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REPORT OF THE

# SAFETY REVIEW MISSION ON SAFETY ASPECTS OF CONSTRUCTION PROGRAMME OF THE PALLAS RESEARCH REACTOR

TO THE

## PALLAS RESEARCH REACTOR

**PETTEN, NETHERLANDS, KINGDOM OF THE**

**25 June – 2 July 2024**

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
DIVISION OF NUCLEAR INSTALLATION SAFETY

**INTERNATIONAL ATOMIC ENERGY AGENCY**

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| **Mission Date:** | 25 June – 2 July 2024 | |
| **Location:** | Petten, Netherlands, Kingdom of the | |
| **Facility:** | PALLAS Research Reactor | |
| **Organized by:** | IAEA at the request of the Authority for Nuclear Safety and Radiation Protection (ANVS), Netherlands, Kingdom of the | |
| **Conducted by:** | Mr J. Christensen | RRSS/NSNI – Team Leader |
| | Ms A. Bradford | Director, NSNI |
| | Mr M. Kovachev | Bulgaria |
| | Mr P. O'Bryan | USA |
| | Mr D. Rao | India |
| | Mr D. Sears | Canada |
| | Mr A. Stritar | Slovenia |

# EXECUTIVE SUMMARY

From 25 June to 2 July 2024, a safety review mission of the PALLAS reactor construction site was conducted by an IAEA team. The team consisted of one IAEA staff member as the team leader and five international experts. The mission reviewed various aspects of the construction and commissioning programmes associated with construction of the planned PALLAS research reactor.

The mission consisted of advance review of documents provided by PALLAS; discussions with PALLAS staff and staff members from the general contractor, FCC, the reactor designer, ICHOS, and representatives from the Dutch regulatory body, Authority for Nuclear Safety and Radiation Protection (ANVS); a construction site walkthrough; and deliberations between the team members and the counterparts. The team was provided detailed presentations on all the review topics which highlighted the current status of the project and future activities.

The review areas for the mission included:

- Management system for construction (including QA programme for construction);
- Organizational structure for construction, commissioning and operation, including managing the interfaces between different entities and groups;
- Interaction between the future operating organization and regulatory body during construction, and preparation for commissioning;
- Interface between design and construction: design safety features of construction and commissioning;
- Construction programme: Inspection and test plan, construction procedures, maintenance of installed equipment during construction phase, system handover during construction and from construction to commissioning.
- Training and qualification of the reactor future operating personnel, including during construction and commissioning;
- Update of reactor safety and operating documentation; and
- Leadership in construction and safety culture with focus on human factors.

The safety review was conducted on the basis of the IAEA Safety Standards, and generally concluded that the PALLAS organization is closely aligned with IAEA safety standards needed to undertake the design and construction of the PALLAS research reactor. The organization has established comprehensive organizational and technical measures to ensure that safety is given the highest consideration in planning and implementing the design and construction activities. Management and staff are highly motivated, knowledgeable, and sensitive to the importance of nuclear safety at all levels of the organization.

The IAEA team identified areas with opportunities for improvement and provided recommendations and suggestions to address these areas. These areas cover organizational and management aspects, construction programme and activities, training and qualification programmes, and safety documents.

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# 1. INTRODUCTION

## 1.1 BACKGROUND

In a letter dated 22 December 2020, Mrs. A.M.P. van Bolhuis, Chair of the Board, Authority for Nuclear Safety and Radiation Protection (ANVS), the Kingdom of the Netherlands, requested an IAEA safety review mission on the safety aspects of the construction programme of the Pallas Reactor (PALLAS) in the province of North Holland. It was proposed that the practical arrangements for the implementation of this mission – including its exact date, scope, work plan and technical documents to be submitted for review, and IAEA documentation to be used as basis of the review – would be discussed and agreed upon at a preparatory meeting to be held during the first half of 2021 and attended by the officials from the Authority for Nuclear Safety and Radiation Protection (ANVS), PALLAS, and the IAEA.

The preparatory meeting for this mission was conducted via virtual means in April 2021 between IAEA, ANVS and PALLAS representatives. A follow-up virtual meeting was held on 11 May 2023 with [redacted] of PALLAS; Mr Vincent van Rixel, Mr Stef Carelsen and Mr Philip Valkiers of ANVS; and Mr Amgad Shokr, Mr David Sears, and Mr Kaichao Sun of IAEA, for preparation of the mission. Terms of Reference for this mission were developed and agreed upon during these meetings.

The PALLAS project began in 2010, with significant licensing progress starting in 2017. From 2017 to 2019, the focus was on the conceptual design phase, accompanied by site characterization studies. In parallel regular meetings with ANVS experts have started. Between 2017 and 2022 there were more than 150 such meetings. The preparation of the Preliminary Safety Analysis Report (PSAR) started in mid-2018. The basic design phase followed in 2019-2020, during which the Deterministic Safety Analyses (DSA) and Probabilistic Safety Analysis (PSA) were developed.

In September 2022 the government of the Kingdom of the Netherlands announced it put aside €1.290M ($1.393M) for the PALLAS project, which has cleared the path for ANVS and PALLAS to proceed with practical arrangements for an IAEA safety review mission on safety aspects of the construction programme of the reactor.

## 1.2 OBJECTIVE AND SCOPE

The objective of the mission was to review the safety aspects of the PALLAS construction programme and the transition from the construction to the commissioning phase.

The scope of the mission covered:

- Management system for construction (including QA programme for construction);
- Organizational structure for construction, commissioning and operation, including managing the interfaces between different entities and groups;
- Interaction between the future operating organization and regulatory body during construction, and preparation for commissioning;
- Interface between design and construction: design safety features of construction and commissioning;

- Construction programme: Inspection and test plan, construction procedures, maintenance of installed equipment during construction phase, system handover during construction and from construction to commissioning.
- Training and qualification of the reactor future operating personnel, including during construction and commissioning;
- Update of reactor safety and operating documentation; and
- Leadership in construction and safety culture with focus on human factors.

## 1.3 BASIS OF THE REVIEW

### 1.3.1 Basis Documents

The following IAEA documents were used as the basis for the review:

- 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)
- IAEA Safety Standards No. GS-G-3.5, The Management System for Nuclear Installations (2009)
- IAEA Safety Standards Series No. SSG-10 (Rev. 1), Ageing Management for Research Reactors (2023);
- IAEA Safety Standards Series No. SSG-20 (Rev. 1), Safety Assessment and Preparation of the Safety Analysis Report for Research Reactors (2022);
- IAEA Safety Standards Series No. SSG-24 (Rev. 1), Safety in the Utilization and Modification for Research Reactors (2023);
- IAEA Safety Standards Series No. SSG-37 (Rev. 1), Instrumentation and Control Systems and Software Important to Safety of Research Reactors (2023).
- IAEA Safety Standards No. SSG-38, Construction of Nuclear Installations (2015)
- IAEA Safety Standards No. SSG-50, Operating Experience Feedback for Nuclear Installations (2018).
- IAEA Safety Standards No. SSG-69, Equipment Qualification for Nuclear Installations (2021);
- IAEA Safety Standards Series No. SSG-80: Commissioning for Research Reactors (2023);
- IAEA Safety Standards Series No. SSG-81, Maintenance, Periodic Testing and Inspection for Research Reactors (2023);
- IAEA Safety Standards Series No. SSG-82: Core Management and Fuel Handling for Research Reactors (2023);
- IAEA Safety Standards Series No. SSG-83, Operational Limits and Conditions and Operating Procedures for Research Reactors (2023);
- IAEA Safety Standards Series No. SSG-84, The Operating Organization and Recruitment Training and Qualification for Research Reactor Personnel (2023);
- IAEA Safety Standards Series No. SSG-85, Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors (2023).

### 1.3.2 Review Criteria

The mission was conducted on the basis of the IAEA safety standards. The recommendations and suggestions in this report have been formulated in accordance with the following definitions:

*Recommendations*

Recommendations are IAEA team advice for improving safety based on IAEA safety standards and recognized good practices. The recommendations focus on WHAT is recommended to be done. The "Suggestions" described below may mention approaches on HOW to implement the recommendations. The recommendations are designated with the letter "R" in the mission report.

*Suggestions*

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

## 1.4 CONDUCT OF THE MISSION

The mission was conducted on the basis of the IAEA safety standards. The mission team was consisted of an IAEA staff member, Mr J. Christensen (Senior Nuclear Safety Officer, IAEA Research Reactor Safety Section (RRSS), Team Leader), and five international experts: Mr D. Rao (India), Mr M. Kovachev (Bulgaria), Mr D. Sears (Canada), Mr A. Stritar (Slovenia), and Mr P. O'Bryan (USA). The main technical counterpart of the mission was Mr M. Groothuis (NRG-PALLAS). The discussions during the mission were held with the participation of senior managers and staff of NRG-PALLAS, technical advisors of FCC Construcción (FCC) and ICHOS, the reactor designer, and representatives from the regulatory body, ANVS. Ms A. Bradford (Director, Division of Nuclear Installation Safety, IAEA) participated in the last two days of the mission.

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

- Examination and assessment of PALLAS reactor safety documents. The reviewed documents are listed in Annex I;
- A project site walkthrough;
- Discussions with the PALLAS management and technical staff and representatives from the main contractors, ICHOS and FCC. The agenda of activities during the mission is listed in Annex II;
- Discussions among the IAEA team members;
- Preparation of the mission report;
- Exit meeting.

During the walkdown of the reactor site, the IAEA team observed the construction activities and staging of equipment used in construction, installed safety equipment and informational postings, and provisions to ensure safety of the construction site from radiological hazards arising from adjacent operational nuclear facilities. These provisions were discussed with NRG-PALLAS throughout the walkthrough.

Using the provided documents and discussions with NRG-PALLAS counterparts, the IAEA team developed several observations and conclusions. The review process compared the observations and conclusions of the team with the IAEA safety standards. This comparison resulted in recommendations and suggestions for enhancing the safety of the project during commissioning and facility operations in general.

The mission's main recommendations and conclusions were presented in a summary report and discussed with the PALLAS counterparts during the exit meeting. There was general agreement by the counterparts on the IAEA recommendations.

## 1.5 SUMMARY INFORMATION OF THE FACILITY

The PALLAS reactor is an under-construction research reactor designed to accommodate medical isotopes production and irradiation facilities for research, located in the Kingdom of the Netherlands at the site of the existing High Flux Reactor (HFR). The reactor has an open-pool design which consists of the reactor core in a tank which serves to direct cooling flow to the fuel elements. The core tank is contained in a large cooling pool which provides secondary and back-up cooling capability to the reactor, as well as enabling access to the core for servicing and fuelling. The reactor fuel elements are low-enriched uranium, and the reactor has both beryllium and heavy water reflectors. The reactor building also houses hot cells which enable safe and efficient access to irradiated materials from the reactor for isotopes extraction or examination of experiments.

The project is currently in a 'comprehension' phase in parallel with the beginning stages of construction. The site excavation and construction of the sub-foundation structures are ongoing in preparation for construction start of the nuclear foundation and reactor facility. The comprehension phase is intended to ensure that sufficient resources and plans are in place and to sub-divide those plans using contract mechanisms which batch the work and establish appropriate progress milestones.

At the time of the mission, there were four contract batches, of an expected fourteen, in various stages of development and implementation. The primary excavation of the sub-grade facility features had been completed and preparations were being made to pour the first level of sub-grade concrete which will serve as a base-mat for a subsequent facility foundation.

# 2. CONCLUSIONS AND RECOMMENDATIONS

The mission team concluded that the PALLAS organization is closely aligned with IAEA safety standards needed to undertake the design and construction of the PALLAS research reactor. The organization has established comprehensive organizational and technical measures to ensure that safety is given the highest consideration in planning and implementing the design and construction activities. Management and staff are highly motivated, knowledgeable, and sensitive to the importance of nuclear safety at all levels of the organization.

The IAEA team noted that use of IAEA Safety Standards is apparent and emphasized throughout the documentation and presentations provided to the mission team. The standards are considered as part of the basis for the design, construction, regulatory review, and licensing of the reactor. The standards are planned to be used as a basis for development and implementation of the commissioning programme. The team highlighted this behaviour and encouraged the organization to continue this good practice.

The IAEA team also observed formal and informal communication between the PALLAS organization and ANVS in planning and implementing activities of safety significance, including those related to development of the operating organization, safety assessment, fabrication and installation of structures, systems, and components (SSCs) important to safety, training and qualification of future operating staff, and preparation for commissioning. The team encouraged the PALLAS organization to continue to strengthen the formal and informal communication with its regulatory body to ensure that activities of safety significance are appropriately reviewed and approved.

The IAEA team observed the work done to-date by the PALLAS organization to develop a strong culture for safety during construction. Nevertheless, the team highlighted that in a complex project, such as the PALLAS reactor, there will be a large amount of work to be completed, important milestones to be achieved, and there may be a significant number of challenges to be overcome before the first fuel loading into the reactor core. In this regard, the team stressed the need to continue to observe good safety practices and continue to promote a strong culture for safety so that safety is not compromised when meeting the planned project schedules and deadlines.

The IAEA team also highlighted the establishment of a design authority within the operating organization. The early and effective implementation of the design authority, particularly at an early stage in development, will enhance safety and capacity-building for the PALLAS organization. Additionally, the team assessed that development of an operational readiness programme and allocation of resources for management and implementation of this programme at an early stage of the reactor project is a good practice that will improve safety during the commissioning and operating phases of the reactor. Similarly, the PALLAS organization has systematically incorporated Build Assurance Justification from the onset of the design process throughout construction and commissioning, which is expected to enhance safety throughout the reactor lifetime.

The IAEA team identified areas with opportunities for improvement and provided recommendations and suggestions to address these areas. These areas cover organizational and management aspects, construction programme and activities, training and qualification programmes, and safety documents. These recommendations and suggestions are presented below.

*Organizational and Management Aspects*

- The PALLAS organization should review and update the Terms of Reference and functioning of the Safety Committee in accordance with IAEA Safety Standard No. SSR 3 to ensure the membership of the committee is effectively independent from the line management of the operating organization and all items required by the standard to be reviewed by the committee are included, as appropriate to the phase of the project.
- The PALLAS organization should update the documents describing the organization to clearly reflect the responsibilities for safety, functions, interfaces, and line of communications of all groups and individuals involved in the construction phase, including suppliers and constructors. In particular, the documents describing the organization should clearly reflect the reporting and communicating relationship between the Safety Committee and the Leadership Team for Nuclear Safety (LTNS).
- The PALLAS organization may consider revising the organizational documentation to rephrase the term, "Nuclear Safety Organization," and to emphasize that all persons in the operating organization have responsibility for nuclear safety while ensuring that each role is appropriately categorized based on its impact on nuclear safety.
- The PALLAS organization may consider developing a consolidated document within the integrated management system which clearly describes the roles, duties, and lines of communication for all the positions and committees involved in the construction and commissioning of the reactor.

*Construction Programme and Activities*

- The PALLAS organization should update the construction management plan to include the actual and planned arrangements for construction, including updating information regarding the construction organization structure, reference to the construction inspection and test plans, tests and verification procedures, and schedules and sequence of construction work, which should include hold points (as agreed with the regulatory body). The regulatory body should continue to be provided with regular and timely updates of the construction schedule.
- The PALLAS organization should evaluate and revise its information management system to ensure that information security measures and safety measures do not compromise one another, particularly the communication of design and safety information between project stakeholders and regulators. Additionally, consideration should be given to the generation of records, including videos and photographs, related to safety-significant SSCs during construction that may be needed for ageing management and decommissioning.
- The PALLAS design authority should review inspection and test plans in addition to the quality management organization to ensure that all requirements of the codes and standards used and other design features are included in the inspection and test plans.

- The PALLAS organization should ensure the ageing management plan for all stages of the lifetime of the reactor includes provisions for the necessary monitoring, testing, sampling and, inspection for the detection, assessment, prevention, and mitigation of ageing effects; for example, surveillance specimens to monitor ageing degradation of components important to safety, establishing time limited ageing analysis, and collection of baseline data in accordance with the IAEA Safety Standards Series No. SSG 10 (Rev.1).

*Training and Qualification Programme*

- The PALLAS organization should evaluate the need for, and implement as needed, a training and qualification process for persons reviewing design changes and performing change level categorizations.

*Safety Documents*

- The PALLAS organization should review and update the facility safety documents, including the safety analysis report, to consolidate information needed to justify the design of the research reactor, eliminate redundancies, and to ensure consistency. Changes to the facility design should be reviewed and approved as necessary and incorporated into the safety analysis report within a reasonable time period.

*General Safety Considerations*

- The PALLAS organization may consider mapping the design of the reactor against all applicable requirements of SSR-3 for any further safety improvements, including design extension conditions, before releasing it for construction.

The team recommends that PALLAS management develop a plan to implement the above recommendations which could be followed up during a future IAEA mission.

# 3. RESULTS OF THE MISSION

## 3.1 MANAGEMENT SYSTEM FOR CONSTRUCTION

PALLAS has developed and implemented an Integrated Management System (IMS) for the PALLAS programme that includes the PALLAS research reactor and Nuclear Health Centre. The IMS is intended to cover the entire life cycle of the PALLAS research reactor i.e., design, construction, commissioning, operation, and decommissioning. The IMS has identified thirty-nine primary processes and the associated management and support processes.

The processes are being developed and implemented in a phased manner following the PALLAS project schedule and the processes that are required early are being implemented.

### 3.1.1 Construction organization

PALLAS has established a construction organization with a defined structure specifically for the construction phase of the project. The roles and responsibilities of the positions are defined and documented. The structure includes a programme director as the overall in charge of the PALLAS organization with directors for different functions that include technical (design), construction, operational readiness, finance, information management and programme office. The structure ensures proper interfaces at the management level between design, construction, and operation.

Two companies exist in parallel with the construction organization, ICHOS and FCC. ICHOS is the responsible design organization and FCC is the main construction contractor for the PALLAS research reactor facility. To ensure co-ordination between PALLAS and the two other entities, a “joint delivery organization” (JDO) is established, which comprises representation from PALLAS, ICHOS, and FCC.

In addition to the joint delivery organization, specific roles and responsibilities are identified as the “Leadership Team for Nuclear Safety,” (LTNS). These positions occupy positions within the organization to manage and co-ordinate issues associated with nuclear safety. The mission team observed, however, that the roles, responsibilities, interfaces, and lines of communications between the LTNS and the other elements of the construction organization were not clearly defined in the organization documentation. Consequently, the team recommended that the documents describing the organization should be revised to clarify this information.

The IAEA team observed an additional sub-component of the construction organization called the “Nuclear Safety Organization,” (NSO). Based on the presentations and descriptions contained in the PALLAS organization documentation, this sub-component encompasses positions with specific responsibilities related to nuclear safety functions throughout the organization. The team perceived that this designation of positions as “in” the NSO and “not in” the NSO has the possibility of creating a division within the organization where persons in positions not designated as NSO positions may not be aware of their responsibilities for ensuring nuclear safety. After discussion with PALLAS management, it was made clear to the IAEA team that the organizational safety policy does implement the IAEA safety standards with respect to its nuclear safety policy. Nevertheless, the phrasing and use of the term “Nuclear Safety Organization” as applied to some positions and not others may hinder effective communication of management safety expectations. Consequently, the IAEA team suggests that the organizational documentation be revised to clarify the nuclear safety policy so that all personnel are aware of the policy and their responsibility for ensuring nuclear safety.

**[R1]** The PALLAS organization should update the documents describing the organization to clearly reflect the responsibilities for safety, functions, interfaces, and line of communications of all groups and individuals involved in the construction phase, including suppliers and constructors. In particular, the documents describing the organization should clearly reflect the reporting and communicating relationship between the Safety Committee and the Leadership Team for Nuclear Safety (LTNS).

**[S1]** The PALLAS organization may consider revising the organizational documentation to rephrase the term, "Nuclear Safety Organization," and to emphasize that all persons in the operating organization have responsibility for nuclear safety while ensuring that each role is appropriately categorized based on its impact on nuclear safety.

### 3.1.2 Safety Committee

The IAEA team reviewed the Terms of Reference for the Safety Committee at PALLAS. The membership of the Safety Committee includes four representatives from the PALLAS organization and two external members, all of whom are appointed by letter from the Programme Director. The Terms of Reference includes instructions on how membership appointments are performed, a general description of review scope, and instructions on the conduct of meetings of the Safety Committee and post-meeting actions.

The IAEA team noted that the Terms of Reference for the committee does not include a complete list of documents required to be reviewed by the Safety Committee as required by IAEA Safety Standards No. SSR-3. The team also observed that the membership of the Safety Committee does not have independence from the Programme Director in that several members have reporting relationships to that position internal to the PALLAS organization.

**[R2]** The PALLAS organization should review and update the Terms of Reference and functioning of the Safety Committee in accordance with IAEA Safety Standard No. SSR-3 to ensure the membership of the committee is effectively independent from the line management of the operating organization and all items required by the standard to be reviewed by the committee are included, as appropriate to the phase of the project.

### 3.1.3 Leadership and Safety Culture During Construction

The PALLAS organization has a robust safety culture programme which is based on sound principles, including the IAEA Harmonized Safety Culture Model. The concepts and practices associated with good safety culture were evident throughout the mission, including visible postings and other tools to promote discussion and emphasis on safety culture. Through the presentations by PALLAS and discussions with personnel, it was apparent to the IAEA team that a strong emphasis on safety culture exists at all levels in the organization. The PALLAS organization has a dedicated group of personnel (Organizational Development, OD) working in parallel with human resources to develop and maintain the safety culture programme.

Nevertheless, opportunities for improvement in the implementation of safety culture at PALLAS exist. In the organizational model, a "Nuclear Safety Organization" (NSO) is identified. The terminology used ("organization") implies that there is a barrier between specific roles and jobs as "in" the NSO and "not in" the NSO. This categorization creates the potential for mis-communication of the responsibility for safety throughout the organization. The responsibility for safety remains with the operating organization, and the categorization of the relevance of a particular role to the organizational responsibility should not be exclusive. (See S1)

Another opportunity for improvement is in the performance of safety culture self-assessments. It was not apparent to the IAEA team that the safety culture programme included assessments of its own effectiveness. The role of PALLAS management in fostering and supporting safety culture was emphasized throughout the mission, but the team found that there was a lack of evidence for assessment of performance of the safety culture programme itself.

### 3.1.4 Management System Processes and Procedures

PALLAS has developed and implemented an Integrated Management System (IMS) policy for the PALLAS programme that includes the PALLAS research reactor and Nuclear Health Centre. The implementation of the IMS policy is implemented in accordance with an associated IMS manual, and an individual is appointed as an IMS manager responsible for implementation. The IMS is intended to cover the entire life cycle of the PALLAS research reactor, i.e. design, construction, commissioning, operation, and decommissioning. The IMS manual includes provisions for performance management and audit and review processes to ensure that the PALLAS IMS is being implemented, monitored, and continuously improved in accordance with the IMS policy.

The IMS consists of thirty-nine primary, management, and support processes. These processes are being developed and implemented in a phased manner following the PALLAS project schedule and the processes that are required early in the project have been or are being implemented. The IMS includes: processes and the documentation system; process classification; safety-relevant processes; risk management; review and audit; management of resources; stakeholder management; processes to control design integrity; processes to demonstrate reactor safety; licensing and compliance process; processes to control construction; processes to control testing and inspection (including during commissioning); processes to control operations; processes to control health, safety, and environmental protection; quality assurance and quality control for PALLAS and ICHOS; security; information management; knowledge management including knowledge transfer from ICHOS and learning from experience; and document management.

The IAEA team holds the opinion that the PALLAS IMS has been developed and is being implemented in accordance with the IAEA safety standards.

### 3.1.5 Control and Supervision of Contractors

In addition to PALLAS, two stakeholders exist and interface with the construction organization, ICHOS and FCC. ICHOS is the responsible design organization and FCC as the main construction contractor for the PALLAS research reactor facility. To ensure co-ordination between PALLAS and the two other entities, a "joint delivery organization" (JDO) is established, which is comprised of representation from PALLAS, ICHOS, and FCC.

The IAEA team was of the opinion that the joint delivery organization structure which includes the major contractor stakeholders while ensuring that PALLAS as the operating organization retains overall responsibility for safety is adequately aligned with the IAEA safety standards. The IAEA team assessed that there are adequate measures in place to ensure effective supervision of contractors' work.

### 3.1.6 Interface Management

The activities of the PALLAS programme are overseen/reviewed by several committees, e.g. a steering committee, JDO boards, a safety committee, a configuration control board, the leadership team, a design feedback committee, as well as independent review teams. The roles and responsibilities of these committees are separately documented as part of the IMS.

Because of the number and complexity of the network of committees and stakeholders, the IAEA team observed that it may be useful to have a consolidated document that describes the roles, duties, and lines of communication for all the positions and committees involved in the construction and commissioning of the reactor.

**[S2]** The PALLAS organization may consider developing a consolidated document within the integrated management system which clearly describes the roles, duties, and lines of communication for all the positions and committees involved in the construction and commissioning of the reactor.

### 3.1.7 Interface with Design

A structured systems engineering approach is used to perform the research reactor design. The design is performed by ICHOS and internally reviewed by an independent team, followed by the review by the design authority For selected SSCs, a third-party independent review is performed in addition to the review by the regulators.

PALLAS is designated as the design authority in co-ordination with ICHOS as the overall responsible designer. The design approach envisages that safety functions are accounted for, and the design complies with established safety requirements. A multi-step design review is proposed in the design process which includes a third-party independent review for SSCs most important to safety and construction organization feedback on the constructability aspects.

The design review is performed in three stages as the design progresses: preliminary design review, intermediate design review, and the critical design review. At the time of the mission, the design was not completed, and the detailed design is ongoing.

Design control is achieved by integrating several important aspects: the systems engineering approach that includes the technical specifications drawn from the user requirements, records of design inputs, and verification and validation of the design; configuration management to ensure data integrity and management of changes; information management to ensure single structured traceable data; and interface management to control interactions that occurs between systems and subsystems, enabling systems, design areas and external stakeholders.

The IAEA team highlighted the establishment of a design authority within the operating organization. The early and effective implementation of the design authority, particularly at an early stage in development, will enhance safety and capacity-building for the PALLAS organization. The IAEA team noted specifically that the PALLAS organization incorporates guidance from the IAEA safety report INSAG-19, "Maintaining the Design Integrity of Nuclear Installations throughout their Operating Life," for the establishment of the design authority function in their organization and encouraged its continued use for this purpose.

The mission team noted that the IAEA safety standards have been considered in the design and the team encouraged the design authority to map the design against all applicable requirements of SSR-3 for any further safety improvements, including design extension conditions, before releasing it for construction.

**[S3]** The PALLAS organization may consider mapping the design of the reactor against all applicable requirements of SSR-3 for any further safety improvements, including design extension conditions, before releasing it for construction.

### 3.1.8 Control of Design Changes

PALLAS has established an elaborate change management process. The scope of this process is to manage change requests while the detailed design phase is ongoing and after the final design is completed and the technical baseline is established for the PALLAS research reactor. Only those changes that impact the technical baseline are managed through this process. Changes during construction in 'as-built' configuration are managed through the non-compliance management process. If a design change is needed to resolve a non-compliance, the change management process is used, with the results returned to the non-compliance management process.

To facilitate the control of design changes, a change control board comprising members from the PALLAS and ICHOS has been established to oversee and approve design changes. The process includes change initiation, categorization of changes, change review, change impact assessment, change approval, change implementation, and change closure.

Categorization of changes based on impact to safety is performed following the guidance in IAEA SSG-24 into three categories: A++, which has a major impact to safety; A+ with a significant impact to safety; and A, with a minor impact to safety. Changes are also categorized based on impact to project scope, schedule, and cost and on the impact to the technical baseline.

The change control process is managed by the configuration control manager and the approval process for safety categories changes includes review by safety committee and ANVS review, as necessary. All relevant process owners are included in the process and final approval is given by the change control board. Change closure includes update of the relevant documents.

### 3.1.9 Handling of Non-Conformances

The PALLAS organization has developed a comprehensive non-compliance management process within its quality control process. The process applies to both material components, i.e. SSCs, and services. Identification of a non-compliance can be initiated by any of the organizations involved in the project including FCC, ICHOS, PALLAS, ANVS, or other regulators. Non-compliances are categorized in two categories: 'deviations' and 'non-conformances.' Deviations are non-compliances that do not have any impact on safety and non-conformances are non-compliances that have an impact on safety and may also include repetitive deviations. By this definition, all non-compliances related to SSCs important to safety will be categorized as non-conformances.

Disposition of non-compliances is the responsibility of the PALLAS QC manager. A graded approach is used for the disposition of deviations or non-conformances. The steps involved in the non-compliance management include identification of a non-compliance, categorization into deviation or non-conformance, proposal for correction(s), involvement of the regulator (if required), root cause analysis (if required) and proposal for systemic correction(s), evaluation and approval of the proposed correction(s), implementation of the approved correction(s), verification of the implemented correction(s), documentation of lessons learned, and closure of the non-compliance.

The IAEA team reviewed examples of the application of the non-compliance management process. These examples included supplier traceability and information management issues. The review showed that the process is implemented effectively. Nevertheless, it was noted that, specifically with regards to information management, the collection and sharing of information between stakeholders is limited by the established information security measures and may limit the information available for use in important design elements, such as aging management.

### 3.1.10 Document Control

Documentation of the PALLAS programme is managed through an information management process within the IMS. PALLAS stores all documents in its electronic document management system as records. The IAEA team considered the information management system to be aligned with the IAEA safety standards.

### 3.1.11 Quality Assurance Programmes for Contractors and Sub-contractors

PALLAS has established a quality management process as a support process within the IMS. To support the quality management process, a quality management group is established with two distinct functions of quality assurance and quality control. The quality management group has developed a project quality plan based on the European and Dutch regulations, ANVS requirements, and international and national codes and standards including IAEA safety requirements and ISO standards. Several supporting documents have been developed that include quality level setting, quality stream plans, supply chain audit, inspection and test plans, third party review, and includes a build assurance justification to verify that the construction has been done as per design.

The main responsibilities of the quality assurance function include: verification activities; defining the project quality requirements; issuing a clear quality framework with plans and procedures; supporting the project team in developing deliverables that comply with the requirements; cascading the quality requirements down to the supply chain; assessing and auditing the supply chain for compliances and improvements; defining additional hold or witness points; assessing key performance indicators including trend analysis; identifying and implementing continuous improvements; and communicating with the regulators.

The main responsibilities of the quality control function include: developing and implementing the procedures and instructions to ensure quality; adopting fit for purpose quality control tools; on-site and off-site quality inspections including performing spot checks; approving ITPs issued by supply chain; monitoring of inspections and tests; managing non-compliances; ensuring suitably-qualified experience persons (SQEPs) for quality control conducted by the supply chain; and communicating with the regulators. The quality assurance function also includes audits of the contractors' and sub-contractors' quality assurance programmes performed by PALLAS.

The IAEA team observed that, at present, PALLAS does not have an adequate number of qualified and experienced personnel to perform all quality control tasks for the project. PALLAS has outsourced the tasks to an accredited company.

#### 3.1.12 Classification of Structures, Systems, and Components

The PALLAS organization has a process for safety classification of structures, systems, and components (SSCs). The process is incorporated into the 'Reactor Safety Demonstration Process' based on the Dutch safety requirements (DSR) and the IAEA safety standards. The process thus defines two types of safety functions, 'fundamental safety functions' (FSFs) and 'specific safety functions.' The fundamental safety functions relate to ensuring the research reactor reaches a controlled condition and then a safe condition based on the defence-in-depth (DID) levels. The specific safety functions are defined as the safety functions that are considered in the safety analysis and radiological assessment that otherwise do not relate to the fundamental safety functions. These specific safety functions do not take part in the DID levels related to the reactor core.

The safety classification of SSCs that contribute to the fundamental safety functions starts with the identification of the functions themselves. After identification of the FSFs, SSCs which perform them are categorized into types, considering: the severity of the consequence of the failure to perform the function, the probability of the occurrence of the postulated initiating event for which the function will be called upon, and the significance of the contribution of the function in achieving either a controlled condition or safe condition. Following categorization by type, SSCs performing FSFs are further classified into class based on the relationship to DID levels.

For SSCs that contribute to specific safety functions, safety class is assigned based on the consequences of their failure. Examples of this type of SSC include confinement functions other than those fulfilling fundamental safety functions, e.g. hot cells; monitoring systems; and support and auxiliary systems.

After each SSC has been assigned an initial safety classification, the safety class is reviewed for possible reduction based on the IAEA safety standards.

The safety classification has been performed by ICHOS and accepted by the PALLAS organization. A comparison with the safety classification process of the IAEA Safety Standards was presented by PALLAS during the mission. The IAEA team assessed that the safety classification process followed by PALLAS is in line with the IAEA safety standards.

## 3.2 CONSTRUCTION PROGRAMME

The IAEA team reviewed the project management plan (PMP) for the construction phase, (Ref. P-00220803, 28/03/2024), which indicates that the PALLAS programme has three projects: the research reactor; the Nuclear Health Centre Project, and the Operational Readiness Project, and it is aligned with the plan to merge NRG and PALLAS in 2024 into NewCo B.V. It reflects the current status of the PALLAS project and describes the organization, including the joint delivery organization (JDO), and the roles and responsibilities of PALLAS, ICHOS and FCC for the construction phase.

The IAEA team also reviewed the construction management plan (CMP), (Ref. P-00198840, 21/08/2023), which covers procurement, manufacturing, transportation, civil construction and installation, mechanical completion, and pre-commissioning activities. The plan describes the construction in 3 phases: (1) preparatory work including lay down area and access roads; (2) construction of the pit and foundation; and (3) scope of the general contractor for completion of the detailed design, procurement, construction, and assistance in commissioning.

To support manufacturing and assembly of SSCs for the research reactor, PALLAS has entered a NEC4 type C contract with FCC, the construction contractor. This contract consists of a main contract (umbrella agreement) containing general clauses, and distinct contract batches. The transition between contract batches is integrated into the larger construction plan with specific milestones and terms which are evaluated prior to each transition.

During the current comprehension phase, the determination of contract batches (CB) will be finalized. At the time of the mission, PALLAS was working to define the scope followed by schedule and cost for the first contract batches. Using facility design information, a system breakdown structure is defined which will be linked to the project work breakdown structure (WBS). Each contract batch will be subsequently linked to this WBS to ensure all of the scope is covered. The first contract batches are defined as follows:

- CB 0: Construction Site management, scope definition ongoing;
- CB 1: Nuclear Island civil construction floors -1, -2 and -3 including “installation” of primary pumps, heat exchangers and HWS and decay tanks;
- CB 2: Secondary Cooling water pit, Horizontal drilling and outlet.

The CMP provides details of the civil construction work for the pit and foundation, but it does not cover detail design, manufacture, and construction of SSCs, which are under the responsibility of ICHOS and FCC. The content of the plan was discussed with the counterparts during the mission, including the need to update this document for completeness and to reflect the actual arrangements and activities for construction of the reactor in line with roles and responsibility of ICHOS as overall responsible designer and supplier of proprietary equipment and of FCC as general contractor to complete the design and procure, manufacture, install and construct, and to support maintenance and commissioning of the reactor.

**[R4]** The PALLAS organization should update the construction management plan to include the actual and planned arrangements for construction, including updating information regarding the construction organization structure, reference to the construction inspection and test plans, tests and verification procedures, and schedules and sequence of construction work, which should include hold points (as agreed with the regulatory body). The regulatory body should continue to be provided with regular and timely updates of the construction schedule.

### 3.2.1 Manufacturing and Assembly of SSCs

Within the system breakdown structure, work breakdown structure, and contract batches, the PALLAS organization has identified three categories of SSC, each with a different approach in contracting, procurement, and supervision/quality control: proprietary equipment, long-lead items, and all other SSCs. Proprietary equipment uses ICHOS as the general contractor with INVAP as the supplier. Long-lead items use PALLAS as the general contractor with quality control delegated to ICHOS, and all other SSCs use FCC as the general contractor. This arrangement is co-ordinated through the JDO to ensure that the PALLAS organization retains overall responsibility for manufacturing and assembly of SSCs and that the other stakeholders remain appropriately informed.

The IAEA team assessed that the existing process for manufacturing and assembly of SSCs is in line with the IAEA safety standards.

### **3.2.2** Equipment Qualification

The PALLAS organization has established a programme for qualification of SSCs important to safety, based on safety function, hazards, threats and design life. The PALLAS staff indicated that the programme is based on IAEA Safety Standards No. SSG-69 and ANVS "Guidelines on Seismic Design and Qualification for Nuclear Power Plants – Seismic Design and Qualification for Nuclear Power Plants," which is a revised version of IAEA Standards No. NS-G-1.6. The equipment qualification programme verifies that the SSCs can perform their intended functions, under operational states and accident conditions, and due to hazards not excluded by the design, e.g. seismic events, electromagnetic phenomena such as arcing and lightning, throughout their design life.

The qualification criteria for instrumentation and control (I&C), electrical, and mechanical equipment is based on the SSC safety function, type, class, DID, and seismic class and is included in the draft documentation for the facility, which is under review and awaiting final approval by PALLAS. The resulting table of SSCs for environmental qualification was discussed during the mission including examples of SSCs for core cooling and post-accident monitoring.

Qualification of SSCs will be carried out during the design, procurement, manufacturing, construction, and installation activities while the sub-systems and systems' qualification will be carried out during pre-commissioning and commissioning stages.

In accordance with its general contractor role, FCC will support the establishment of the qualification of SSCs in its scope by following the ICHOS qualification programme and ICHOS qualification plan. FCC will prepare and submit for approval within the JDO: (a) qualification plans for the SSC in its scope including a description of the qualification methods to be used, e.g. analysis, testing, experience; and (b) qualification reports describing the outcome of the qualification activities. FCC is also responsible to ensure the preservation of the qualified SSCs in its scope until hand-over after pre-commissioning is completed.

The IAEA team assessed that the equipment qualification programme is in line with the IAEA safety standards.

### 3.2.3 Assessment of Construction and Site-Specific Risk

The PALLAS project has identified site risks and has developed mitigation measures accordingly. The risk categories have been grouped as follows: nuclear safety; radiation protection; operations, project execution; occupational safety and health; environment, and flora and fauna.

The IAEA team discussed with PALLAS staff an example of risks identified resulting from construction of the PALLAS reactor near the existing NRG hot cell facility, calculations done to re-evaluate the radiation dispersion from the hot cells ventilation system, and changes made to the site radiation monitoring provisions. Other examples of mitigation measures and interface provisions were also discussed including constraints implemented on the use of the PALLAS construction tower crane over the NRG hot cells, use and allocation of fresh water during construction, coordination of a shared response team for NRG and PALLAS, and interface of a new security fence with the campus security fence.

Regarding emergency preparedness, the PALLAS organization has entered into agreements with other NRG site facilities and organizations to provide support to construction site personnel during emergencies, including radiological emergencies, to ensure safety is maintained during the PALLAS construction period. This work includes assessment of the effects and impacts of a radiological emergency at the HFR research reactor, which is co-located with the PALLAS construction site.

The IAEA team assessed that the assessment of construction and site-specific risks during the construction phase is in line with IAEA safety standards.

### 3.2.4 Construction Inspection and Test Plans

The IAEA team reviewed the process for the development and execution of inspection and test plans (ITP). At the time of the mission, the schedule and details of inspection, tests and hold points for manufacturing and assembly of SSCs was not available.

Each of the main stakeholders has a significant role in the development of ITPs. The main contractors develop the initial ITP, which is reviewed by PALLAS. ICHOS, as the overall responsible designer, will review portions of the ITP that are prepared by FCC and will prepare and review the portions of the ITP related to their own scope, e.g. the proprietary equipment. PALLAS QA/QC reviews all portions of the ITP and defines hold points and witness points. The PALLAS design organization is an integral part of the review of the ITP by participating in workshops related to finalising the ITPs and can be approached at any time by PALLAS QA for assistance in their reviews.

The review and approval process also includes third-party reviews, and ANVS reviews the ITP hold points and witness points. The ITP is chronologically written for each ITP item, including production steps, criteria, tolerance, method, frequency, and registration. The ITP also includes witness points, hold points, spot checks, and a list of documents reviewed. The contractor is organizing workshops to discuss the execution method and to highlight points of attention and risks with all stakeholders involved in the execution, including designers.

The approach used in preparation of the construction inspection and test plan includes Quality Level requirements for each item, requirements based on the design and contract, technical and execution specification as per design, applicable codes, and regulations. The team was informed that the suppliers are required to provide certificates for all material supplied which are checked by PALLAS. In addition, 80% of the materials are qualified by PALLAS through contracted accredited laboratories. The IAEA team reviewed and discussed several examples of aspects of the ITP related to the ongoing pit and foundation project execution.

The IAEA team assessed that the process for review and approval of ITPs might have potential to create conflicts of interest for stakeholders when reviewing and approving the ITPs for SSCs in their scope of supply. To ensure that ITPs are reviewed with sufficient independence, the team recommends that the PALLAS design authority review ITPs in addition to the quality management organization.

**[R5]** The PALLAS design authority should review inspection and test plans in addition to the quality management organization to ensure that all requirements of the codes and standards used and other design features are included in the inspection and test plans.

### 3.2.5 Construction Verification and Test Procedures

PALLAS and its contractors have developed and agreed to a process for verification of the completion of construction activities and the transfer of completed work. This process is described in the work plan method statement. In the method statement, 'who, what, and how,' are described in addition to health and safety and risk management measures needed for the work to be performed safely. In addition to the work plan method statement, inspection and test plans are developed to verify completion of the construction activities.

Test plans and their acceptance criteria are documented by the contractor such that they can be independently assessed. The results of the tests (scope, content, results, and timing) are compared with the specified acceptance criteria. Testing and verification are performed by certified laboratories for items important to safety. This verification is formally documented to confirm that the items important to safety are constructed according to specified requirements and comply with the acceptance criteria. Verification records include item identification of the SSCs, criteria/reason, tolerance, method/procedure, when, process/factory/site, frequency, responsibility, registration, and who performs the verification (contractor, PALLAS, ANVS).

The IAEA team noted that there is no specific mentioning of designer as part of the verification bodies in the example for Pit and Foundation project, however it was informed that during later stages of construction implementation, ICHOS will be associated with the verification records.

*Build Assurance Justification*

As part of the approach established by PALLAS, a standard list of content is under development in collaboration with the operational readiness organization which consists of information handed over from construction, including manufacturing data, plans, ITPs, material certificates and test results, inspection reports (contractor and subcontractors), traceability and document reviews, inspection results, photos, design changes, non-compliances. The information collected follows the WBS and is stored in data containers and is controlled for completeness against the contract deliverables by the work package owners.

The purpose of this approach is to establish build assurance justification (BAJ) early in the lifetime of the research reactor facility. The IAEA team identified that having this elaborate approach toward BAJ at this stage of the project can be considered as good practice.

### 3.2.6 Ageing Management Considerations in Construction

The IAEA safety standards require that an ageing management programme for research reactors shall be established at the design stage and specify actions to be taken in a proactive manner during fabrication, construction, and commissioning of the reactor SSCs. During the mission, the counterparts provided documents describing the ageing management plan, including procedures for screening of SSCs for ageing management purposes.

The counterparts mentioned that, during the comprehension phase, ICHOS is expected to develop an aging management plan in accordance with IAEA Safety Standards Series No. SSG-10, to be reviewed and accepted by PALLAS. The IAEA team discussed with the counterparts that the plan should include specimens to monitor ageing degradation of components important to safety.

The IAEA team specifically inquired about ageing management for beryllium components in the reactor. The counterparts informed the IAEA team that a beryllium management plan will be developed based on experience of HFR. ICHOS is expected to design the beryllium reflector for a 40-year lifetime, with periodic inspections every ten years. The counterparts mentioned that PALLAS plans to implement more frequent inspections and measurement of the straightness and swelling of the beryllium elements, as well as procedures for shuffling and rotation of the beryllium elements to limit the maximum fluence achieved to within the acceptance levels.

At the time of the mission, the ageing management plan was not yet finalized, and the design and construction of the facility is proceeding at-pace.

**[R6]** The PALLAS organization should ensure the ageing management plan for all stages of the lifetime of the reactor includes provisions for the necessary monitoring, testing, sampling and, inspection for the detection, assessment, prevention, and mitigation of ageing effects; for example, surveillance specimens to monitor ageing degradation of components important to safety, establishing time limited ageing analysis, and collection of baseline data in accordance with the IAEA Safety Standards Series No. SSG-10 (Rev.1).

### 3.2.7 Regulatory Supervision of Construction

ANVS oversight started immediately following the project's licensing in March 2023. Significant focus was placed on meeting license conditions, particularly in change management, organizational change management, and quality assurance. There were several rejections due to vagueness and inconsistencies in submitted plans, followed by resubmittals by PALLAS. Formal and informal communications were used effectively to resolve the issues associated with the initial submittals, resulting in a license grant to begin facility construction.

Recent achievements included the approval of several key procedures after multiple submissions, demonstrating progress in regulatory compliance. Ongoing efforts are directed towards maintaining focus on quality and ensuring organizational readiness for upcoming construction phases.

The ANVS inspectors are present at PALLAS very frequently. Their oversight follows a risk-informed annual plan prepared based on external review parties' involvement, safety class of SSCs, influence on core damage frequency (CDF) and on operational experience feedback. There are hold and witness points set primarily related to phase transitions of the project. ANVS inspections are supported by reviews by external parties, which must be either appointed by ANVS, properly accredited, or can prove their competence and independence in some other way.

#### 3.2.8 Interfaces with Commissioning

FCC will perform constructability reviews to ensure the design is constructable. The construction will be executed in contract batches (e.g. #1 – Civil works below ground level, #2 – Secondary Cooling Pit, #3 – Nuclear Island and logistics building civil works, #4 – Nuclear Island installation). A total of 14 contract batches are expected to complete the construction phase, and each contract batch will be run by a construction batch project manager, who is a member of the operating organization. During construction, the PALLAS technical managers will work closely with the ICHOS Site Engineer and the FCC site manager to coordinate the construction & manufacturing activities.

Coordination between PALLAS and the contractors for the site during the construction phase, through the use of contract batches, is expected to enhance the interface between construction and commissioning by ensuring that appropriate contract milestones for each batch are fulfilled, including handover of documentation associated with each batch. Completion of the contract batches also includes interfaces with the operational readiness programme and training for future operators.

The IAEA team assessed that development of an operational readiness programme and allocation of resources for management and implementation of this programme at an early stage of the reactor project is a good practice that will improve safety during the commissioning and operating phases of the reactor.

## 3.3 CONSTRUCTION PROCESSES AND PROCEDURES

### 3.3.1 Cleanliness and Control of Foreign Material

During the mission, PALLAS staff described the scope of work for FCC to develop the plans, processes, and procedures for the above in accordance with the general construction contract. It is expected that FCC will implement measures and controls during construction for housekeeping, cleanliness, foreign material exclusion (FME), control and protection of SSCs. FCC will develop plans and procedures for pre-acceptance maintenance and preservation of SSCs with review by ICHOS and approval by PALLAS. These will define storage conditions for SSCs (and spare parts) prior to installation.

The plan will include SSCs in storage on-site and installed SSCs for the duration from receipt at the site until handing over to the commissioning team. FCC will submit the periodic reports and records of the preservation and maintenance activities to the PALLAS and ICHOS for their review.

### 3.3.2 Receipt, Transport, Storage, and Control of Items at Release for Construction

During the mission, PALLAS staff described the scope of work for FCC to develop the plans, processes, and procedures for receipt, transport, storage, and control of items at release for construction above in accordance with the general construction contract.

### 3.3.3 Preservation and Maintenance of Constructed Items

A preservation and maintenance plan for the SSCs during the construction phase has been developed following the integrated logistics system. PALLAS also plans to receive the SSCs timely to avoid long storage. The objective of the preservation and maintenance plan is to ensure that SSCs remain in proper condition when handed over to commissioning and are able to fulfil their safety function and perform according to the design specifications.

Preservation and maintenance of constructed items will be managed by the general contractor in coordination with the operating organization as part of the batched construction contract. Each batch contract will contain specific milestones related to handover and transfer of responsibility for preservation and maintenance of SSCs contained within the batch. The operational readiness programme is integrated into the contract batches to ensure that the operating organization has appropriate cognizance of SSCs which are handed over on completion of each batch contract.

FCC and ICHOS are required to submit a pre-acceptance maintenance and preservation plan for each SSC to the JDO for the items to be procured by them. The responsibility of execution lies with general contractor. The plan will include, as a minimum, the activities to be performed, schedule, needed resources (material, equipment and human resources), responsibilities and management of interfaces. The plan needs to be approved by the JDO before it can be implemented.

### 3.3.4 Traceability

The PALLAS organization design control process is integrated into the construction management programme to ensure traceability of items during the design and construction phases through to commissioning. Processes and procedures are in place to ensure traceability of SSCs important to safety.

The team assessed that the processes and procedures in place are aligned with the IAEA safety standards.

### 3.3.5 Handover of Installed Items

Handover of installed items is incorporated into the terms of each contract batch and is coordinated between the general contractor and the operating organization through the operational readiness programme. Processes and procedures are in place to ensure effective handover of SSCs important to safety.

The team assessed that the processes and procedures in place are aligned with the IAEA safety standards.

## 3.4 INFORMATION MANAGEMENT

The information management system is used as a single repository. The system is designed in such a way that every document is uniquely identified; has a clear status, e.g. “released for construction;” has clear revisioning such that the current revision valid for each purpose can be identified; is classified for information security and has sufficient metadata to be found when needed. The system also has capabilities to control access to documents in accordance with information security requirements; facilitate a structured review process, including internal and third-party reviews, and record the results; facilitate the recording of review comments and their responses; ensure that only current and valid versions are available for use and previous versions are archived for records.

The information management system has several additional capabilities, e.g. generating drawings using a federated 3-D model. The system is hosted in the PALLAS network and made accessible to project participants following a security protocol.

In the current state of the project, documents are routinely exchanged between PALLAS, ICHOS, and FCC. Under the control of PALLAS and within the information management system, a common data environment is maintained to exchange all necessary design and project information.

The IAEA team noted that the security protocols limit the generation of digital records such as videos and photos during the construction phase. These records are vital for subsequent operation of the research reactor including for ageing management and decommissioning. Similarly, the access to documentation by the various stakeholders including the staff of the responsible designers and the construction contractors to the extent needed needs to be smooth. The process for the generation of videos and photos and the access to the necessary documents by all stakeholders during the construction phase needs review to streamline the process and smooth progress of the project. It is also noted that the IAEA team faced initial challenges in accessing the information that was made available to the team.

The IAEA team discussed information access with PALLAS, ICHOS, FCC, and ANVS during the mission, and it was apparent that information security measures create challenges to the effective flow of design information between stakeholders. Consequently, the team recommended that the information security measures be evaluated and revised as needed to ensure that safety is not compromised by security or vice versa.

**[R7]** The PALLAS organization should evaluate and revise its information management system to ensure that information security measures and safety measures do not compromise one another, particularly the communication of design and safety information between project stakeholders and regulators. Additionally, consideration should be given to the generation of records, including videos and photographs, related to safety-significant SSCs during construction that may be needed for ageing management and decommissioning.

## 3.5 TRAINING PROGRAMME OF FUTURE OPERATING PERSONNEL

PALLAS has established a detailed programme for training future operating personnel. The programme is based on a firm foundation that safety culture is "built-in" and integral to the training and qualification activities. The team observed the preliminary organizational structure for the operating facility and its connection to the training and qualification program.

The training and qualification programme is established based on IAEA Safety Standards Nos. SSR-3 and SSG-84 and will be accomplished using several necessary elements of an effective training programme: classroom training, simulator training, and practical/field training. The evaluation of training effectiveness will include written and oral examinations and practical demonstrations of competency by future operators.

Training and qualification during the construction of the facility is separated into several phases which approximately correspond to the phased approach of the facility construction process itself. Future operators will be integrated, trained, and qualified with the construction and commissioning personnel with the intent to develop and maintain important institutional knowledge as the facility is constructed and commissioned.

The training and qualification requirements appear to be effectively derived from the processes and roles associated with those processes in accordance with the IAEA safety standards. At the time of the mission, specific training plans and records were not available.

The team noted that the process of authorization for operating personnel is not clearly defined. For example, it was unclear whether or not the operator authorizations are granted by the reactor manager or by the regulatory body, or some other entity. The process for granting authorizations of operators and the authorities granted by such authorizations, needs to be clarified to improve effective communication and ensure safety.

The team also noted that the training and qualification requirements for the reactor manager and the duty managers were not yet clearly prescribed by the training and qualification programme. The team discussed that, according to SSG-84, the reactor manager should be subject to training on relevant technical and administrative requirements similar to other operating personnel and highlighted the importance of training and qualification of all personnel with functions which impact safety, including the reactor manager.

It was noted by the team that specific training and qualification requirements for some non-operational positions were not defined as part of the programme. Consideration of specific training requirements for personnel performing safety-related activities, such as SSC classification, evaluation of design changes, and performing change level categorizations, is considered by the team to be an important element for a training and qualification programme, based on the potential impact to safety for a research reactor.

**[R3]** The PALLAS organization should evaluate the need for, and implement as needed, a training and qualification process for persons reviewing design changes and performing change level categorizations.

## 3.6 UPDATES TO SAFETY AND OPERATING DOCUMENTS

The PALLAS project began in 2010, with significant licensing progress starting in 2017. From 2017 to 2019, the focus was on the conceptual design phase, accompanied by site characterization studies. In parallel, regular meetings between ANVS and PALLAS have started. Between 2017 and 2022 there were more than 150 such meetings. The preparation of the Preliminary Safety Analysis Report (PSAR) started in mid-2018. The basic design phase followed in 2019-2020, during which the Deterministic Safety Analyses (DSA) and Probabilistic Safety Analysis (PSA) were developed. In 2022 the Safety Report (SR) in Dutch language was prepared as a summary of the PSAR and submitted to the ANVS as a part of the application for the license for establishment of PALLAS. In February 2023 that license was issued by ANVS.

In addition to the Safety Report and the PSAR, there is a third document describing management of safety with the acronym SMOR. It is based on the example of the similar document required for similar facilities in the United Kingdom. The IAEA team observed that there appears to be an inadequate process or procedure in place to harmonize the content and for updating of the three existing safety related documents (PSAR, SR, and SMOR).

The construction license sets several conditions for the license holder. Among others it requires that the license holder must have a PSAR assessed by the ANVS, that the design and construction must be in accordance with provisions of the PSAR and that any changes to the PSAR must be submitted to the ANVS for assessment at least six weeks in advance.

Another condition requires that the design and construction of the facility, buildings and installations must be in accordance with the provisions of the SR. The conditions also oblige the license holder to get approval from ANVS for any change that has influence on nuclear safety. The construction of different phases of the project may commence only after their design has been approved by ANVS.

Since the license was obtained, the detailed design phase of the PALLAS reactor has continued. During this time, the safety demonstration continued with the review and further development of the DSA and PSA. Site preparation began in 2021, followed by foundation work in 2024. The construction and installation phase are expected to span from 2025 to 2028, during which ongoing safety demonstrations will include the creation of the Pre-Operational Safety Analysis Report (POSAR). In 2026 the operational license application will be submitted, leading to the commissioning of the project in 2029. The project is slated to become fully operational by 2030.

At the time of the mission, the safety analysis report in force was the PSAR that was originally delivered to the ANVS before the license was issued. In the meantime, a number of design changes, proposed by PALLAS, have already been approved by the ANVS, but they have not been included in the PSAR. It was explained to the IAEA team that there is no plan to prepare any updated versions of the PSAR. The PALLAS management are instead investing efforts into preparation of the POSAR, which is expected to be approved by the ANVS in early 2027.

The POSAR is the next version of the SAR for the PALLAS reactor, essential for obtaining the operating license. The POSAR reflects the final status of the detailed design and project changes as well all the relevant information from the PSAR. It includes information requested by the ANVS and commitments by PALLAS, forming the basis for applying for the Operational License. Key documents guiding the preparation and review of the POSAR include IAEA Safety Standards Nos. SSR-3 and SSG-20, Dutch Safety Requirements (DSR), and Technical Review Plan (TRP), ensuring safety and compliance.

The licensee, the future operating organization, PALLAS design authority, and Overall Responsible Designer are all involved in the preparation of the POSAR. The POSAR will undergo both internal and independent reviews by PALLAS and ICHOS. Inputs for the POSAR are based on the PSAR. The review process includes drafting, multiple levels of review (including ICHOS and Safety Committee), grammar correction, and approval by PALLAS process owners and directors.

The preparation process is step-by-step, ensuring quality through a document management system, independent reviews, and a document control system. Regular monthly meetings and workshops with ANVS are conducted to discuss schedules, document submissions, and licensing activities. ANVS provides feedback and performs informal reviews to ensure the quality and completeness of submissions. The Design Feedback Committee facilitates discussions on reactor design and safety demonstration, addressing design changes and improvements.

The interface between construction and commissioning is managed in detail, both before and during commissioning, to ensure clear communication and responsibility assignment.

It is expected that the POSAR will present a comprehensive summary of everything related to the safety of the PALLAS reactor once submitted to ANVS and approved by them, but that is not expected to happen until 2027. Until that time the existing PSAR is increasingly more obsolete and the information about actual safety status is scattered among number of applications to ANVS and their approvals of design changes.

The IAEA team believes that this situation is not in line with Requirement 1 of IAEA Safety Standards No. SSR-3.

**[R8]** The PALLAS organization should review and update the facility safety documents, including the safety analysis report, to consolidate information needed to justify the design of the research reactor, eliminate redundancies, and to ensure consistency. Changes to the facility design should be reviewed and approved as necessary and incorporated into the safety analysis report within a reasonable time period.

## ANNEX I. DOCUMENTS DELIVERED TO IAEA FOR PALLAS MISSION

- Preliminary Safety Analysis Report
- Project Status and Plans: Programme Status Report Q1, Programme Management Plan, SMOR
- QA Programme documents: Project Quality Plan, Quality Stream Plan, Non-Compliance Management, Quality Control Management, PALLAS Third Party Review, Quality Level Setting, Quality Procedure Hierarchical structure, Second Party Quality Control, Supply Chain Audit Management, NPER SSC Classification
- Construction Programme documents: Construction Management Plan, Umbrella Agreement Scope (Appendix 4), Umbrella Agreement Requirements (Appendix 2)
- Preservation and Maintenance Management Plan for Construction Phase
- Audit Plans: ICHOS Audit 19443 (2022), Integrated Audit Plan
- Operational Readiness Plan
- Licensing documents: Licensing Register, License
- Engineering Design Documentation: Design Framework, Configuration Management Procedure, Change Request Procedure, Change Classification Procedure
- Additional Documents: Third Party Review Procedure, ICHOS Methodology for SSC Safety Classification, Quality Level A-D, PALLAS Equipment Qualification, Qualification Programme – General Qualification Approach, Methods and criteria for Environmental Qualification, Methods and criteria for Seismic Qualification of Mechanical SSC, SSC general reference list for seismic and environmental Qualification, Justification of codes, standards and guides for Reflector Vessel, Codes and Standards Framework – Selection Method, Consolidated codes and standards and guides list
- Presentations: Management for Construction, Construction Programme, Inspection, testing and verification, Training & Qualification of Operating Personnel, Leadership and Safety Culture During Construction

## ANNEX II. AGENDA

*(All sessions began with a briefing by PALLAS staff on the topic under consideration)*

| **Monday 24 June 2024**<br>**Alkmaar** | |
|---|---|
| 18:00- 19:30 | **IAEA Team meeting at hotel:**<br>• Conduct of the Mission (**Christensen**)<br>• Briefing by team members on preliminary comments from review of the advanced information Package (10 minutes per team member) |

| **Tuesday 25 June 2024**<br>**Petten** | |
|---|---|
| 09:00-11:00 | **Entry Meeting**: Opening remarks by ANVS, PALLAS, and IAEA<br>Presentation by ANVS: Background of the mission request and expectations<br>Presentation by PALLAS: Reactor characteristics, project status, and plans<br><br>IAEA: All (**Christensen**)<br>PALLAS: [redacted]<br>ANVS: Bernd Keller ('Director Competent Authority'), Carelsen, Somers, Valkiers |
| 10:45-11:00 | Coffee break |
| 11:00-13:00 | Walkthrough the construction site<br><br>IAEA: All<br>PALLAS: [redacted] |
| 13:00-14:00 | Lunch break |

| | |
|---|---|
| 14:00-17:00 | **Management system for construction**<br>• Construction organization<br>• Management system processes/procedures: Control and supervision of contractors, interface management, control of design information, handling of non-conformances, control of design changes, and documents control<br>• QA programmes for contractors and subcontractors<br>• Classification of SSCs<br><br>IAEA: All (**Rao**)<br>PALLAS: [redacted]<br>ANVS Observers: Carelsen, Somers |

<table>
<tr><th colspan="3">Wednesday 26 June 2024<br>Alkmaar</th></tr>
<tr><td>09:00-12:00</td><td>Construction programme<br>• Manufacturing and assembly of SSCs<br>• Equipment qualification programme<br><br>IAEA: Sears, O’Bryan, Stritar<br>PALLAS: [redacted]<br>ANVS Observers: Carelsen, Van Ostaay</td><td>Management system for construction (cont.)<br><br>IAEA: Rao, Kovachev, Christensen<br>PALLAS: [redacted]<br>ANVS Observers: Somers, Tolud</td></tr>
<tr><td>12:00-13:00</td><td colspan="2">Lunch break</td></tr>
<tr><td>13:00-16:00</td><td colspan="2">Construction programme (Cont.)</td></tr>
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<tr><th colspan="2">Wednesday 26 June 2024<br>Alkmaar</th></tr>
<tr><td></td><td>• Assessment of construction and site-specific risk (interface of construction with other nuclear installations in the site)<br>• Process and procedures: cleanliness and control of foreign material; receipt, transport, storage, and control of items at release for construction; preservation and maintenance of constructed items; traceability; and handover of installed items.<br>• Ageing management considerations in construction.<br><br>IAEA: All (Sears)<br>PALLAS: [redacted]<br>ANVS Observers: Carelsen, Van Ostaay, Somers</td></tr>
<tr><td>16:00-17:00</td><td>Team meeting (on site)</td></tr>
</table>

<table>
<tr><th colspan="3">Thursday 27 June 2024<br>Alkmaar</th></tr>
<tr><td>09:00-09:30</td><td colspan="2">Briefing to the main counterpart (Christensen)</td></tr>
<tr><td>09:00-10:00</td><td colspan="2">Information Management<br><br>IAEA: All (Rao)</td></tr>
<tr><td>09:00-12:00</td><td>Construction programme (Cont.)<br>• Construction inspection and test plan<br>• Construction verification and test procedures<br><br>IAEA: Kovachev, Sears, Rao<br>PALLAS: [redacted]</td><td>Construction Programme (Cont.)<br>• Regulatory supervision of construction<br><br>IAEA: Stritar, O’Bryan, Christensen<br>ANVS: [redacted]</td></tr>
</table>

| | | |
|---|---|---|
| | [redacted]<br>ANVS Observers: Tolud | |
| 12:00-13:00 | Lunch break | |
| 13:00-15:15 | **Construction programme (Cont.)**<br>• Oversight of licensee of construction work<br>• Update of safety and operating documents<br>• Interface with commissioning<br><br>IAEA: **Stritar**, Rao, Kovachev<br>PALLAS: [redacted]<br>ANVS Observers: Carelsen, Somers | **Training programme of future operating personnel**<br><br>IAEA: **Christensen**, Sears, O'Bryan<br>PALLAS: [redacted]<br>ANVS Observers: Tolud |
| 15:15-17:10 | Discussion of Safety Committe and Presentation of a Design Change (Vortex Diodes)<br><br>IAEA: All (**Christensen**)<br>PALLAS:<br>ANVS Observers: Tolud, Somers | |
| 17:10-18:00 | Team meeting (on site) | |

| **Friday 28 June 2024**<br>**Alkmaar** | |
|---|---|
| 09:00-09:30 | Briefing to the main counterpart (**Christensen**) |

| **Friday 28 June 2024**<br>**Alkmaar** | | |
|---|---|---|
| 09:00-12:00 | **Construction Programme (Cont.)**<br>• Interface with design<br><br>IAEA: **Sears**, Kovachev, O'Bryan<br>PALLAS: [redacted]<br>ANVS Observers: Somers | **Leadership and safety culture during construction**<br>- Safety Culture<br><br>IAEA**: Christensen**, Rao, Stritar<br>PALLAS: [redacted]<br>ANVS Observers: Tolud |
| 12:00-13:00 | Lunch break | |
| 13:00-14:15 | **Review of Design and Interface with ICHOS and FCC**<br><br>IAEA: **Sears**, O'Bryan, Kovachev<br>PALLAS: [redacted]<br>ANVS Observers: Somers | |
| 14:15-15:00 | **Leadership and safety culture during construction (Cont.)**<br>- Organizational Change Management Procedure<br>- Safety Emergency Preparedness<br>- Issues Management and Linked Procedures<br><br>IAEA**: Christensen**, Rao, Stritar<br>PALLAS: [redacted]<br>ANVS Observers: Tolud | |
| 15:00-16:00 | Team meeting (on site) | |

| **Saturday 29 June 2024** |
|---|

| **Hotel** | |
|---|---|
| 09:30-17:00 | Consolidation of the mission findings and development of the draft report (**IAEA team**) |
| **Sunday 30 June 2024**<br>**(Rest Day)** | |

| **Monday 1 July 2024**<br>**Petten and Alkmaar** | | |
|---|---|---|
| **Location** | **Petten** | **Alkmaar** |
| 09:00-12:30 | 09:00-11:00: Walkthrough construction site (Bradford, Christensen, and PALLAS)<br><br>11:00-12:30: Movement to Alkmaar and Lunch Break (Bradford, Christensen) | Discussion of any remaining open points from previous sessions:<br><br>IAEA: Rao, Kovachev, **Sears**, O'Bryan, Stritar<br>PALLAS: |
| 12:30-13:30 | Briefing to ANVS<br><br>IAEA: Bradford, Christensen<br>ANVS: Carelsen, Valkiers | Lunch Break (Others) |
| 13:30-14:00 | Presentation of 3D model to DIR-NSNI (Bradford, PALLAS) | |
| 13:30-17:00 | Drafting of the mission summary report: Conclusions, recommendations, and suggestions (IAEA team) | |

| **Tuesday 2 July 2024**<br>**Alkmaar** | |
|---|---|
| 09:30-11:00 | Discussion of PALLAS comments on the mission summary report (IAEA and PALLAS) |
| 11:00-13:00 | **Exit meeting:** Conclusions and recommendations of the Mission and closure (ANVS, PALLAS, and IAEA) |

## ANNEX III. LIST OF PARTICIPANTS

### PALLAS Participants

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**ANVS Participants**

| | |
|---|---|
| A. van Bolhuis | Chair of the Board |
| B. Keller | Director, Competent Authority |
| S. Carelsen | Site Inspector – PALLAS Reactor |
| P. Somers | Deputy Site Inspector – PALLAS Reactor |
| P. Valkiers | Advisor International Affairs |
| W. Tolud | Specialist Inspector – Human and Organizational Factors |
| H. van Ostaay | Specialist Inspector – Structural & Mechanical Integrity |

IAEA Participants

| | |
|---|---|
| J. Christensen | IAEA/NSNI/RRSS |
| D. Sears | Canada |
| D. Rao | India |
| A. Stritar | Slovenia |
| M. Kovachev | Bulgaria |
| P. O’Bryan | USA |