistencies between the descriptions of organizational scheme of the RID in the new SAR and those presented to the team during discussions. It has been explained by the RID that the presented organizational scheme is based on the internal document Beschrijving KEW-vergunningsgebonden organisatie Technische Universiteit Delft Reactor Instituut Delft, issued in 2020 and approved by the ANVS. On approval it became the amendment of the license and therefore in force.

It was explained to the IAEA team that there is no process in place for regular updating of the SAR, therefore the description of the organizational scheme in it is outdated.

The team has also observed that the SAR is not among the documents that are available to operating personnel for convenient daily use via the well-established document management system. The SAR is stored in another electronic archive together with documents, for whose daily use is not expected. Accordingly, the IAEA team was of the opinion that the SAR is not treated as the main document describing nuclear safety of the facility and is not considered as the comprehensive source of information on the current safety status of the facility.

The RID explained that in addition to the SAR, the SR is prepared in line with the requirements of the Dutch legal system. It does not contain any sensitive information and is open to the general public for comments during the licensing process. The same legal requirement is also in place today, so before submitting the application for renewing the license, the RID will need to prepare the new version of the SR document in addition to the new SAR. At the time of the mission, the formal status of those two documents (SAR and SR) in relation to the operating licence was not satisfactorily explained to the IAEA team. (See ISSUE REG 01)

The RID explained that the safety analysis of the future cold neutron source facility is being prepared as a separate document. The RID does not intend to include this safety analysis as a part of the SAR but to be submitted separately to ANVS for review and assessment.

3. POSSIBLE SAFETY CONSEQUENCES

Without the SAR fully and accurately describing all the current safety significant aspects of the nuclear facility in a single, systematically consolidated and structured document, the probability for wrong decisions regarding operation or modification of the installation in the years to come would be much higher.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R8) Updating of the SAR, which is being performed by RID, should be taken as an opportunity to further improve its contents and comprehensive nature as the main document on the safety of the facility by including up-to-date information on modifications, integrating all necessary technical information (e.g., OLCs) and resolving any potential inconsistencies including with other facility's documentation. The SAR should be periodically updated to reflect modifications made to the facility and on the basis of experience and in accordance with regulatory requirements.

ISSUE IMS01: Integrated management system for operation

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 Series No. GS-G-3.1: Application of the Management System for Facilities and Activities, (2006)
- Integrated Management System, PowerPoint presentation, RID, September 2021
- Document Management System, internal database based on Manual Master system

2. ISSUE CLARIFICATION

The RID has established an integrated management system (IMS), which covers the HOR reactor as well as the operation of the associated laboratories. The reactor related parts of the IMS are available to all HOR personnel. The IMS manager is assigned within the RID, directly responsible to the RID director.

The IMS covers most of the processes related to safe operation of the reactor and includes adequate processes for dealing with non-conformities. Programme of internal audits is established, the findings are recorded and resolved in a well-documented manner. The reactor staff has been trained on the IMS processes and the daily use of the documents in the IMS, which are continuously kept up-to-date, mostly by the IMS manager.

The IAEA team witnessed an example of a reactor staff member using the document management system, aiding him in his routine work, specifically in preparation for Monday reactor operation (also see ISSUE COP02).

The IAEA team identified that some processes important to safety are not formally established, such as the use of operating experience feedback, and maintenance work permits. Nevertheless, the RID clarified that feedback from other reactors and from international meetings is informally provided via meetings with HFR staff.

The IMS processes cover the management of organization changes. An example was presented to the IAEA team of the latest organization change, which include the assessment of safety impact by the safety committee and the regulatory review and assessment.

The IMS includes records of irradiation experiments, which are typically initiated by experimental technicians and informally approved by the operator on duty. The records, however, are not used for scheduling purposes in terms of coordinating between operators and experimenters. There is a separate Outlook calendar informally used for the coordination purposes. This calendar, which is not subjected to official use, does not consist of the complete set of experiments to be conducted.

3. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

The practices of the HOR reactor in this area are generally in line with the IAEA safety standards and there are no recommendations in this area.

ISSUE TRQ01: Need to improve the training and qualification programme

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 Series No. NS-G-4.5: The Operating Organization, and Recruitment, Training and Qualification of Research Reactor Operating Personnel, (2008)
- HOR PowerPoint Presentation, Training and Qualifications, September 2021

2. ISSUE CLARIFICATION

A formal training programme is established for the HOR reactor. It includes documents specifying the recruitment and competence requirements for all positions. In particular, the programme outlines the detailed training curriculum for reactor operators and shift supervisor (or the so-called chief operators at the HOR reactor).

The basic training of new personnel includes topics on nuclear physics and reactor technology, nuclear safety, the management system and documentation, and radiation protection. The training curriculum also includes reactor specific facility topics such as the control system and its testing procedures, electrical safety, crane operation, etc. Before an operator is assigned, he/she also receives training on reactor operation principles, the safety analysis report and operating rules, operational instructions and manuals, and is required to pass a course on reactor physics and radiological protection.

The training materials are based on relevant textbooks and HOR documents. The trainers are the RID specialists, including senior personnel from the operating organization.

Two years of full-time training is needed to become an operator. A formal qualification process is established for reactor operators and the assessment includes written and practical examinations. The formal training curriculum for shift supervisor includes extra training, 25 shifts acting as a shift supervisor plus five years' experience as an operator, where the two years' operating training can be taken into account.

The retraining programme exists at the HOR reactor. The retraining is conducted for the reactor operating personnel twice per year and it includes radiation protections and operating feedback experience from the reactor. However, feedback from other similar nuclear facilities is not systematically integrated in the retraining programme. The contents of the retraining curriculum could include changes and modifications that have been introduced to the reactor systems and documentation, operating feedback experience from the reactor and other similar facilities, operating procedures which are not frequently executed, new procedures and selected topics from the initial training programme.

The IAEA team also observed the lack of a formal re-qualification process for the reactor operating personnel to resume normal operation after the prolonged shutdown for over 2.5 years. The IAEA team discussed the need for re-qualification under the current circumstances, where many operating procedures are not being frequently executed. In effect, the prolonged shutdown of the HOR reactor, which was to facilitate modifications and upgrades, resulted in an extended absence of operators from their authorized duties. According to the international practice, a staff member who did not participate in reactor operation over a period of 6 months, is subjected to a formal re-qualification process.

3. POSSIBLE SAFETY CONSEQUENCES

Lack of a formal re-qualification process for the reactor operators who have not frequently executed operating procedures and who have had an extended absence from their authorized duties could have significant impact on the safety of the reactor and personnel. Establishment of such re-qualification process for reactor operating personnel will have a positive impact on their qualification for enhanced safety and reliability of the reactor.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R9) A training programme for the reactor operating personnel should be developed and implemented for restart of HOR operation after the prolonged shutdown period. This programme should include items such as modifications and changes to the reactor systems and components, safety documents, procedures that are not frequently performed, selected topics from the initial training programme, and operating experience feedback from the reactor and other similar facilities.

R10) A formal re-qualification process should also be established, and implemented before restart of reactor operation, for operating personnel who have not performed their duties for long periods (suggested more than 6 months).

ISSUE RPR01: Need to further improve the operational radiation protection programme

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 Guide No. NS-G-4.6: Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, (2008)
- IAEA Safety Standards Series No. GSG-7: Occupational Radiation Protection, (2018)
- IAEA Safety Standards Series No. GSR Part 3: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, (2014)
- HOR PowerPoint Presentation, Radiation Protection Programme, September 2021
- Safety Analysis Report Hoger Onderwijsreactor Reactor, Chapter 12, February 2019

2. ISSUE CLARIFICATION

A radiation protection programme is in place featuring the relevant characteristics required for a facility of the HOR's type and performance. These features were discussed with the leaders of the SBD (radiation protection team of the HOR reactor).

The discussions were based on a presentation on the radiation protection programme delivered by a SBD staff but also included information presented in the Chapter 12 of the SAR and some insights captured during the facility walkthrough.

The routine workplace monitoring for radiation protection of the HOR reactor, such as equipment calibration and cross checks and surveillances on the abidance to establish procedures and recommendations, is supported by the SBD. The official dosimetry service, which is based on thermoluminescent dosimeter (TLD) and outsourced to a qualified supplier, is in place and it is complemented with the use of additional TLDs and/or electronic dosimeters process by the SBD. The latter is utilized for a close follow up on the doses being received by the operating personnel. The IAEA team also discussed with the counterpart the procedure for issuing internal permits for activities involving radiation exposures and the environment monitoring. In additional to the area monitoring available for the reactor operators (i.e. members of the HOR-B group), an additional network of gamma detectors are installed in the technical and research areas providing online radiation monitoring to the SBD staff. This includes alarms routed towards a pager for the radiation protection officer on duty.

The IAEA team discussed the procedures to be used under abnormal circumstances, when corrective actions are needed. The counterpart presented an investigation for the situation that radiation doses slightly above natural levels was observed within the facility boundaries but outside of the premises. The presence of N-16 in the cooling circuits running in a trench under the reactor building has been identified as the root cause. The counterpart implemented corrective action by adding more radiation shielding on the roof of this trench.

The IAEA team observed that the identification of radiological hazards and the associated measures are still based on the outdated hypothesis and the original design of the HOR reactor. Discussions with the counterpart were thus held on the benefits of revisiting these assessments. The team also observed that no charcoal filtering system is installed for protecting the operating personnel as well as the environment against airborne release. The IAEA team discussed with the counterpart regarding a system for area classification and zoning for radiation protection, which is required by the IAEA safety standards No. SSR-3. The layout of the HOR reactor has been modified several times by introducing additional structures, such as the experiment hall, the new control room, the building housing the ancillary equipment for the cold neutron source, various laboratories, storages, etc. These additions have generated scattered radiation areas across the HOR reactor buildings, which practically fall into different regulations (e.g. Dutch standards for laboratories, Dutch safety requirements, etc).

3. POSSIBLE SAFETY CONSEQUENCES

Using outdated concepts and assumptions in the radiation protection programme may impact on the radiological safety of the staff considering that new or augmented hazards were generated by the modifications introduced in the facility, and associated procedures. In particular, the hypothesis adopted at the HOR reactor that internal contaminations are unlikely and negligible thus do not require direct or indirect assessments of the potential intake of radionuclides, or that iodine releases to the environment is excluded for consideration, should be revisited. In addition, an inappropriate area classification, such as mixing concepts applicable to laboratories within the reactor premises handling radioactive substances with those recommended by IAEA for research reactors, could impair the identification of the applicable radiological requirements as well as the associated responsibilities.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R11) Assessment of the radiological hazards within the reactor building should be performed based on the facility’s actual status. Adequate radiological protection measures (including workplace contamination monitoring) should be established accordingly. This includes assessment of the likelihood and magnitude of possible airborne releases, and investigation of the need for installation of charcoal filtering system for protection of reactor personnel as well as the environment.

R12) The system for area classification and zoning from radiological protection should be revised in accordance with the IAEA safety standards No. SSR-3 and NS-G-4.6, considering the requirements for research reactors and taking into consideration the laboratories within the reactor premises.

ISSUE COP01: Observations from walkthrough of the HOR reactor facility

1. BASIS AND REFERENCES

- IAEA Services Series No. 25: INSARR Guidelines, (2013)
- IAEA Safety Standards Series No. SSR-3: Safety of Research Reactors, (2016)

2. ISSUE CLARIFICATION

A walkthrough of the HOR reactor facilities was performed on 07 September 2021. Prior to the walkthrough, a safety instruction video was presented to the IAEA team, covering the alarm signals inside the reactor hall, appropriate radiation protection measures, area classification/zoning and use of personnel protective equipment. A prerequisite for entering the reactor hall with unaccompanied access is successful completion of an online test based on the topics covered in the safety instruction. The walkthrough provided the team with a general appreciation of the conditions and physical status of the structures, systems, and components (SSCs), housekeeping, and industrial, health and safety practices.

The walkthrough covered the following reactor areas:

- Reactor hall (pool area and cold neutron source system);
- Reactor control room;
- Experiment hall (beam-tube area);
- Piping corridor (primary system);
- Reactor basement (waste water treatment system, reactor ventilation, etc.).

In the reactor hall, there was generally good housekeeping observed. The floor of the reactor hall was clean and tidy, and the operation tools were observed to be well organized and appropriately stored. Items such as labelling and tagging were observed to be incomplete. For example, the hydrogen system for the cold neutron source that is located inside the reactor hall was not finalized, but there were neither signs shown and nor “tag out” performed to prevent access to the partially completed components.

During the walkthrough, the IAEA team observed a need to strengthening the radiation protection measures, which were inconsistent with the safety instruction video provided prior to entering the reactor. For example, no safety glass and lab coat were provided at the top of reactor, even though these items were specifically mentioned as necessary in the training materials. Another example is that one team member asked if it was necessary to wipe an item that had been held by hand during the reactor hall walkthrough. The health physicist was reluctant to conduct the wipe down due to rather low contamination risk, even though such a preventive measure was also mentioned in the training materials. Overall, it is understandable that the radiation risk remains low due to the prolonged reactor shutdown condition, but the operating organization is suggested formalizing any reduced measures needed for radiation protection (e.g. by providing up-to-date radiation protection instructions in the safety instructions provided prior to entering the reactor hall) in order to avoid inconsistency between the present status of the facility and the outdated information.

In the reactor control room, the IAEA team observed multiple modernizations of the instrument and control system, including the digital nuclear channels and the newly installed voting logic. The reactor operators on duty demonstrated adequate knowledge of reactor systems and of the responses to anticipated operational occurrences. The housekeeping in the control room was observed to be less satisfactory than the reactor hall. The printed materials behind the main control desk were not neatly ordered. The exception is that the operating procedures and check lists were properly distributed in specially designed drawers.

In the experimental hall, good housekeeping was observed. The beam lines were under good conditions, with experimental stations ready for resuming operation. The team was initially informed that there was a reactor scram button installed in the experimental hall, but such reactor trip function could not be identified.

In the piping corridor, the recently replaced primary and secondary circuits were observed. A lead wall has been installed in front of the entire coolant system for protecting against short lived activation products in the primary coolant. However, the signs and displays, for indicating the (potential) radiological areas, were absent.

In the reactor basement, the IAEA team observed that there are more than 10 large tanks installed for waste water storage, which appears to be beyond the need of the HOR reactor. The team was informed that the system is maintained by the real estate service of the TU Delft campus (CRE), but the reactor operating personnel could not justify the need for such a large storage capacity for the campus waste water storage.

During the walkthrough, the IAEA team also discussed the current status of the major modifications and the planning of the restart activities. The team observed that further improvement is needed to ensure the resumption of required radiation protection measures after HOR restart.

3. POSSIBLE SAFETY CONSEQUENCES

Continuation of the reduced radiation protection measures after the HOR restart may increase the risk of inadvertent exposure of operators and experimenters to radiological dose. Lack of necessary re-training for the operating personnel may result in lack of familiarization of the onsite radiological environment and of the routine operating procedures due to the prolonged period of reactor shutdown.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the suggestion.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

S5) Safety awareness at the HOR during prolonged reactor shutdown may be further improved by:

- Applying reduced measures for radiation protection based on formalized procedures and ensuring the resumption of required measures after the HOR restart;
- Clearly showing signs in front of the (potentially) high dose areas.

ISSUE COP02: Need to improve the information flow for the operational management

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 Series No. NS-G-4.5: The Operating Organization, and Recruitment, Training and Qualification of Research Reactor Operating Personnel, (2008)
- HOR PowerPoint Presentation, Conduct of Operation, September 2021

2. ISSUE CLARIFICATION

The HOR reactor starts to operate on Monday and remains in operation till Friday evening. Through the week, it is operated by three shifts. The first shift on Monday morning receives information from the maintenance personnel about the planned surveillances and tests. These activities are performed during Monday morning, so that the reactor can be started in the early afternoon. The reactor operates continuously until the operators shut it down by manual scram on Friday. Such practice is considered as the weekly test for the scram system.

All activities important to safety at the HOR reactor are carried out in accordance with approved written procedures that guarantee reactor operation within the established OLCs. The current version of valid procedures is available to the reactor operators through the digital document management system. In addition, during performance of procedures reactor operators need to check appropriate fields in a paper checklist, which will be eventually archived.

Fresh fuel elements are typically received every three years, but fuel shuffling is routinely performed approximately every six months. Core calculations to support the fuel management are first prepared by HOR-O (the department for development), and then reviewed by HOR-B (the department for operation), and finally approved by the heads of HOR-O and HOR-B. The reactor manager, who is also the director of RID, is not involved in the above-mentioned fuel management activities. Similar procedure as the fuel management is also in place for modifications of any kind. Analyses are typically prepared by HOR-O, reviewed by several staff members in HOR-B, and approved by heads of HOR-O and HOR-B without direct involvement of the reactor manager.

The IAEA team observed that, in addition to the plan A of the loading scheme, three more plans (B, C, and D) are also developed by HOR-O prior to each fuel shuffling. When the physical tests during start-up show discrepancies that exceed the pre-defined limits, the core will be re-configured using the next planned loading scheme. The new core configuration will be approved by heads of HOR-O and HOR-B in a similar way as the first one without the involvement of the reactor manager. Instead, the reactor manager is informed about the operational issues during regular meeting with heads of RID departments. Such a meeting takes place every three weeks.

The RID is currently developing a commissioning plan, which has been adapted to the absence of the in-pile section of the cold neutron source. This plan has been internally reviewed and approved for execution. It was also shared with the ANVS (as part of the Oyster project). The plan includes the comprehensive instructions needed for resuming the HOR reactor operation, such as the updates for procedures affected by the major modifications and the necessary retraining for operating personnel. The IAEA team expressed concerns regarding the tight time schedule in the plan for implementing all the specified steps, including a review by the safety committee of the plan, the modified procedures, the staff retraining and, among others, the release from construction and the testing stage required before being in suitable condition to resume the operation.

3. POSSIBLE SAFETY CONSEQUENCES

The situation where the reactor manager is not communicating with the operational personnel frequently enough and is informed of current operational challenges only periodically could jeopardize discharging of his prime responsibility for the safety of the facility. This in turn could lead to greater possibility for undesired situations.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R13) RID should consider improving the process of information flow between all levels of management so that the reactor manager would be in position to fully carry out his responsibility for safety. In particular, the reactor manager should ensure adequate checks and verification during the refuelling process and that the safety parameters of the newly assembled core configurations are verified in accordance with the OLCs.

R14) Operating procedures and work instructions, including for radiological protection, should be revised to account for the modifications and to be consistent with the actual status of the facility.

ISSUE MPTI01: Need to further improve the maintenance and inspection programme

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 Series No. NS-G-4.5: The Operating Organization, and Recruitment, Training and Qualification of Research Reactor Operating Personnel, (2008)
- IAEA Safety Standards Series No NS-G-4.2: Maintenance, Periodic Testing and Inspection for Research Reactors, (2006)
- IAEA Safety Standards Series No. SSG-10: Ageing Management for Research Reactors, (2010)
- HOR PowerPoint Presentation, Maintenance, Periodic testing and Inspection, September 2021
- HOR English translation of maintenance, periodic testing and inspection documents for HOR1997-031P, HOR2016-014P, (2021)
- HOR ageing management program (version 4), HOR2016-015I, HOR2016-016I, (2021)

2. ISSUE CLARIFICATION

During the INSARR mission, an overview of the maintenance, periodic testing and inspection programme for the HOR reactor was given by the counterpart. The IAEA team noted that reactor maintenance tasks were executed by "Technische Dienst HOR-B" (a dedicated maintenance service) and "Bedieningsgroep HOR-B" (the group of operators that has also the responsibility for the maintenance of the nuclear instrumentation). The IAEA team also noted that a fraction of the maintenance tasks is performed by the general building service of the university (Campus & Real Estate or CRE). A service agreement, which describes the safety responsibilities, exists between RID and CRE. Such an arrangement is a common practice for research reactors that are embedded in a larger organization, however it is important for the RID to ensure its prime responsibility for safety including within this process.

The IAEA team reviewed several examples relevant to the HOR maintenance programme, including 1) resolution and record keeping of system malfunctions and the associated corrective maintenance, 2) database of preventive (routine) maintenance activities, and 3) record keeping for CRE maintenance activities. The IAEA team noted the HOR has a well-established and systematic maintenance programme, which enables effective malfunction recognition and resolution development. The record keeping system for the preventive and corrective activities is also appropriately established. In addition, the IAEA team observed good communication between the two maintenance groups (i.e. RID maintenance and CRE maintenance). The communication has been conducted at the level of execution personnel. There is, however, generally lack of communication between the maintenance teams and the reactor manager. The RID staff also presented to the IAEA team a management system aiming to integrate all maintenance service at the university level, in which the CRE maintenance for the HOR reactor has been included. Such a system, however, has not yet been in service. The IAEA team noted that a work permit system, which is required by SSR-3, has not yet been developed for the HOR maintenance programme, even though the counterpart recognized the importance of this requirement in management system and was actually considering developing one.

The IAEA team noted that certain periodic tests have been waived due to the prolonged shutdown condition of the HOR, since they may be simply not applicable for the current status of the facility. Some of these surveillance requirements are part of the OLCs, e.g. the periodic test of the primary pump. The approval of waiving these requirements, especially for the ones involving a nonconformance of OLC, is however not formalized with adequate and clear approval route. Additional discussion of this issue and the associate recommendation can be found in ISSUE OLC01.

The ageing management programme for the HOR reactor is considered as part of its maintenance, periodic testing, and inspection programme. A working file for the ageing management has been developed to cover SSCs important to safety and according to their respective ageing mechanisms. The considerations are in-line with the recommendations provided in the IAEA safety standards No. SSG-10. In general, the physical degradations of the HOR reactor SSCs, such as changes of properties, motion or wear, chemical process, corrosion/erosion, are better addressed in its ageing management programme; whereas the preparedness for non-physical degradations (i.e. obsolescence) are not equally covered. For example, there are gaps in terms of developing a strategy for components obsolescence management in case that spare parts of SSCs important to safety become unavailable. Also, there is no dedicated maintenance personnel to investigate the obsolescence issues.

As described in the Issue Page for safety analysis (see ISSUE SA01), a probabilistic safety assessment (PSA) has been performed to provide complimentary information in addition to the deterministic safety analysis. The PSA results contain the risk importance factors of SSCs important to safety and provide the priority insights in terms of their failure frequency and the subsequent safety consequence. Such information can be used as valuable inputs to the further improvement of the HOR maintenance, periodic testing and inspection programme as well as of its ageing management programme. The RID, however, has not yet leveraged the technical benefits of the existing PSA results.

3. POSSIBLE SAFETY CONSEQUENCES

Administrative controls, such as a work permit system, ensure that all work undertaken is conducted with the knowledge and authorization of the person responsible for the operational control of the reactor. It is used to ensure the operating personnel have knowledge of the status of the reactor at all times during maintenance activities. It reduces the risk of conflicting activities being performed simultaneously and facilitates planning, record keeping and analysis, thereby improving the safety of the personnel and of the reactor.

When certain SSCs need to be replaced and the spare parts are unavailable due to obsolescence issues, the reactor may have to operate with minimum required redundancy. The vulnerable situation may result in safety implications and need to be addressed.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R15) A work permit system should be established in accordance with the IAEA safety standards No. NS-G-4.2. This system should be used to improve record keeping in order to facilitate operating experience feedback and trending of maintenance, periodic testing, inspection, and ageing management.

R16) The results of the probabilistic safety assessment, including the risk importance factors of SSCs, should be utilized for further improvement of the maintenance, periodic testing and inspection programme as well as for ageing management.

R17) Ageing management programme should be further improved by covering obsolescence of SSCs, identification of degradation mitigatory measures, and establishment of a process for managing spare parts for systems and components important to safety.

ISSUE EXP01: Need to improve the process for categorization and approval of experiments

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 Series No. SSG-24: Safety in the Utilization and Modification of Research Reactors, (2012)
- HOR PowerPoint Presentation, Safety of utilization and experiments, September 2021
- Safety Analysis Report Hoger Onderwijsreactor Reactor, Chapter 11, February 2019

2. ISSUE CLARIFICATION

The HOR reactor provides neutron radiation to a variety of facilities for radioisotope production and neutron activation analysis. It contains multiple irradiation facilities, including the in-core ones for small samples (BigBeBe and SmallBeBe), the ex-core ones for large samples (BISNIS and FlexBeFa), the pneumatic tube and fast rabbit systems, and the gamma irradiation facility. The reactor is also equipped with six horizontal beam-tubes in two sets of three at opposite sides of the core, and a tangential beam tube, mainly used for neutron scattering experiments. A cold neutron source is installed as part of the Oyster project.

For irradiation experiments, the procedures are integrated in a well-established management system. For irradiation requests that have been bounded by previously conducted experiments, the technicians from the scientific department can directly proceed the irradiation after approval from the reactor operator in an electronic registration system. For irradiation requests that exceed the existing data envelope, a formal review for assessing reactor safety will be conducted by the responsible personnel. In addition, an internal permit from health physics is required to ensure radiation safety when handling irradiated material will be involved. Prior to the implementation phase of the irradiation experiment, an authorization from the head of reactor operation (HOR-B) will be needed. The existing management system for irradiation experiments does not cover well-defined review and approval routes for those categorized to be with major or significant effect on safety and are subjected to regulatory approval as recommended in the IAEA safety standards No. SSG-24.

For neutron beam tube utilization, the experimenters will need to coordinate with the reactor operators for the shutter opening/close and will conduct the experiments primarily in the experiment hall. There is no formal authorization procedure and a scheduling system for using beam lines. It is thus suggested to integrate the management system for beam line utilization (as well as other reactor experiments) with the one being used for irradiation experiments.

One major ongoing effort for the HOR utilization is to commission the cold neutron source that is used to moderate thermal neutrons into cold neutrons, delivered into the neutron scattering instruments through the neutron guide. Most of the construction works that related to this utilization/modification have been completed. The associated safety analyses and the commissioning plan have also been completed and approved by the regulatory body.

The IAEA team observed that the current RID practice conducts the safety classification for SSCs, including the various facilities used in the utilization programme, in a comprehensive manner. However, while discussing the individual experiments, the team observed lack of systematic categorization process based on the safety assessment results for each single experiment regardless the classification of the involved facilities. This practice is not in line with the guidance provided in the IAEA safety standards No. SSG-24. The review and approval route for a utilization project should be based on the safety category determined for the experiment, for which the nature of the experiment, i.e. a new experiment, a repetitive experiment or isotope production, should be taken into account.

3. POSSIBLE SAFETY CONSEQUENCES

The lack of systematic safety categorization process for HOR experiments will result in inconsistent review and approval routes for its utilization programme and will thus increase the risk of inadequate assessment of their effect on safety. It will also reduce the effectiveness of the integrated management system.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R18) A formal process for safety categorisation of utilization and experiments should be established in accordance with the IAEA safety standards No. SSG-24. Utilization and experiments with major safety significance should be subjected to safety analysis, routes of approval, and procedures for design, quality, fabrication, and commissioning equivalent to those applied for the reactor itself.

ISSUE MOD01: Need to establish criteria on modifications

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 Series No. SSG-24: Safety in the Utilization and Modification of Research Reactors, (2012)
- HOR PowerPoint Presentation, Safety of Modification, September 2021
- Safety Analysis Report Hoger Onderwijsreactor Reactor, Chapter 11, February 2019

2. ISSUE CLARIFICATION

Comprehensive procedures exist at the RID for carrying our major modifications, where the focus has been placed on modifications of SSCs. The procedures provide guidance for safety classification of the planned modification and its verification, in which the safety class (SC) 1 and 2 modifications are required for detailed modification proposal, safety committee review and regulatory approval. The RID does not have specific instructions in case of modifications of process and organization, except its integrated management system requires to assess the impact of these modifications on nuclear safety.

The replacement of individual HOR SSCs can be implemented based on the case-by-case evaluations. If the replacement part has the same (or very similar) functional parameters as the original, it is thus not considered as a modification and can be replaced without further assessment. The counterpart indicated that such a consideration remains valid even if the replaced parts may differ by type or vendor, but this is also subjected to case-by-case evaluation. The IAEA team was of the opinion that the distinction between replacement and modification is not well described and this decision is usually made by the head of HOR development.

The IAEA team discussed with the counterparts several examples from recent modifications, including:

- Modernization of reactor protection system voting logic (SC1);
- Modernization of primary (SC2) and secondary (SC3) cooling systems;
- Modernization of remote monitoring room (SC3).

Although the safety classification of above-mentioned modification projects is slightly different from the recommendations of the IAEA safety standards No. SSG-24, the RID practice is on the conservative side. For example, the secondary cooling circuit could be categorized as non-safety item. In addition, the implementation of these modifications follows all necessary administrative steps, including vendor auditing, commissioning plans, documentation updates, personnel training, etc. The IAEA team observed that their safety analyses, however, are not included in the SAR. Instead, they are documented in separate files. The counterpart explained that the update of SAR with such information has been planned, but only a brief list of experiments and modifications will be included.

3. POSSIBLE SAFETY CONSEQUENCES

Inadequate assessment of modification projects can jeopardise reactor safety. Replacement, even with the SSCs featuring the same functional parameters, may potentially result in safety risks for reactor operation. The case-by-case evaluation, rather than a systematic process, may also introduce inconsistency in the decision-making process.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R19) Criteria should be clearly defined, and documented, on what constitutes a routine replacement or a modification of SSCs important to safety. This should be supplemented by definition of the relevant safety requirements, including the need for safety analysis, routes for approval, and procedures for implementation.

ISSUE RWM01: Need to further improve the operational radioactive waste management

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 No. NS-G-4.6: Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, (2008)
- HOR PowerPoint Presentation, Radiation Waste Management, September 2021
- Safety Analysis Report Hoger Onderwijsreactor Reactor, Chapter 12, April 2019

2. ISSUE CLARIFICATION

Gaseous, liquid and solid wastes are produced from the HOR reactor and its associated laboratories. The waste management is handled by the SBD (radiation protection team of the HOR reactor). Discussions and clarifications on the procedures and equipment in place for the types of radioactive waste abovementioned were held based on a presentation prepared by the SBD and the information provided in Chapter 12 of the SAR.

Gaseous waste: The gaseous effluents are released to the environment via a 60 m stack, which collects the streams coming from the several areas in the HOR premises and its associated laboratories. The gross gamma activity of these effluents is measured by a detector calibrated four times per year and providing a global on-line measurement of the gaseous releases. In addition, aerosols present in these effluents are collected in a filter and measured for isotope identification purposes. Considering the relevance of the Ar-41 production for this type of facilities, a dedicated detector was included in a buffer air box providing a reference volume for the measurements, as well as a method for averaging the readings thus preventing spurious peaks in the signal. This method is also used for averaging the peaks produced by the utilisation of the pneumatic system to prevent reactor trips due to spurious signals. An aliquot of the air being released is pumped back from the stack and filtered by a charcoal filter which is measured off-line for determining possibly iodine releases. Differently, tritium and C-14 are not directly measured. Instead, the predictions of their release, by adopting assumptions developed some time ago, are reported to the regulatory body. These results are not well documented nor validated in recent years.

Liquid waste: A substantial amount of waste water is produced from the HOR reactor and its associated laboratories (averaging more than 1 m^3 per day). It is collected in tanks for adequate sampling and measuring. This practice ensures that the RID has full control of the waste water streams produced in the several generation points across the facility. Waste water gamma, beta and gamma gross concentrations are measured and, after multiplying the values obtained by the volume of the batch and the conversion factors adopted in the Netherlands, parameters compatible with the ones specified in the license (called Re or equivalent radiotoxicity) are obtained. In the rare cases in which the calculated Re value exceeds the release limit, the water will be evaporated, and the solids collected are handled as solid waste. A recent case has been recorded for the waste water collected after maintenance activities releasing scales present in old piping replaced as part of the Oyster project. In some laboratories, the production of waste water contaminated with radioactive products or chemically inadequate for being disposed to the normal network, are collected in the so called "jerry cans" and, after characterisation, transferred to COVRA for adequate treatment.

Solid waste: Solid waste produced in laboratories and disposable items used by the operating personnel, researchers and visitors, are segregated and packaged in bags of different colours. Bags not containing radioactive material are measured for clearance and disposed properly by the SBD. Packages identified by the generator as radioactive are directly sent to COVRA after characterisation. Sometimes certain experimental equipment is installed in the reactor pool. The researchers often prefer to leave it in the pool after the conclusion of experiment for potential future projects. The HOR-O (department of development) maintains a list of such equipment and each such item in the pool is also labelled. This is in line with the requirement of the IAEA safety standard No. SSR-3. However, if after certain period there is no use of certain equipment, it is the responsibility of the HOR-B (department of operation) to proclaim it as a radioactive waste and start the procedure for its delivery to COVRA with the assistance of the SBD. As of the time of this INSARR mission, there is no written procedure, which is required by SSR-3, developed for how this list of equipment in the pool is maintained and when and how it will be declared as a waste. The IAEA team observed that samples used in beam experiments are being recorded and tracked by the researchers. When they are no longer in use, the SBD collects them for dispatching to COVRA.

Resins: The resins used for maintaining the quality of the cooling water in the HOR reactor are considered as a special waste when their retention efficiency is degraded. These resins are regenerated periodically thus enlarging its lifetime. After a certain time, they will be disposed. Spent resins are then collected by the SBD and the HOR-B in plastic containers and sent to COVRA for final incineration.

3. POSSIBLE SAFETY CONSEQUENCES

Reporting radionuclides based on assumptions and models that have not been revisited in recent years may lead to a lack of credibility in the reports submitted for regulatory review. Non-existence of written procedures on when and how obsolete equipment should be removed from the reactor pool and declared as a radioactive waste could result in unsafe situation with improper handling of radioactive items.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R20) RID should update the models and assumptions used for assessing the magnitude of the radionuclides released as gaseous effluents that cannot be measured by online methods, and submit the results to the safety committee and the ANVS for review and assessment.

R21) RID should establish a procedure for keeping record of unused experimental equipment in the reactor pool and improve the process for declaring unneeded equipment as radioactive waste.

ISSUE EMR01: Need to conduct emergency drills before return to normal operation

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 No. NS-G-4.6: Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, (2008)
- HOR PowerPoint Presentation, Emergency Planning, September 2021
- Safety Analysis Report Hoger Onderwijsreactor Reactor, Chapter 20, April 2019

2. ISSUE CLARIFICATION

The emergency plan for the RID is in place and covers the needs of the HOR reactor and its associated facilities. The RID emergency plan and supporting documents are aligned with the national requirements. It interfaces with the emergency response plan of the Haaglanden safety region. On its turn, this regional response plan calls for the National Radiation Incident Crisis Plan (NRICP) developed by and under the control of the national government. These three plans allow for having an adequate coverage of a wide range of abnormal scenarios requiring local, regional or nationwide responses.

The emergency scenarios at the HOR reactor are handled by the RID emergency plan, which describes the internal organizational details for emergencies as well as it provides specific instructions for the identified types of emergencies and related response actions. It also provides graphical flowcharts describing the decision process to be followed, including the measures to be taken in case of escalation being required.

The recent modifications that are included in the Oyster project were evaluated by NRG as part of a Risk Inventory and Evaluation (RIE) process thus identifying new potential hazards not covered before. In particular two items were discussed between counterparts:

- Cryogenics handling: The cryogenic equipment supporting the cold neutron source will not introduce additional risks to the ones already present in the facility when handling liquid nitrogen for some detectors and experiments;
- Oxygen depletion: Displacement of oxygen produced by helium used in the ancillary equipment of the cold neutron source has been accounted and oxygen concentration meters are available at the working place, in particular at the confined spaces.

Emergency equipment is available at the HOR reactor in pre-prepared kits, including handheld detectors and sampling tools (other than gaseous samples can be currently taken with this kit). The operability of this equipment is periodically tested. Suitable stretchers for the control room evacuation via a spiral staircase are assessed by the HOR-B staff as alternative route.

A room located outside the RID premises (building 62 of TU Delft) is available for accessing the measurements taken by the SBD monitoring network. The reading of these detectors may also be accessed via a mobile app and alarms are automatically forwarded to a “pager” in possession of the SBD officer on-call.

Periodic emergency drills to practice the internal and external arrangements are conducted, but its periodicity has been affected by the COVID-19 restrictions and the prolonged shutdown of the facility. Nevertheless, the SBD has periodic meetings for ensuring that the routine activities, as listed in the so called “to do list” are followed accordingly. It serves to ensure the operability of the equipment, such as those monitors included in the emergency kit.

3. POSSIBLE SAFETY CONSEQUENCES

Considering the upcoming resumption of operation, a drill that demonstrates the adequacy and availability of emergency procedures is considered advisable for ensuring the facility staff and the external organizations are fully aware on the operable status of the HOR reactor. If the staff and the relevant organizations are not fully aware on the reactor status, their responses to a potential emergency may be below the expectations.

4. COUNTERPART VIEWS AND MEASURES ON THE FINDINGS

The counterparts agree with the observations and the recommendations.

5. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

R22) RID should conduct an emergency drill before the planned return to normal operation for ensuring the awareness of the operating personnel, external response organizations and relevant authorities about the change in operational status after the prolonged shutdown of the reactor.

ISSUE DECOM01: Decommissioning plan for the HOR reactor

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 No. NS-G-4.6: Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors, (2008)
- HOR PowerPoint Presentation, Decommissioning Plan, September 2021
- Safety Analysis Report Hoger Onderwijsreactor Reactor, Chapter 19, April 2019

2. ISSUE CLARIFICATION

The RID has developed a preliminary decommissioning plan for the HOR reactor. It covers the following areas:

- Description of facility;
- Physical and radiological inventory;
- Main assumptions on external requirements such as clearance levels;
- Decommissioning strategy including outline of several decommissioning phases; used decommissioning techniques and waste management;
- Cost estimation including comparison with the previous plan.

The decommissioning plan is periodically updated every 5 years and is submitted to the ANVS (regulatory body) for approval. The presented cost estimation for decommissioning is subjected for approval by the Dutch Ministry of Finances. The latest approved plan is dated 2015. A new one is currently under review by the ANVS.

The decommissioning goal is the green field, which is mandatory by the Dutch law. The planned decommissioning start date is 2050.

The estimated cost is reserved by the TU Delft in form of a financial guarantee, which ensures adequate funding even in case of a decommissioning prior the planned date.

The waste treatment plan is not developed to the details of having waste treatment solutions for each material. Such details will be prepared during the preparation of decommissioning license. The same is valid for the accident analysis.

The impact on decommissioning has been analysed during each major modification project. The approach of wastes minimization is generally applied, such as routine nuclear activation analysis to evaluate the ^{60}Co content in structural material. The decommissioning plan is being periodically updated. For example, the 2015 plan includes the cold neutron source materials for decommissioning.

3. RECOMMENDATION/SUGGESTIONS/GOOD PRACTICES

The practices of the HOR reactor in this area are in line with the IAEA safety standards and there are no recommendations in this area.

ANNEX I: DOCUMENTS FROM THE COUNTERPARTS

The following documents (or tables of contents) were provided by the RID in advance of the INSARR mission:

- Safety analysis report (snapshot 15.09.2020);
- Regulatory inspection programme (2018 – 2020) and inspection report (2020);
- Description for integrated management system;
- List of major modifications (HOR V2);
- Operational limits and conditions (OLC or VTS in Dutch);
- Maintenance and ageing management programme;
- Term of reference and list of items reviewed for safety committee;
- Training and quantification programme;
- Radiation protection and waste management programme;
- Emergency plan;
- Operating procedures (list and architecture only);
- Finding from 2011 periodic safety review;
- Decommissioning plan;
- Report on safety culture survey (2021);
- References for the chapter of safety analysis;
- PowerPoint presentations on all review areas (August 2021).

ANNEX II: AGENDA

<table>
<tr><th colspan="3">MONDAY 6 September 2021 (Hotel)</th></tr>
<tr><td>17:00-
18:30</td><td colspan="2">IAEA Team Meeting:
Conduct and reporting of an INSARR mission (led by Sears)
Preliminary comments from available documents (10 minutes for each team member)</td></tr>
<tr><th colspan="3">TUESDAY 7 September 2021</th></tr>
<tr><td>09:00</td><td colspan="2">Entry meeting
Opening address: HOR and IAEA
ANVS: Bos, Boom, Bulk, Dijkman, Schipper</td></tr>
<tr><td>09:30</td><td colspan="2">Presentation from HOR: General description of the HOR reactor and its safety status
IAEA: All
HOR: All
ANVS: Bos, Boom, Bulk, Dijkman, Schipper

(Fermi-Lorentz room)
Wolterbeek; Presentation RID
Kaaijk; Presentation General description of the HOR reactor and its safety status</td></tr>
<tr><td>10:30</td><td colspan="2">Operating organization and reactor management[1]
IAEA: All (led by Sears*)
HOR: Wolterbeek, Blaauw, Ardesch, Kaaijk
ANVS: Bos, Boom, Bulk, Dijkman, Schipper
(Fermi-Lorentz room)</td></tr>
<tr><td>11:30</td><td colspan="2">Safety committee
IAEA: All (led by Sears*)
HOR: Kloosterman, Okx, Schut, van den Heuvel, (Wolterbeek)
ANVS: Bos, Boom, Bulk, Dijkman, Schipper
(Fermi-Lorentz room)</td></tr>
<tr><td>12:00</td><td colspan="2">Lunch break (Reception hall) (Kloosterman, Okx, Schut, Wolterbeek Kaaijk, Ardesch)</td></tr>
<tr><td>13:00</td><td colspan="2">Training and qualification
IAEA: All (led by Sears*)
HOR: Ardesch, van der Horst, van den Hurk
ANVS: Dijkman
(Fermi-Lorentz room)</td></tr>
<tr><td>14:00</td><td colspan="2">Safety Instruction
IAEA: All
(Meitner room)</td></tr>
<tr><td>14:15</td><td colspan="2">HOR Reactor walkthrough
IAEA: All
HOR: 1 or 2 groups (Kaaijk, van Wijk, Ardesch, SBD)</td></tr>
<tr><td>17:00-
18:00</td><td>IAEA Team Meeting
(Fermi-Lorentz room)</td><td>RID team meeting feedback from sessions
(1 person per session)
(Curie room)</td></tr>
</table>

[1] As agreed in pre-INSARR meeting, the discussions in all sessions will start by a presentation from HOR on relevant review areas.

WEDNESDAY 8 September 2021			
09:00	**Briefing the main counterpart** (Sears)		
09:00	**Maintenance, periodic testing and inspection, including ageing management activities** **IAEA:** Joppen*, Juricek, Sun **HOR:** Ardesch, van den Hurk, Daams (Curie room)	**Radiation protection programme** **IAEA:** De Lorenzo*, Stritar, Sears **HOR:** Okx, Dezentje, van den Heuvel **ANVS:** Arends (Fermi room)	**Safety Culture (1) General overview of safety culture work at HOR** **IAEA:** Pike* **HOR:** Wolterbeek, Blaauw, van Rijn **ANVS:** Dijkman (Lorentz room)
12:00	Lunch break (Reception hall) (Ardesch, Okx, Dezentje, Blaauw, Wolterbeek, van Rijn, Kaaijk)		
13:00	**Maintenance, periodic testing and inspection, including ageing management activities (Cont)** **IAEA:** Joppen*, Juricek, Sun, Stritar, De Lorenzo, Sears **HOR:** Ardesch, van den Hurk, Daams (Curie room)	**Safety Culture (2) Institute level** **IAEA:** Pike* **HOR:** Wolterbeek, Blaauw **ANVS:** Dijkman (Lorentz room)	
		Safety culture (3) – Training **IAEA:** Pike* **HOR:** Kaaijk, van der Horst **ANVS:** Dijkman (Lorentz room)	
17:00-18:00	IAEA Team Meeting (Fermi room)	RID team meeting feedback from sessions (1 person per session) (Curie room)	
THURSDAY 9 September 2021			
09:00	**Briefing the main counterpart** (Sears)		
09:00	**Utilization and experiments** **IAEA:** Sun*, Juricek, Joppen **HOR:** Molag, Winkelman, Kaaijk (Curie room)	**Conduct of operations** **IAEA:** Stritar*, De Lorenzo, Sears **HOR:** Ardesch, van der Horst, van den Hurk **ANVS:** Dijkman (Fermi room)	
	Major modifications **IAEA:** Juricek*, Sun, Joppen **HOR:** van Wijk, Molag, Kaaijk (Curie room)		
12:00	Lunch break (Reception hall) (van Wijk, Molag, Ardesch, van der Horst van den Hurk, Kaaijk)		
13:00	**Safety analysis including external hazards assessment** **IAEA:** Sun*, Joppen, Juricek, Stritar, De Lorenzo, Sears **HOR:** Hassink, Winkelman	**Safety culture (4) Corrective Action System** **IAEA:** Pike* **HOR:** Ardesch, van der Horst, Blaauw **ANVS:** Dijkman (Curie room)	

<table>
<tr><td></td><td>ANVS: Bulk
(Fermi room)</td><td>Safety Culture (5) Human Factors management
IAEA: Pike*
HOR: Ardesch, Kaaijk, Molag
ANVS: Dijkman
(Curie room)</td></tr>
<tr><td>17:00-
18:00</td><td>IAEA Team Meeting
(Fermi room)</td><td>RID team meeting feedback from sessions
(1 person per session)
(Curie room)</td></tr>
<tr><td colspan="3">FRIDAY 10 September 2021</td></tr>
<tr><td>09:00</td><td colspan="2">Briefing the main counterpart (Sears)</td></tr>
<tr><td>09:00</td><td colspan="2">General Comments on Safety Culture
IAEA: All (led by Pike*)
HOR: Wolterbeek, Blaauw, Ardesch, Kaaijk, Kloosterman, Pos, van Rijn
ANVS: Boom
(Fermi-Lorentz Room)</td></tr>
<tr><td>10:00</td><td>Operational Limits and Conditions
IAEA: Joppen*, Juricek, Sun
HOR: van Wijk, Winkelman
(Fermi-Lorentz Room)</td><td>Radioactive waste management
IAEA: De Lorenzo*, Stritar, Sears
HOR: Okx, Dezentje, van den Heuvel
ANVS: Ménard
(Curie room)</td></tr>
<tr><td>13:00</td><td colspan="2">Lunch break: (Reception hall) (van Wijk, Winkelman, Okx, Dezentje, Kaaijk)</td></tr>
<tr><td>14:00</td><td>Management system for the operation phase
IAEA: Juricek*, Joppen, Sun
HOR: Blaauw, van der Horst

(Fermi-Lorentz Room)</td><td>Regulatory supervision

IAEA: Stritar*, De Lorenzo, Sears
HOR: Okx, Kaaijk, Dezentje
ANVS: Bulk, Boom
(Curie room)</td></tr>
<tr><td>17:00-
18:00</td><td>IAEA Team Meeting
(Fermi-Lorentz Room)</td><td>RID team meeting feedback from sessions
(1 person per session)
(Curie room)</td></tr>
<tr><td colspan="3">SATURDAY 11 September 2021 (Hotel)</td></tr>
<tr><td>09:30</td><td colspan="2">Development on issue pages (Team members)</td></tr>
<tr><td>12:30</td><td colspan="2">Lunch</td></tr>
<tr><td>14:00-
17:00</td><td colspan="2">Discussion on issue pages (Team members)</td></tr>
<tr><td colspan="3">SUNDAY 12 September 2021- Free Day</td></tr>
<tr><td colspan="3">MONDAY 13 September 2021</td></tr>
<tr><td>09:00</td><td colspan="2">Briefing the main counterpart (Sears)</td></tr>
</table>

<table>
<tr><td>09:00</td><td>Decommissioning plan
IAEA: Juricek*, Joppen, Sun,
HOR: Kaaijk, Rutten
ANVS: Beuker
(Fermi Lorentz room)</td><td>Emergency Planning
IAEA: De Lorenzo*, Stritar, Sears
HOR: van den Heuvel, Okx (Nouse)
ANVS: Boxman
(Curie room)</td></tr>
<tr><td>12:00</td><td colspan="2">Lunch (Reception hall) (Kaaijk, Rutten, Okx, Ardesch)</td></tr>
<tr><td>13:00</td><td colspan="2">General comments on the safety analysis report
IAEA: All (led by Sears*)
HOR: : Hassink, Kaaijk, van Wijk, Winkelman, Ardesch, van den Heuvel
ANVS: Bulk
(Fermi Lorentz room)</td></tr>
<tr><td>15:00-
17:00</td><td colspan="2">Drafting of the mission executive summary report (IAEA Team)
(Fermi Lorentz room)</td></tr>
<tr><td colspan="3">TUESDAY 14 September 2021</td></tr>
<tr><td>09:00</td><td colspan="2">Finalization of the mission executive summary report (IAEA Team)
(Fermi Lorentz room)</td></tr>
<tr><td>10:30</td><td colspan="2">Exit Meeting: Mission conclusions and main recommendations
IAEA: All (led by Sears)
HOR: All
ANVS: Van der Heijdt, De Jong, Boom, Dijkman
(Fermi Lorentz room)</td></tr>
<tr><td>12:30</td><td colspan="2">Closing</td></tr>
</table>

* Leads the discussion

ANNEX III: LIST OF PARTICIPANTS

RID Participants:

Bert Wolterbeek, Director RID
Jan-Leen Kloosterman, Department chair RST; Chairman Reactor Safety Committee (RVC)
Camiel Kaaijk, Head of department HOR-Development
Henk Ardesch, Head of department HOR-Operations
Alex van den Hurk, Technical project coordinator HOR-operation
August Winkelman, Reactor Physics software specialist
Arjen Molag, Engineer HOR-Development
Rene Nouse, Head security
Gerwin Hassink, Engineer HOR-Development
Henk Schut, Researcher
Jan Okx, Head Health physics department
Josette Dezentje, Radiation Hygienist & Policy Advisor
Maikel Rutten, Engineer HOR-Development
Menno Blaauw, Programme Manager Integrated Management System/ Head of lab INAA
Erwin van Rijn, Department Safety Officer
Tristaan Daams, Chief Operator
Niels van Wijk, Engineer HOR-Development
Milan van der Horst, Chief operators/ QA coordinator HOR
Gijs van der Mijden, Coordinator technical services HOR
Raymon van Banen, Starting operator

ANVS Representatives:

Jurrian Boom, Coordinator International Affairs, Dept. of Strategy and Regulatory Affairs
Bertie van der Heijdt, Department Head, Nuclear Installations and Transport
Rick Bulk, Team Lead for Authorization
Rodney Bos, Team Lead for Regulatory Oversight and Enforcement
Joran de Jong, Deputy Inspector RID-HOR, Regulatory Oversight and Enforcement
Ronald Schipper, Senior Inspector, Regulatory Oversight and Enforcement
From the Department of Research, Review, and Assessment:
Anja BoxmanDijkman, Officer Senior Inspector Human and Organisational Factors
Patrick Arends, Senior Inspector Radiation Protection
Hubert Boxman, Coordinator Emergency Preparedness
Niels Beuker, Consultant Radioactive Waste and Dismantling

IAEA Team:

David Sears, RRSS/NSNI – Team Leader
Kaichao Sun, RRSS/NSNI – Deputy Team Leader
Caroline Pike, OSS/NSNI – Nuclear Safety Officer
Nestor De Lorenzo, Argentina
Frank Joppen, Belgium
Vlastimil Juricek, Czech Republic
Andrej Stritar, Slovenia