NATIONAL NUCLEAR REGULATOR

For the protection of persons, property and the environment against nuclear damage

REGULATORY GUIDE

INTERIM GUIDANCE ON CONSTRUCTION MANAGEMENT FOR NUCLEAR FACILITIES

RG-0012

Rev 0

professionalism integrity value our people excellence teamwork openness & transparency

UNRESTRICTED

APPROVAL RECORD				
	Name	Designation	Signature	Date
Prepared	S Nhleko	Specialist		
	P Bester	Special Nuclear Projects Coordinator		
Edited	L Kleu	Language and Technical Editor		
Reviewed	P Damba	Functional Coordinator: Design Safety		
	I Korir	Senior Specialist		
	S Tshobeni	Senior Specialist		
	J Joubert	Principal Specialist		
	U Coetzee	Principal Specialist: Operational Safety		
	EXCO			
Recommended	O Phillips	Senior Manager: SARA		
Approved	Dr MB Tyobeka	Chief Executive Officer		

[redacted]

Note: The original, signed document is retained by the Record Management.

The following persons contributed to the preparation of the document:

Ian Korir

Jean Joubert

Sobhuza Tshobeni

Pumza Damba

Siyabulela Geza

TABLE OF CONTENTS

1 INTRODUCTION

The mandate of the National Nuclear Regulator (NNR) is to, amongst others, exercise regulatory control over the construction of nuclear facilities to protect the public, property and the environment against nuclear damage. As part of this mandate, the NNR has prepared this guideline to ensure that the country's nuclear facilities are constructed in compliance with safety requirements, approved plans and procedures. However, the holder of the nuclear facility construction licence (the licensee) bears the primary responsibility for ensuring that the facility is constructed in compliance with applicable safety requirements, approved plans and procedures. The licensee is also obliged to ensure that the facility's suppliers and subsuppliers, delivering services and products important to nuclear safety, comply with safety requirements.

The document provides guidance on the regulatory requirements as contained in the draft General Nuclear Safety regulations and the draft Specific Nuclear Safety Regulations: Nuclear Facilities as it pertains to the construction of nuclear facilities.

The NNR strives to ensure that this Regulatory Guidance document is complete and accurate. However, in recognition of the fact that this document is being presented to authorisation holders prior to the promulgation of its associated Regulations, the NNR makes no warranty, express or implied, to the accuracy, completeness, or usefulness of any information, including warranties to the adequacy of its contents. This Regulatory Guidance document is provided as INTERIM guidance in good faith and its aim is to assist authorisation holders to achieve high levels of safety for facilities and activities that are part of the nuclear fuel cycle. The NNR assumes no legal liability or responsibility for any action taken by you due to information in this document and such actions are expressly carried out at your own risk. The information in this document is subject to change due to promulgation of its associated Regulations. Complying with applicable laws remains the responsibility of authorisation holder.

2 PURPOSE

While the holder of a nuclear facility construction licence bears the primary responsibility for ensuring that the facility is constructed in compliance with applicable safety requirements, approved plans and procedures, this document provides guidance to ensure that South African nuclear facilities are constructed in compliance with NNR safety requirements as well as international nuclear safety guidelines.

3 SCOPE

This guideline was prepared primarily for the construction of nuclear power plants as they demand the most stringent safety standards and guidelines.

However, it is also applicable in a graded approach to modifications to operating nuclear facilities and to nuclear facilities, other than nuclear power plants, being regulated by the NNR.

4 TERMS, DEFINITIONS AND ABBREVIATIONS

In this Regulatory Guide (RG) any word or expression to which a meaning has been assigned in the NNR Act (henceforth referred to as "the Act") or the Regulations promulgated in terms of the Act, shall have the meaning so assigned. Only additional terms, definitions and abbreviations are provided.

4.1 Terms and Definitions

"**Commissioning**" means the process by means of which systems and components of facilities and activities, having been constructed, are made operational and verified to be in accordance with the design and to have met the required performance criteria. Commissioning may include both non-nuclear and/or non-radioactive (cold) and nuclear and/or radioactive (hot) testing.

"**Construction**" means those actions required to assemble components, parts and appurtenances to functional units at site. Those actions may include forming, machining, assembling, welding, brazing, heat treating, examination, testing, inspection and certification of manufactured products as well as activities associated with civil works such as driving of piles, subsurface preparation, placement of backfill, concrete or permanent retaining walls within an excavation, installation of foundations and erection of civil structures. Construction in the context of section 5 of the Act includes commissioning, but does not include design and manufacturing.

"**Construction organisation or Constructor**" means the entity managing the construction activities such as civil and architectural works, assembly, installation and testing of items important to nuclear safety at the level of the facility.

"**Construction project for a nuclear facility**" refers to the construction of a new nuclear facility or modifications at an operating nuclear facility (including commissioning).

"**Contractor**" means any individual or organisation who provides items or renders services in accordance with a contract or a procurement document. The term "contractors" includes designers, manufacturers, producers, assemblers, installers, distributors, importers, sellers, suppliers, subcontractors, technical support organisations, consultants and their subsidiaries.

"**Design specification**" means a document that provides the mechanism by which applicants integrate their suppliers with the authorisation process and it becomes the principal document governing the design and manufacturing of components.

"**Manufacturing**" means those actions required to manufacture source material, components, parts and appurtenances. These actions may include forming, machining, assembling, welding, brazing, heat treating, examination, testing, inspection and certification.

"**Regulatory oversight**" during construction refers to the monitoring and direct observation of construction work practices, items and equipment. It also includes inspection and assessment of safety-related construction activities through such methods as: discussions and interviews with relevant personnel; examination of procedures, records and documentation; and measurements and tests.

4.2 Abbreviations

CCAP	Construction Compliance Assurance Programme
CIDB	Construction Industry Development Board
GOR	General Operating Rules
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
IAEA	International Atomic Energy Agency

NDE	Non Destructive Examination
NNR	National Nuclear Regulator
PER	Pressure Equipment Regulations
PIE	Postulated Initiating Events
PSER	Preliminary Safety Evaluation Report
QA	Quality Assurance
RG	Regulatory Guidance Document
SER	Safety Evaluation Report
SSC	Structure, System and Component
SSR	Site Safety Report

5 REGULATORY FRAMEWORK

5.1 Legal Basis

1) The legal basis for the NNR relating to the construction of nuclear facilities is derived from the NNR Act, specifically sections 5(b), 20(1), 21(1) and 23.

2) Section 5(b) of the Act grants the NNR the power to exercise regulatory control over the safety of siting, design, construction, operation, manufacture of component parts, and decontamination, decommissioning and closure of nuclear installations through the issuing of nuclear authorisations.

3) Section 20(1) of the Act states that: “No person may site, construct, operate, decontaminate or decommission a nuclear facility, except under the authority of a nuclear installation licence”. In terms of the provisions of this section, the siting, construction, operation, decontamination or decommissioning of any nuclear facility as defined in section 1(xviii) of the Act must be authorised by way of a nuclear licence granted by the NNR.

4) Section 21(1) requires that any person wishing to site, construct, operate, decontaminate or decommission a nuclear facility may apply in the prescribed format to the Chief Executive Officer of the NNR for a nuclear licence and must furnish such information as the NNR board of directors requires.

5) In terms of Section 23 of the Act, the Chief Executive Officer may impose and amend conditions of authorisation that are necessary to ensure the protection of persons, property and the environment against nuclear damage, or to provide for rehabilitation of the site.

5.2 Regulatory Standards

1) In Regulation R388 on Safety Standards and Regulatory Practices, the NNR has promulgated, in terms of section 36 of the Act, nuclear safety criteria for dose and risk relating to the safety of the public that must be complied with.

2) The following requirement documents and position papers should also be complied with for the construction of nuclear facilities:

   a) RD-0014: Emergency Preparedness and Response Requirements for Nuclear Installations;

   b) RD-0016: Requirements for Authorisation Submission Involving Computer Software and Evaluation Models for Safety Calculations;

   c) RD-0022: Radiation Dose Limitation at Koeberg Nuclear Power Station;

   d) RD-0024: Requirements on Risk Assessment and Compliance with Principal Safety Criteria for Nuclear Installations;

   e) RD-0034: Quality and Safety Management Requirements for Nuclear Installations;

   f) PP-0008: Design Authorisation Framework;

   g) PP-0014: Consideration of External Events for Nuclear Installations;

   h) PP-0015: Emergency Plan Technical Basis for New Nuclear Installations;

   i) PP-0016: Conformity Assessment Framework; and

   j) PP-0017: Digital Instrumentation and Control.

3) The following draft regulations, specifically addressing the construction of nuclear facilities, will supersede the above regulatory standards once promulgated:

   a) Part THREE: Management of Safety of the General Nuclear Safety Regulations addressing management systems;

   b) Regulation 4(5) of Part FOUR: Authorisation of Activities of the General Nuclear Safety Regulations addressing nuclear licensing;

c) Regulation 4(4) of Part FIVE: Safety Assessment of the General Nuclear Safety Regulations addressing safety assessments;

d) Regulation 4 of Part FIVE: Safety Assessments of the General Nuclear Safety Regulations;

e) Regulation 3 of the Specific Nuclear Safety Regulations: Nuclear Facilities; and

f) Regulation 7 of the Specific Nuclear Safety Regulations: Nuclear Facilities.

5.3 Other Legal Considerations

1) A prerequisite for construction is that all applicable licences, permits and approvals required in South Africa, to initiate construction activities, must be in place.

2) The licensee should therefore identify and understand jurisdictional boundaries and responsibilities where there is more than one regulatory body governing an area (i.e. national and provincial governance over occupational health and safety, protection of the environment, etc.).

6 MANAGEMENT SYSTEMS

6.1 General

1) The management system of the applicant and all service providers, including the contractor, must comply with the requirements in a graded approach as contained in regulation 4 of Part THREE: Management of Safety of the General Nuclear Safety Regulations.

2) General guidance on the management system, including safety culture implementation, is provided in section 6 of RG-0007: Regulatory Guide on Management of Safety and should be complied with.

3) The management system of the applicant should specifically address the following:

a) Safety culture;

b) Licensee responsibility;

c) Project management, including construction management, requirements management and traceability;

d) Transfer of responsibility during construction and commissioning;

e) Construction resources;

f) Control and supervision of contractors (see guidance in section 6.9 of RG-0007);

g) Control of design information; and

h) Measurement, assessment and improvement (see guidance in section 6.12 of RG-0007).

6.2 Safety Culture

1) Regulation 4(2) of Part THREE: Management of Safety of the General Nuclear Safety regulations stipulates requirements relating to safety culture that should be complied with by all organisations involved in activities important to nuclear safety. This includes the applicant, contractor, suppliers and subsuppliers.

2) General guidance on safety culture implementation is provided in paragraph 6.3 of RG-0007: Regulatory Guide on Management of Safety.

3) These requirements and guidance apply to every stage of the nuclear facility's lifecycle and should be implemented by all organisations that have a potential impact on nuclear safety.

4) The following additional guidelines are applicable during the construction stage and should be implemented:

   a) Training on safety culture and its essential characteristics should be provided to all organisations involved in the construction project.

   b) The training should promote awareness and understanding of the importance of the work being performed or service rendered on nuclear safety requirements and nuclear risks. The training should also promote reporting and acting when deviations are detected.

   c) Conflicting priorities between schedule, cost and nuclear safety should not compromise or adversely affect conservative decision making and a questioning attitude.

   d) Special attention should be paid to training on nuclear safety requirements and matters particularly in organisations not familiar to nuclear projects.

   e) The applicant should ensure that all contractors and subcontractors in the supply chain, or involved in surveillance or construction activities, are fully aware of the importance to nuclear safety of what they have been contracted to supply or do.

6.3 Licensee Responsibility

1) The applicant for a nuclear licence to construct should develop and maintain their capability to control all activities for which the licence is sought.

2) The management system should describe how the applicant will exercise overall responsibility for the safe and satisfactory completion of all construction and commissioning activities, including the procurement of equipment and services. It should also demonstrate how effective oversight of these activities will be carried out.

3) The applicant should maintain the core capability of being an intelligent customer in all oversight and contracting processes.

4) During construction, the applicant should take the responsibility for all activities that could affect the nuclear safety of the facility regardless of location. This includes:

   a) Developing and implementing a management system covering construction activities to ensure the required quality. This includes an oversight plan for the items important to nuclear safety, such as audits, surveillances to verify contractor and supplier activities, witness/hold points and field walk downs.

   b) Taking and maintaining ownership of the safety case, especially for the information provided by contractor(s) or design/construction organisations.

   c) Inspections, tests and verification of items important to nuclear safety in a graded approach.

   d) Reporting of significant safety non-compliances and events.

   e) Preparing the commissioning programme and taking into account tests performed during construction.

   f) Ensuring that appropriate records, relevant to plant life and ageing management, are preserved.

   g) The transfer of documentation when moving from construction to commissioning.

6.4 Transfer of Responsibility During Construction and Commissioning

1) The construction organisation should establish and document procedures to control and coordinate the handover of completed works from one supplier to another in order to maintain the integrity of the completed works.

2) Rules and procedures for access control for items important to safety and working areas should also be documented and should be implemented for the transfer.

3) Provisions should be established and implemented to control and coordinate the handover from construction to commissioning.

6.5 Control of Design Information

1) A comprehensive process should be established to address non-conformities in design, manufacturing, construction and operation. Resolutions to correct differences from the initial design and non-conformities should be documented.

2) Provisions should be in place to:

   a) Make permanent and temporary design changes during construction and commissioning.

   b) Identify, resolve and approve deviations from the design.

   c) Ensure that changes to the design baseline are identified, reviewed, approved and documented for the handover of completed work from the:

      i) Construction organisation to the commissioning organisation; and

      ii) Commissioning organisation to the operating organisation.

   d) Control the drawings, design codes and documentation that describe the basis for licensing the construction, commissioning and operation of the nuclear facility in order to maintain design configuration control.

   e) Arrange for communication between the design organisation and construction organisation and between the construction organisation and its contractor(s) to deal with queries on the design.

   f) Change proposals to the design from contractor(s).

3) Design changes occurring after submission of the safety case and design information to the Regulator, which impact products important to nuclear safety and affect safety functions, should be submitted to the Regulator for approval prior to implementation of such changes.

7 CONSTRUCTION PROJECT MANAGEMENT

7.1 Lessons Learned From Construction Projects

1) Construction experience and best practices from specific nuclear technologies as well as from nuclear and non-nuclear construction should be collected and lessons learned implemented for the enhancement of quality and safety. Criteria should be established for reporting of construction related experience and measures should be put in place to ensure the dissemination of this information to the relevant parties. Mechanisms to enable sharing of construction experience in a systematic and timely manner should be put in place.
2) The licensee should be proactive in sharing relevant safety experiences nationally and internationally.
3) Where new or innovative construction processes, such as modular construction and manufacturing techniques like welding and non-destructive testing are introduced, a comprehensive qualification programme for the process or technique, including training, should be in place.
4) Compared to traditional construction processes, modular construction presents additional challenges that should be appropriately considered in the construction and installation plan. These include:
   a) Assembly technology of large-sized modules;
   b) Welding technology of modules;
   c) Lifting deformation control technology of large-sized structural modules;
   d) Transportation plan of large-sized modules; and
   e) Installation, measurement and positioning technology for large modules.

7.2 Reporting and Communication

1) The requirements on reporting, as provided in regulation 7(8) of the Specific Nuclear Safety Regulations: Nuclear Facilities, must be implemented and complied with.
2) The construction organisation should have:
   a) A system in place for communication and reporting of important nuclear safety non-compliances and events to the NNR.

b) Procedures and means for communicating matters related to nuclear and radiation safety, quality, and security and emergency preparedness arrangements within the organisation to interest groups.

c) A system in place for periodic communication and reporting of construction progress as well as the achievement of safety significant progress milestones to the NNR.

3) The periodic report on construction should include, amongst others, the following:

a) Facility construction status:

i) Progress of construction, equipment manufacturing, installation and commissioning;

ii) A summary of changes in the manufacturing, installation and commissioning of safety-classified systems, structures and components; and

iii) The construction project real-time overall schedule as well as a detailed schedule for the next quarter.

b) Demonstration of safety and licensing:

i) A summary of significant tests and analyses to verify facility safety as well as their results; and

ii) Items pending an NNR decision, which are significant for project progress.

c) Occupational safety at the construction site and a list of the most important occupational safety-related observations and events.

d) Suppliers and subcontractors:

i) Planned supplier audits and assessments; and

ii) Changes in the most significant supplier organisations.

e) Licensee management system and organisation:

i) New and updated documents covered by the management system;

ii) Status of internal audits and other management system assessments (plan/realisation);

iii) Changes in the licensee's project organisation (recruitments, decrease in the number of personnel, etc.); and

iv) Progress in recruitment and training of the personnel necessary for operation.

f) Non-conformance management – a summary and listing of:

i) Non-conformances in the design, manufacturing, installation and testing of the facility's safety systems as well as in accident analyses relating to their functioning;

ii) Critical and significant quality non-conformances observed in the licensee's own operations;

iii) Critical and significant quality non-conformances observed in the operations of suppliers and their subcontractors; and

iv) Product non-conformances important to nuclear safety systems, structures and components.

7.3 Project Organisation and Resources

1) In order to appreciate the challenges surrounding project organisation and resources for a construction project, the reader is advised to consult the relevant sections in two IAEA documents, namely IAEA Nuclear Energy Series NP-T-2.7, Project Management in Nuclear Power Plant Construction: Guidelines and Experience [6] and draft IAEA Safety Guide DS441, Construction for Nuclear Installations (preferably its approved version once it is published) [5].

2) The requirements for licensee organisation and personnel resources presented in regulation 4 of Part THREE: Management of Safety of the General Nuclear Safety regulations will apply in the construction project for a nuclear facility. Corresponding guidance is provided in RG-0007: Regulatory Guide on Management of Safety.

3) If the licensee is unable to fulfil the function of the construction organisation, they may appoint a contractor or contractors to carry out specific functions for part or all of the facility. The responsibilities of the contractor should be clearly defined and controlled by the licensee. In addition, the contractor's governance of activities and the activities themselves should be inspected by the licensee.

4) Since activities relating to the nuclear facility's construction, commissioning and operation by several different organisations partly take place at the same time, the responsibilities of the organisations should be specified and detailed so that no unsolved or undefined matters remain regarding the functions of the different organisations.

5) The licensee organisation should have adequate human resources, infrastructure and working environment available for the implementation and supervision of a construction project or plant modification project.

6) The management of the licensee and the organisations of suppliers essential for the project, as well as tasks essential for nuclear and radiation safety and quality, should employ persons with competence and experience in the nuclear field and of demanding construction projects or plant modification projects.

7) The licensee should have procedures in place to:

   a) Identify and manage their own resource needs during construction projects or plant modification projects;

   b) Procure, familiarise, instruct and supervise external service suppliers and persons employed by the licensee organisation;

   c) Regularly assess resources, the functionality of inter-organisational interfaces between their own organisation and the supplier as well as in supplier organisations; and

   d) Verify the competence of those in the organisations and their management as well as those carrying out duties important for nuclear and radiation safety and quality.

8) Licensee procedures and resource plans should cover the commissioning of the facility under construction.

9) The licensee organisation should have adequate human resources and competence for the facility's commissioning and operation in good time before the start of commissioning so that the persons can familiarise themselves with and become experienced in the nuclear facility's operation during the project.

10) Once the organisation is established and its lead engineers and managers are known, the project manager should define and assign the work within the scope of the organisation. Work packages should be identified and should be assigned to the competent organisational units.

11) The work packages related to construction activities usually follow the divisions of the main disciplines, with adjustments, taking into account expertise and skills and should include:

   a) Civil/architecture;

   b) Mechanical;

   c) Electrical; and

   d) Instrumentation and control.

7.4 Licensing Plan

1) The licensee should draw up a licensing plan for the construction of a new nuclear facility or an extensive plant modification of an operating facility describing how the fulfilment of nuclear and radiation safety requirements are ensured and demonstrated in the different phases of the construction or plant modification project.

2) In connection with the construction licence application for a new nuclear facility, a licensing plan should be submitted to the Regulator for acceptance that includes the following:

   a) The main project phases with their planned schedule (i.e. design and manufacturing schedule for the main components; duration of the design, construction, installation and commissioning phases; configuration freeze points in relation to the phases of regulatory review; submission of the operating licence application; and starting the operation of the facility).

   b) The titles and descriptions of the main content of the document types that are to be submitted to the NNR during the construction (see also section 14, Regulatory Oversight by the NNR, of this document), principles for the document submission schedule and the time available for the NNR review.

   c) A plan for the licensing of important to safety matters at system level in the construction licence phase in accordance with the Regulator's requirements, including those stated in section 14 of this document.

   d) A plan for addressing important to nuclear safety matters at component level in different documents and their scheduling in relation to component design, manufacturing and construction, including advance approvals for long lead items in compliance with NNR requirements in this regard.

3) When the plant modification of an operating nuclear facility concerns several important to nuclear safety classified systems, the design information to be submitted to the NNR should be accompanied with a licensing plan for information that should present:

   a) The main phases of the plant modification with their schedules (design, manufacturing, construction, installation and commissioning).

   b) A list of the systems to be modified and their safety classification.

   c) Pre-inspection documentation of the systems and commissioning-related plans to be submitted to the NNR for approval or information, their planned submission schedule and the time available for the NNR review.

d) A plan on how safety-related matters are addressed at component level in different documents and their scheduling in relation to component design, manufacturing and implementation of modifications.

e) An assessment of the need to update the documents that comply with the NNR requirements and facility procedures.

4) If the principles presented in the licensing plan submitted to the regulator essentially change during the construction of a new nuclear facility or the modification of an operating nuclear facility, the updated licensing plan should be submitted to the regulator for information. Such changes include changes in titles and contents of documents to be submitted to the NNR that are matters of principle and schedule postponements, which essentially affect the progress of the project.

7.5 Risk Management During Construction

1) The licensee and suppliers of products or services important to nuclear safety should have in place systematic procedures for identifying, analysing and controlling risks relating to the safe implementation of construction or plant modification projects of nuclear facilities as well as procedures for making decisions about preventive actions and monitoring their implementation.

2) Risk management procedures should cover risks relating to nuclear and radiation safety, quality and inter-organisational cooperation as well as construction-related risks significant for the nuclear and radiation safety of other nuclear facilities on the same site. Risk assessments should also take into account risks arising from nuclear facilities operating on the site.

3) Risk management processes and procedures should be described in a risk management plan to be submitted to the NNR for information with the submission of the construction licence application and always after updating the risk management plan.

4) The risks identified, risk categorisation, risk management plan, measures to mitigate the consequences, and procedures to monitor the measures should be entered in a risk register that should be maintained for the project's entire life cycle.

5) The NNR should be provided with the possibility to review nuclear and safety significant entries of the risk register.

6) The project management, those in charge of different operations and other essential personnel, should be made familiar with the identification and management of risks relating to nuclear and radiation safety, quality and the operation of organisations.

7) The personnel should be encouraged to foresee and identify risks as well as inform supervisors and management about such observations.

8) Other matters that may be considered relevant to risks during construction are considered below:

   a) The construction should start only after licensees have satisfied themselves by means of verification that the main safety issues in the design have been resolved and that relevant authorisations have been issued.

   b) Adequate completion of design, including acceptance criteria, and engineering work commensurate with the authorisation process should be verified prior to the start of construction. Before construction begins, a forward action plan covering the remaining design and engineering works and the necessary resource requirements should be developed and monitored as construction proceeds.

   c) The licensee should carry out a risk and threat assessment to determine the possible risks of the construction site to the existing facilities and the effect of existing facilities on the construction site. These risks depend on the site and construction method which therefore should be analysed for each individual site. Possible risks are caused by, but not limited to, dredging, quarrying, excavation, blasting, piling, dust, transportation and lifting. Preventive measures should be taken to manage the construction related risks.

   d) Environmental monitoring and protection measures at the site should be in place to ensure adequate mitigation of potential environmental effects related to construction activities.

   e) Necessary fire protection measures at the construction site should be available until final plant fire detection, protection and suppression systems are installed and operational. Details of these measures should be included in the emergency planning arrangements.

   f) Relevant mechanisms should be put in place to ensure that industrial strike action, construction delays and risks of a similar nature do not adversely affect the quality of construction works. Care should be taken to ensure that the form of contract does not result in late completion of design work resulting in parties being placed under time and cost pressures that may affect quality and ultimately safety. Design changes and late completion of design works should be minimised after construction starts.

   g) The safety implications of implementing organisational changes should be assessed. The planning and implementation of changes should be proportionate to the outcome of the assessment. The different phases of a change should be documented.

7.6 Management of Suppliers and the Supply Chain

1) The applicant must ensure compliance with the requirements on procurement, and production and service provision as contained in regulation 4(7) and 4(8) of Part THREE: Management of Safety of the General Nuclear Safety regulations.

2) General guidance on the management of suppliers and the supply chain is provided in paragraph 6.9 in RG-0007: Regulatory Guide on Management of Safety.

3) The following additional guidance is applicable during the construction stage and should be implemented:

   a) Requirements for purchased products should be defined.

   b) Adequate quality requirements should be established for products, and compliance with the quality requirements and achievement of the required quality level should be ensured.

   c) Systematic procedures should be in place for resolving and reporting deviations from the purchasing requirements.

   d) The requirements for the selection of suppliers and the selection procedures should be defined. These should include the requirements pertaining to the suppliers' management system and their quality management.

   e) Appropriate procedures should be in place for supplier assessment and selection. Records should be kept of the assessments. Prior to ordering a product, the supplier's ability to deliver the product and the related documentation in compliance with the requirements should be evaluated. Where necessary, a follow-up audit should be used to ensure the supplier's capability to deliver a product compliant with the requirements prior to the commencement of manufacturing.

   f) The approval of suppliers of products important to nuclear safety should be for a fixed duration only. The periods of validity should be defined in the purchasing procedures.

   g) Suppliers of important to nuclear safety products should have in place a management system that is appropriately certified or independently evaluated by a third party. In addition, the suppliers should comply with regulatory requirements contained in Part THREE: Management of Safety of the General Nuclear Safety regulations.

   h) Meeting the requirements set for products should be ensured prior to commissioning. Product conformity should be systematically monitored. The experiences with the product

should be evaluated for possible further actions and the supplier should be given feedback on the product, where necessary.

i) The purchasing procedures should define the conditions for the supplier's use of subcontractors and for the communication and relaying of requirements within the supply chain.

j) The management system should define procedures for the licensee to ensure that, when purchasing sets of equipment involving several fields of technology, the contractual relationships and responsibilities within the entire supply chain are unambiguously defined.

k) The licensee is responsible for supervising all the suppliers in the supply chain. The licensee should also incorporate the oversight rights of authorities into the supervision procedures.

l) For all purchases, the documentation that needs to be attached to a product and control during product manufacture and implementation should be defined. The control procedures should be presented in supplier-specific delivery control plans.

m) The purchasing procedures should contain procedures for the purchasing of type-approved products for important to nuclear safety components. The procedures should define the validation of the suitability and conformity of the products as well as the documentation to be attached to the products.

n) Suppliers should draw up a delivery-specific quality plan for the supply of important to nuclear safety products. Through the use of a quality plan, it can be ensured that a product supplier has correctly understood the requirements of quality management applicable to the delivery and demonstrates that the supplier has in place procedures to fulfil the requirements.

o) A single quality plan may be used for all products that have the same quality management requirements and the same implementing organisations guided by the quality plan. In case of minor differences between the quality management objectives of different products, the differences may be specified in a shared quality plan.

p) The licensee should have procedures in place to reliably prevent the purchasing of counterfeit and fraudulent products.

7.7 Construction Quality Management

1) In addition to the requirements on management systems provided in Part THREE: Management of Safety of the General Nuclear Safety regulations and the general guidance on management

systems provided in RG-0007: Regulatory Guide on Management of Safety, the following guidance is applicable to quality management during construction:

a) The licensee should ensure compliance with all hold and witness points specified by the NNR in the respective authorisation and quality control plans.

b) If construction activities important to nuclear safety are outsourced by the licensee or suppliers to other suppliers/subsuppliers, the delegating organisation should implement oversight measures for these activities to retain intelligent customer capabilities.

c) All suppliers of construction works important to nuclear safety should be registered in an up-to-date list (database) of approved suppliers. This list should include the following information:

   i) Scope of works/specification;

   ii) Constructor and subcontractors;

   iii) Construction Industry Development Board (CIDB) grading, or equivalent, of constructor and subcontractors;

   iv) Safety and quality classification of the SSC;

   v) Construction method statement/execution specification;

   vi) Selected codes and standards; and

   vii) Status of qualification/certification.

d) A quality control plan should be used to ensure compliance with project management and quality requirements.

e) Workmanship requirements should be clearly defined in procurement documents. The documentation should specify the required: codes and standards; materials; duties and capacities; operational and environmental parameters; loads; safety margins; settings; design limits; acceptable tolerances as well as quality management requirements based on the classification of the structure, system or component. These requirements should be compatible with the content of the Construction Safety Case and the associated Safety Analysis Report (SAR). Procurement documents or design specifications produced by suppliers on behalf of the licensee should be accepted by the licensee.

f) Procurement documents should provide the following minimum information:

   i) Intended application and operating conditions;

ii) Quality characteristics and safety classifications;

iii) Performance requirements and surveillance of in-process, final and functional tests and inspections;

iv) Documentation and submission requirements for design and analyses, the manufacturing and assembly of parts, components and systems and the construction of civil structures, including the associated tests and inspections;

v) Requirements concerning handling, storage, conservation, transportation and packaging; and

vi) Identification coding for documents and procured items, and product identification and traceability.

g) The organisations should ensure that records are retained to furnish evidence of activities affecting quality and safety.

7.8 Non-conformance Management in Construction

1) The applicant must ensure compliance with the requirements as contained in regulation 4(10) of Part THREE: Management of Safety of the General Nuclear Safety regulations on measurement, assessment and improvement.

2) General guidance on the control of non-conforming products and corrective actions is provided in paragraph 6.12.5 in RG-0007: Regulatory Guide on Management of Safety.

3) The following additional guidance is applicable during the construction stage and should be implemented:

a) A system should be implemented that collects, records and processes all identified non-conformances. Everyone engaged in construction should be made aware that they are expected to identify and report non-conformances. This system should define non-conformance and specify the roles and responsibilities of the licensee, construction organisation and contractors for reporting and correcting non-conformances. In addition, this system should incorporate the regulatory approval process for handling any non-conformance.

b) Non-conformances important to nuclear safety should be treated as events by the licensee, and resolved via a corrective action programme in a graded manner. The process of

determining the safety significance and the corrective actions of the non-conformance should include appropriate experts including the design organisation(s), if necessary.

c) Corrective actions should be assessed based on their importance to nuclear safety to the construction programme and dealt with at the appropriate management level.

d) Records of the corrective actions taken to resolve non-conformances should be maintained. The effectiveness of the process to implement corrective actions and to prevent similar non-conformances should be monitored.

e) Due to the challenging nature of construction projects, such as tight schedules, new technology or limited availability of resources, corrective actions to non-conformances may require a long time and may stay a pending issue even after handovers from one party to another. These pending non-conformances should be tracked to completion. A comprehensive tracking system should be managed to ensure that these non-conformances are resolved as soon as possible, records are maintained and that the relevant parties are informed.

f) Where a fatality or permanent disabling injury occurs on a construction site, the holder of a nuclear licence should provide the NNR with an incident report which includes measures to ensure a safe construction site as far as is reasonably practicable.

7.9 Hoisting and Transfer Equipment of a Nuclear Facility

7.9.1 Construction plan

1) The construction plan should consider the hoisting and transfer of equipment on the site.

2) The use of heavy lift equipment should be carefully planned to minimise disruptions in the construction schedule.

3) The site layout should, in particular, consider the consequences of crane failure and the possibility of cranes falling on the auxiliary building of the existing, support and construction infrastructure.

7.9.2 Procedures

1) Procedures should be in place for the operation of the hoisting device units, the persons authorised to operate them, and the qualification requirements for the operation of the units. The selection of the standard for hoisting devices must be justified.

2) Instructions should be provided for the decommissioning of hoisting device units before decommissioning.

7.9.3 Fuel handling and other hoisting equipment used in the nuclear facility

1) The system-level design of important to nuclear safety hoisting device units and hoisting functions should be part of the construction licence safety case for the nuclear facility.

2) The preliminary safety analysis report of a nuclear facility should present a system description of important to nuclear safety hoisting device units and should define the basic operational and safety requirements set for the various subsystems and fields of technology for the purpose of the detailed design of the hoisting device unit.

3) The design of the hoisting functions and hoisting device units should ensure adequate criticality prevention, nuclear fuel cooling and radiation protection, and that the probability of nuclear fuel damage is minimal.

4) Instructions should be drawn up for the operation of the nuclear fuel hoisting device units and handling systems, and for their malfunction and accidents. These instructions should define, for instance, the functions to which the fuel is subjected, and the preconditions, measures, responsibilities and records of these functions.

5) The conditions linked with the safety of the nuclear fuel handling should be included in the operational limits and conditions.

6) The hoisting functions and hoisting routes should be designed in such a way that:

   a) The handling of heavy loads above the fuel is avoided;

   b) The transfer of heavy loads on top of equipment important to safety is avoided;

   c) The collision of loads is avoided with the transfer of heavy loads;

   d) The tangling of loads is avoided with transfer of heavy loads; and

   e) The integrity of the storage pools and the fuel (including water purity) is not jeopardised.

8 STARTING COMPONENT MANUFACTURING AND PREPARING THE SITE BEFORE THE GRANTING OF A CONSTRUCTION LICENCE

8.1 Manufacturing

1) Before any manufacturing can commence, the applicant must comply with the conditions as set forth in regulation 5 of Part FOUR: Authorisation of Activities of the General Nuclear Safety regulations as well as the requirements contained in regulation 3(1) of the Specific Nuclear Safety Regulations: Nuclear Facilities.

2) The applicant must ensure compliance with the requirements as contained in regulation 4(7) and 4(8) of Part THREE: Management of Safety of the General Nuclear Safety regulations on procurement, and production and service provision.

3) General guidance on procurement and production and service provision is provided in paragraph 6(9) and 6(10) of RG-0007: Regulatory Guide on Management of Safety and should be complied with.

8.1.1 Supplier qualification

1) The regulations require that all suppliers of components important to nuclear safety involved in design, manufacturing, construction, operation and decommissioning have to be registered in an up-to-date list (database) of approved suppliers. These suppliers should be categorised considering the importance of the component to nuclear safety in order for the identification of applicable requirements.

2) The scope and extent of supplier qualification depends on the classification of the components to be manufactured consistent with the implementation of a graded approach. The applicant should apply the management system, and process audits where appropriate, on the suppliers as part of the supplier qualification process and to maintain intelligent customer capability.

3) The guidance provided in section 7.6 of this document relating to management of suppliers and the supply chain during construction should be complied for manufacturing of components as well.

8.1.2 Component qualification

1) An audit, and/or inspection plan or quality control plan should be developed, as part of the applicant's oversight programme, and submitted to the Regulator for input and acceptance.

2) These plans should define the hold and witness points during the manufacturing and construction processes for components classified as important to nuclear safety.

8.1.3 Preconditions for manufacturing

1) The issues that should be addressed and assessed before manufacturing can commence, other than compliance with the management system and process compliance, are listed below:

   a) A safety assessment should demonstrate that the specific component will meet its design intent under all conditions and that the design and performance criteria are met.

   b) For an indication of the individual importance of components, a safety classification system should be implemented reflecting the consequences of component failures in terms of the specific safety functions of the nuclear facilities. In addition, quality, seismic and environmental classes should be assigned commensurate with the required quality and reliability targets for the specific components.

   c) For definition of the design envelope of the nuclear facility a comprehensive evaluation of the operational states and the consequences of the Postulated Initiating Events (PIE) should be performed to specify all operational and accidental loads and to define the design requirements for the entire life cycle of the SSC. Load classes should be defined as a basis for the design process and code application.

   d) Taking the design envelope and the environmental conditions into account, appropriate materials should be selected for the SSC. Proven materials covered by standards and codes should be preferred. Potential gaps between the qualification conditions of proven materials, the nuclear facility design envelope and the environmental conditions need to be demonstrated by an appropriate test and qualification programme.

   e) The applicant has to specify the codes and standards for the design and manufacturing process of the SSC. The selected codes and standards should be justified considering the design envelope and the safety and quality classification. The selected codes and standards important to nuclear safety SSC need acceptance by the Regulator.

   f) A copy of the design specification has to be available before manufacturing begins and should include: the function and boundary of the component; material requirements, including test to be performed; environmental conditions; component classification; code editions and code cases; and load combinations.

8.1.4 Documentation to be provided prior to manufacturing

1) Following the issuance of an authorisation to manufacture, the following documents[1] for the specific components have to be submitted to Regulator and found to be acceptable before manufacturing[2] of that component may commence:
   a) Safety evaluation documents
      i) Performance requirements and design basis;
      ii) The basis, with technical justification, upon which the performance requirements have been established; and
      iii) The evaluations required to show that safety functions will be accomplished.
   b) Design input documents
      i) Design specifications;
      ii) Loading catalogue;
      iii) Interface documents;
      iv) Material selection report; and
      v) Code justification.
   c) Design documents
      i) Design reports; and
      ii) Design drawings.
   d) Overall manufacturing documents
      i) Welding list;
      ii) Quality control plan;
      iii) Purchase (basic design and sizing) documents and drawings; and

[1]The list of documents to be provided is based on the manufacturing of typical metallic components for nuclear installations. Similar or equivalent types of documents should be provided for non-metallic, electrical and other types of components.

[2]Manufacture includes those actions required to procure source materials such as forgings, plates, etc.

iv) Purchase order and specification.

e) Manufacturing documents of subsuppliers

i) Manufacturing plan;

ii) Test (Non Destructive Examination) procedures; and

iii) Drawings.

f) Manufacturing documents of suppliers

i) Manufacturing sequence and schedule;

ii) Quality plan;

iii) Inspection and test plan;

iv) Inspection and test procedures; and

v) Drawings.

8.1.5 Review of final manufacturing reports

1) An end of manufacturing (or assembling if appropriate) report should be provided for components important to nuclear safety that should include:

a) Final design report;

b) Compliance certificate;

c) Inspection and test results;

d) Non-conformance reports;

e) Procurement records;

f) Storage, transport, installation and test instructions;

g) Operation and maintenance manuals;

h) Operating conditions and limits; and

i) As-built drawings.

8.2 Early Site Activities and Early Construction Activities

1) The applicant must comply with the conditions and requirements as set forth in regulation 4(4)(b) of Part FOUR: Authorisation of Activities of the General Nuclear Safety Regulations before any site establishment, early site or early construction activities can commence.

2) For guidance on activities allowed on an authorised site, consult paragraph 6.5 of RG-0011: Guidance for the Siting of Nuclear Facilities.

3) Applications for site establishment activities are subject to either an application for a nuclear site licence or a nuclear licence to site and any other form of authorisation issued by the NNR.

4) Early site activities should only be undertaken under the authority of a nuclear site licence or a nuclear licence to site.

5) Early construction activities will be authorised in terms of a nuclear licence to site, subject to the conditions specified in regulation 4(4)(b)(iii) of Part FOUR: Authorisation of Activities of the General Nuclear Safety Regulations.

6) Preparatory earthmoving and excavation work may be carried out at the site before the construction licence is granted provided that the necessary authorisations have been obtained.

7) Commencing concrete casting of important to nuclear safety structures or of the construction of underground facilities affecting the long-term safety requires a construction licence in accordance with the Act.

9 COMMISSIONING

9.1 General

1) Detailed requirements on commissioning of nuclear facilities are provided in regulation 7 of the Specific Nuclear Safety Regulations: Nuclear Facilities. The applicant must ensure that these requirements are implemented and complied with.

2) Specific guidance on tests and qualifications of SSCs as well as commissioning can be found in RG-0005: Guidance on Test, Qualification and Commissioning for the PBMR DPP [3]. The document has been identified for revision and is generally applicable to nuclear facilities.

3) In addition, the following guidance on commissioning is relevant:

a) During construction and commissioning, the plant should be monitored, preserved and maintained in order to protect plant equipment, support the testing stage and maintain consistency with the safety analysis report.

b) During construction and commissioning, a comparison should be carried out between the as-built plant and its design parameters. A comprehensive process should be established to address non-conformities in design, manufacturing, construction and operation. Resolutions to correct differences from the initial design and non-conformities should be documented.

4) The purpose of the non-nuclear (cold) commissioning phase should be to:

a) Demonstrate that the as-built facility meets relevant safety criteria and is capable of safe operation.

b) Enable the production of a programme of safety commissioning activities that will:

i) Demonstrate as far as practicable the safe functioning of all systems and equipment;

ii) Demonstrate as far as practicable the soundness of structures;

iii) Prove as far as practicable all safety claims;

iv) Confirm as far as practicable all safety assumptions;

v) Confirm as far as practicable the effectiveness of all safety-related procedures;

vi) Identify limits and conditions necessary in the interest of safety during nuclear (hot) commissioning; and

vii) List aspects of safety that cannot be demonstrated prior to hot commissioning.

5) The purpose of the nuclear commissioning phase should be to:

a) Address any shortcomings revealed during cold commissioning.

b) Demonstrate that the cold commissioned plant continues to meet relevant safety criteria and is capable of safe operation.

c) Demonstrate that the hot commissioning activities can and will be carried out safely.

d) Enable the production of a programme of safety commissioning activities that will:

i) Demonstrate the safe functioning of all systems and equipment where not already demonstrated;

ii) Demonstrate as far as practicable the soundness of structures where not already demonstrated;

iii) Prove all safety claims not yet proven;

iv) Confirm all safety assumptions not yet confirmed;

v) Confirm the effectiveness of all safety-related operation and maintenance procedures not yet confirmed;

vi) Demonstrate that there are no aspects of safety that remain to be demonstrated after active commissioning; and

vii) Identify limits and conditions necessary in the interest of safety.

e) Demonstrate that the plant (as-built and commissioned) meets the safety standards and criteria set down in the preconstruction safety case.

f) Demonstrate that detailed analysis has been undertaken to prove that the plant will be safe.

g) Demonstrate that all necessary pre-operational actions have been completed, validated and implemented.

9.2 Commissioning Organisation

1) The requirements on commissioning organisations, as provided in regulation 7(3) of the Specific Nuclear Safety Regulations: Nuclear Facilities, must be implemented and complied with.

2) The applicant should also present information on the interfaces between engineering, construction, and commissioning organisations, and themselves during the commissioning period.

3) The applicant should maintain their own routines for the oversight of the commissioning organisation's activities. When commissioning activities are conducted by contractors, the applicant should participate directly in the commissioning activities, and as a minimum, they should participate in the review and approval of the activities.

4) It should also be shown that sufficient numbers of qualified operating personnel at all levels of the applicant's organisation will be directly involved in the commissioning process.

10 TESTING AND TEST PROGRAMMES

10.1 General

1) Detailed requirements on testing and test programmes of nuclear facilities are provided in regulation 7(6) and 7(7) of the Specific Nuclear Safety Regulations: Nuclear Facilities. The applicant must ensure that these requirements are implemented and complied with.
2) Testing may be divided into any number of steps (e.g. system performance tests, pre-criticality tests, low power tests, power tests).
3) Prior to proceeding from one step to another, the prerequisites for continued testing should be assessed based on the results of the preceding step.
4) The facility's safety should not depend on untested safety functions. If there are functions that can be tested only after the nuclear facility's operation begins, a safety assessment of the matter should be made. The safety assessment should describe why the function cannot be tested earlier as well as possible compensatory arrangements for performing the function, or the possibility of ensuring the function's operability with tests conducted at earlier steps. The safety assessment should be submitted to the NNR for acceptance before the nuclear facility's operation begins.
5) A third party that is independent of the facility and systems design organisation should review the test programmes of important to nuclear safety plant and system performance tests.

10.2 Performance Test Plan

1) For the purpose of testing, a performance test plan should be drawn up as part of the commissioning programme.
2) Test procedures for individual tests should be drawn up in advance of the actual test.
3) The test programme should include, in addition to what is required in regulation 7(6)(b) of the Specific Nuclear Safety Regulations: Nuclear Facilities, acceptance criteria for every test.
4) Test procedures should, as a minimum, cover the following:
   a) Requirement for conducting the test;
   b) Limitations on plant operation and other conditions for the performance of the test;
   c) Test conditions;

d) Initial state of the systems;

e) Instruments to be employed and other testing equipment and systems required, in so far as it is not part of the facility's fixed equipment;

f) A description of mitigative measure for malfunctions during the test performance;

g) Specific regulations concerning occupational safety and component shielding;

h) Personnel necessary for the test and possible special expertise required;

i) The personnel, and their hierarchy, responsible for the test;

j) Instructions for performing the test;

k) Completion of the test;

l) Recording of data to be monitored during the test; and

m) The reporting methodology of the test results.

5) Testing programmes of important to nuclear safety systems and plant tests (such as low power tests and power tests) must be submitted to the NNR for approval, and testing procedures for the testing programmes should be submitted for information.

6) Testing programmes should be conducted in a graded approach.

7) If a testing programme or procedure must be altered, the updated testing programme or procedure should be submitted to the NNR for review well in advance of when it is to be conducted.

8) If a testing programme is subject to NNR approval, the test may take place only after receipt of the approval. Commencement of the test means the first measure taken to demonstrate the performance of the tested item. However, inspections and tuning of e.g. instrumentation and control (I&C) equipment, flushing of piping and other preparatory measures may be carried out without NNR approval.

9) Before the testing of important to nuclear safety systems, the readiness for testing of individual components and structures must be verified in commissioning inspections by the NNR.

10.3 Fuel Loading, Pre-criticality, Low Power and Power Tests of Reactor Systems

10.3.1 Fuel Loading and Pre-criticality Tests

1) Before taking the reactor critical, pre-criticality tests should be conducted after fuel loading. The pre-criticality tests should test functions and properties that cannot be tested before fuel loading, but that do not require reactor criticality.
2) Closing of the primary circuit and pre-criticality tests of the reactor systems may begin after the NNR has inspected the loading pattern of the fuel assemblies and approved the reports on reactor and fuel behaviour during the first operation period and pre-criticality test programmes.

10.3.2 Low Power and Power Tests

1) NNR permission must be applied for and granted in order to take the reactor critical. The NNR must also approve the programme describing the measures to take the reactor critical.
2) The outcome of pre-criticality tests, conducted within the scope necessary to demonstrate fulfilment of the acceptance criteria, should be submitted as part of the application.
3) NNR permission must be applied for and granted in order to conduct low power tests. The NNR must also approve the low power test plan.
4) Low power tests should verify that the reactor core behaves as predicted and that the plant and its systems operate as intended with the reactor in power operation. The power level to be used should be the lowest possible during which the necessary parameters can be reliably measured.
5) NNR permission must be applied for and granted in order to perform power tests to raise the power to the next level presented in the power test programme. The NNR must also approve the test programme.
6) The results of tests conducted at the previous power level, within the scope necessary to demonstrate fulfilment of the acceptance criteria, should be attached to the application.
7) Power tests should verify the nuclear facility's planned operation at various power levels. The facility's behaviour should also be tested for certain anticipated operational occurrences.
8) A testing programme for the determination of neutron and gamma radiation should be in use to map out radiation levels in the vicinity of the reactor, primary circuit and other major radiation sources. The programme should be submitted to the NNR for approval.
9) Radiation measurements should be conducted extensively at different power levels to verify correctness of area classification and markings.

11 BUILDINGS AND CIVIL STRUCTURES OF A NUCLEAR FACILITY

11.1 General

1) The operational life of civil and structural assets should be governed by the original design, standards of construction, the environment and the adequacy of maintenance. These assets should not be allowed to deteriorate over an extended period of time due to unauthorised modifications and lack of maintenance.
2) The licensee should adopt a philosophy of rigid adherence to best industry practice by proactively adopting proven design and construction practices, inspecting their civil and structural assets and ensuring a maintenance strategy is developed, controlled and implemented. Civil inspection services should be built around developing a strategy for maintaining the integrity of the civil and structural assets where the consequences of failure are unacceptable.
3) The scope of construction, inspection and maintenance should be dependent on the type of structure and its importance to nuclear safety. Any remedial actions undertaken should be tracked in the civil inspection database.
4) Prior to construction, a civil inspection management system should be established that provides information for all inspection activities required, such as inspection reports, defect remediation, modifications, scheduling inspections and checking for overdue inspections. It should be designed to be interrogated on any of these aspects and should also closely monitor the progress of remedial actions.

11.2 Construction Plan

1) The licensee should draw up a construction plan for important to nuclear safety steel structures, steel components of composite structures, and concrete elements.
2) The installation construction plan should be submitted to the NNR for approval.
3) As a rule, the construction plan for important to nuclear safety steel and concrete structures and the design documents of concrete structures should be specific to each building or type of structure and should include the following documents:
   a) Organisation description;
   b) The regulations, codes and standards applied;
   c) Design bases;

d) Structural calculations;

e) Structural drawings;

f) Execution specification;

g) Quality control plan;

h) Installation construction plan;

i) Maintenance plan;

j) In-service structural inspection plan;

k) Plan for structural integrity tests; and

l) The licensee's summary of justifications.

4) The construction plan for steel structures should also include the manufacturing plan.

11.3 Execution

1) No excavation of foundations or placing of concrete for important to nuclear safety buildings and structures may take place before a construction licence (which takes into consideration all comments emanating from the public participation process) has been issued by the NNR.

2) The manufacturing of important to nuclear safety concrete structures and composite structures should be based on NNR-approved design documents and on plans for individual work phases or assignments. The installation of formwork and reinforcement for important to nuclear safety concrete structures may begin once the design documents have been submitted to the NNR and the licensee has authorisation that this work may be started.

3) The execution of concrete structures, steel structures and the steel components of composite structures should follow NNR requirements and guidance, national construction regulations and building regulations.

4) An execution quality plan should always be required for the execution of construction work at nuclear facilities. The quality plan is a building project quality control document that includes: a description of the constructor's performance in view of the requirements imposed; a description of the organisation and the responsible entity in charge; the principles and responsibilities of quality control; and a quality control plan and quality control records.

5) The safety class for concrete structures should be presented in the plans.

6) The exposure classes of concrete structures should be defined according to the prevailing environmental conditions.

7) The definition, properties, manufacturing and conformity of concrete should follow chosen codes and standards, as well as relevant national standards, including requirements for durability and allowed cement types.

8) A material certificate should be provided for all carbon steels and materials used for safety-related structures.

11.4 Inspection of Civil Structures

1) The licensee should inspect and approve the quality control protocols concerning all important to nuclear safety concrete and steel structures, and determine that sufficient readiness exists for starting the work.

2) Casting of reinforced concrete structures and installation of reinforcement for composite structures (safety-related structures) may begin once the NNR or an authorised inspection body has performed the installation inspection of the steel components.

3) The concreting, injection or prestressing of safety-related structures may commence after the Regulator has approved the design documents and the detailed work plans, and inspected that concreting readiness exists on the site.

4) The licensee should request a concreting readiness inspection from the Regulator before any casting of safety-related concrete can begin. The concreting work plan should be submitted to the Regulator for approval no later than the agreed time.

5) Application of coatings on important to nuclear safety structures may commence after the Regulator has approved the required documents, and once all the required structural inspections and reviews are complete.

12 MECHANICAL – PRESSURE VESSELS AND PIPING OF A NUCLEAR FACILITY

12.1 Construction Plan

1) The mechanical component work packages can be classified as:
   a) Special components (e.g. pressure vessel, turbo generator, reactor, steam generators, main pumps and motors). Sometimes primary pipes and associated equipment are classified as components and included in this group.
   b) Process components (e.g. tanks, heat exchangers, medium and small size pumps and motors, etc.).
   c) Process components can also be grouped (e.g. nuclear steam supply system and balance of nuclear island).
2) The heating, ventilation and air conditioning systems (HVAC) work packages include prefabrication and installation of ducts and in-line components such as dampers, filters and ventilators including motors. HVAC components can also be grouped (e.g. nuclear steam supply system and balance of nuclear island).
3) The piping work packages include site prefabrication (as defined by the construction technologies used), installation including supports, fittings and in-line components (e.g. valves, instrumentation parts, filters and small process components not included in the mechanical component work packages).

12.2 Pressure Vessels

1) Detailed requirements on the application of codes and standards for nuclear facilities are provided in regulation 6(3)(a) of the Specific Nuclear Safety Regulations: Nuclear Facilities. The applicant must ensure that these requirements are implemented and complied with.
2) In addition, the pressure boundary code or standard should:
   a) Describe the certification of materials used in fabrication and installation;
   b) Contain rules for material identification;
   c) Contain rules for repair of material during fabrication;
   d) Contain rules for the forming, fitting and aligning of materials;
   e) Contain tolerances in the rules for forming;

f) Address allowable offsets in the rules for fitting and aligning;

g) Describe permissible weld joints in components;

h) Contain rules for welding qualification, including welding procedure qualification tests and required records;

i) Contain rules for making, examining and repairing welds;

j) Contain rules for welding attachments;

k) Contain rules for repairing weld metal defects;

l) Contain rules for brazing, if permitted;

m) Contain rules for heat treatment (including requirements for preheat), postweld heat treatment and repair after postweld heat treatment; and

n) Contain rules for mechanical bolted joints including use of lubricants.

3) Materials used in pressure boundary components should be selected taking into consideration their working environment, expected degradation mechanisms, constructability, examinability and replaceability.

4) Components of a nuclear power plant are subjected to identifiable operating conditions. The design and service loadings should be identified considering all operating conditions of the plant.

5) A system should be protected from the consequences arising from the application of conditions of pressure and coincident temperature that would cause either the design pressure or the given service limits to be exceeded. Pressure relief devices should be required when the operating conditions would cause the service limits to be exceeded

12.2.1 Conformity assessment

1) The Pressure Equipment Regulations (PER) [8], as promulgated under the Occupational Health and Safety Act of 1993 [7], and the associated health and safety standards, provide the conformity assessment framework and essential mandatory safety requirements with respect to the use of pressure equipment and should be complied with.

2) Acceptance of a particular health and safety standard in terms of the PER does not infer that the NNR will or may not add technical or administrative requirements in line with best practice, which it deems necessary and expedient and in the interest of the protection of persons and the environment against nuclear damage.

3) The NNR's position on the application of the National Conformity Assessment Framework for Pressure Equipment in Nuclear Service is detailed in PP-0016 [12].

12.2.2 Installation, examination and testing

1) Pressure-retaining components should be manufactured and installed in accordance with manufacturing and installation rules and procedures specified in codes and standards.
2) Non-destructive examinations should be conducted in accordance with examination methods and procedures specified in codes and/or standards.
3) Examination procedures should be detailed and have been demonstrated to achieve their stated capabilities by an actual demonstration or other appropriate method.
4) All pressure-retaining components, appurtenances and completed systems should be pressure tested. The preferred method should be a hydrostatic test using water as the test medium. Bolts, studs, nuts, washers and gaskets may be exempted from the pressure test.
5) Requirements relating to testing of the pressure boundary are provided in regulations 8(13)(e) of the Specific Nuclear Safety Regulations: Nuclear Facilities. The applicant must ensure that these requirements are implemented and complied with.

13 ELECTRICAL AND INSTRUMENTATION AND CONTROL EQUIPMENT OF A NUCLEAR FACILITY

13.1 General

1) Procedures used during the receiving, installation and commissioning of electrical and I&C systems and equipment should describe the duties of the organisations responsible for a specific function, the division of work, the areas of responsibility, the procedures used for documentation and the scope of inspections to be performed.
2) Additional guidance on the Design and Implementation of Digital Instrumentation and Control for Nuclear Installation is provided in PP-0017 [13].

13.2 Receiving Inspection

1) Receiving inspection should be performed on all important to nuclear safety electrical and I&C equipment, cables and their software.
2) During the receiving inspections the licensee should ensure that the:
   a) Component, its assembly, software and configuration correspond to the design.
   b) Final documentation from the quality management of the component or software meets the acceptance criteria.
   c) Component has not suffered any damage during transport.
3) Inspections and tests relating to the receiving inspection should be acceptably performed.

13.3 Installation Plan

1) The installation plan should describe the facility's electrical power systems as well as instrumentation and control systems.
2) The installation plan should provide an explanation of the overall design approach for the facility's electrical power systems and their design basis requirements. It should also provide the following information:
   a) Divisions of electrical power systems, including the differing system voltages and specification of which parts of each system are considered essential.
   b) Assurance that the electrical power systems important to nuclear safety, including circuit breakers, are functionally adequate and that these systems have adequate margins, redundancy, physical separation, independence, reliability and testability in compliance with applicable design criteria.
   c) Description of the electrical equipment protection, including the provisions to desensitise this protection under abnormal conditions and also to bypass this protection under accident conditions.
   d) General description of the utility grid and its interconnection to other grids, and the connection point of the on-site electrical system to the outside HV switchyard, including the capacity, stability and reliability of the grid in relation to the safe operation of the plant.

e) Description of the physical location of the load dispatching centre controlling the grid with the provisions for communications between the dispatch centre, the remote major load centres and the generating plants.

f) Description of the principal means of regulating the voltage and frequency to connect and disconnect safely from the off-site grid.

g) Simplified single-line drawing showing the main grid interconnections.

3) The installation plan should provide an explanation of the overall design approach for the facility's instrumentation and control systems and their design basis requirements. It should also provide the following information:

a) Design basis requirements for individual actuation parameters (physical measurements used to control safety system actions), including a list of the postulated initiating events for which each parameter is credited.

b) Identification of the interfaces with other systems, including the provisions to ensure the proper isolation of electrical signals, the means used to ensure the physical separation of redundant actuation system channels, and the means used to generate coincidence signals from redundant independent channels.

c) A description of the hardware and software quality assurance programmes and the software development process, including software requirements, design, implementation, verification, computer system integration, computer system validation, commissioning, and configuration control. (The software description is needed when digital computer systems are used for safety systems.)

d) Specification of actuation system setpoints for safety systems, the time delays in system operation, the measurement uncertainties, and how these relate to the assumptions made in the safety analysis.

e) Provisions for equipment protective interlocks (e.g. pump and valve interlocks and motor protection) within the actuation system, including a demonstration that such interlocks will not adversely affect the operation of safety systems.

f) Provisions for manually initiating safety systems from the main control room and the secondary control room.

g) Relevant remote operator and/or automatic control, local control, on-off control or modulating control considered in the design and credited in the safety analysis.

h) Elementary logic diagrams of the safety systems from the sensors to the end devices.

i) Provisions for a secure development and operating environment for the protection of a digital computer-based I&C safety system.

4) The electrical and I&C work packages should be grouped by sub discipline:

a) Electrical (e.g. installation of cabinets and electrical power components; cable trays, conduits; junction boxes; auxiliary systems such as lighting, fire alarms, loudspeakers; and laying and connecting of cables).

b) Instrumentation and control (e.g. installation of panels and cabinets, junction boxes, field racks, local instruments and transducers).

5) Physical separation in these disciplines should be carefully analysed taking into account that most components are concentrated in the switchgear building. The laying down of cables cannot be grouped by buildings (except perhaps the reactor building). Similarly, most auxiliary systems are difficult to separate.

6) If the high voltage switchyard is included in the project scope, it is recommended to consider it as a subproject regardless of the disciplines involved because of the special expertise normally required to execute this work package.

13.4 Installation Inspection

1) The scope, actions, responsibilities and records of the installation inspection and functional tests to be done after installation should be defined.

2) The licensee should perform an installation inspection on all important to nuclear safety electrical or I&C equipment and cabling installed.

3) During the installation inspection, the licensee should ensure that the installation is appropriate and that it has been performed according to approved plans and the guidelines and principles concerning a nuclear facility safety classification.

13.5 Commissioning

1) Provisions should be made in the design to ensure that the following test programmes can be implemented:

a) A pre-operational test programme to demonstrate the operational and emergency modes to be conducted following the installation of all components. This test programme should prove that the design requirements have been met and establish that each division is independent of other divisions.

b) A periodic test programme to demonstrate the continuing operability of the system and to detect and identify any degradation of the system or components within the system.

c) A test programme that provides adequate assurance of the readiness of the system to function upon demand and that identifies components with excessively high frequencies of maintenance.

2) The licensee should successfully perform a commissioning inspection on the installed or modified important to nuclear safety electrical or I&C systems, equipment or cabling before they are commissioned.

3) If necessary, the commissioning inspection may be divided into two parts. The first part should review the documentation created before commissioning testing and determine that the system, component or cabling installed is ready for commissioning and testing. The second part should review the documentation containing the results from commissioning and testing. All the results should be documented and form part of configuration control. In this way the inspection load in larger projects may be divided across several steps, which improves the manageability of the installation and commissioning testing phase.

4) The commissioning inspections of important to nuclear safety electrical and I&C systems and equipment may only be performed by an NNR-approved organisation and inspector that is independent of the design and installation. The NNR-approved inspector may belong to the licensee's organisation or be an external consultant.

5) The following information should be appended to the licensee's application for all personnel participating in the commissioning inspections:

a) An organisation description indicating the organisational role of the section and personnel performing the inspections and the independence of the inspection activities;

b) A detailed description of the personnel performing the inspections addressing their education, work experience and competence as well as identifying which inspections need approval;

c) A description of the procedures used in and the safety-significant instructions pertaining to the inspections; and

d) Detailed clarifications, where needed.

6) The inspectors should have sufficient professional competence and experience as well as the appropriate equipment, tools and methods needed to perform the inspections successfully.

7) Commissioning inspections should:

   a) Verify that the component or system installed complies with the approved plans, and that this has been verified and validated by appropriate inspections and tests.

   b) Verify that any defects and faults discovered during previous steps in the process have been corrected.

   c) Ensure that any changes made in the commissioning phase have been implemented according to the procedures specified for the system's configuration management.

   d) Ensure that the parameters of a software-based component or system have been set and recorded according to the configuration management system.

   e) Review the execution of the licensee's quality management that is informed by NNR requirements.

   f) Verify that the electrical or I&C systems, components, cabling and installations fulfil the environmental and operating condition requirements set by their location of use throughout the lifecycle.

   g) Verify that the installation inspections and functional tests have been performed according to quality requirements. The commissioning testing results documentation and the protocols related to commissioning should be reviewed and should not contain deficiencies that prevent commissioning.

   h) Inspect the readiness of the instructions regarding the system.

   i) Ensure that any observations made by the NNR during earlier regulatory engagement have been appropriately addressed.

   j) Verify that no problems exist that would prevent commissioning.

8) If any minor non-conformances are discovered during the licensee's commissioning inspection pertaining to NNR-approved suitability analysis or pre-inspection documents, they should be brought to the attention of NNR.

9) A deviation report should be prepared of any significant deviations observed during the commissioning inspection and should be submitted to the NNR for approval prior to implementation of such deviations.

14 REGULATORY OVERSIGHT BY THE NNR

14.1 General

1) In order to properly implement an oversight programme during construction, the communication between the licensee, NNR and any other authorised bodies should be formally defined before construction begins.
2) Clear terms of references for liaison forums and protocols for communication at all levels should be established.

14.2 Licensing Process and Schedule

1) The licensing process can be broken down into three partially overlapping phases:
   a) The preparatory phase following notification of intent to apply for a construction licence for a new nuclear facility or a nuclear licence to site, construct, operate and decommission a nuclear facility;
   b) The review of the safety case including the public participation process where applicable; and
   c) The board review and decision process.

14.2.1 Preparatory phase

1) The preparatory phase can be initiated by either a notification of intent or a licence application.
2) In the case of a licence application appropriate allowance should nevertheless be made for the preparatory phase.
3) The notification letter of intent from the potential applicant should cover the following:
   a) Intention to apply for a nuclear licence that should be based on a firm investment decision;
   b) Technologies under consideration for design, construction and operation on the site;
   c) Project plan including information on vendor and main suppliers;
   d) Proposed licensing schedule taking cognisance of the time constraints for the construction licensing process (a typical schedule for a nuclear power plant is presented in Attachment A); and

e) Commitment to licensing fees covering the preparatory phase.

4) National priorities and policies as well as the Regulator's resource constraints will determine the prioritisation of the application and impact the proposed licensing schedule, notwithstanding the typical schedule provided in Attachment A.

5) The following preliminary safety case documentation should be submitted with the notification letter, but may follow later in accordance with the schedule in Attachment A:

   a) Plant design information;

   b) Preliminary safety analysis report (SAR);

   c) Proposed general operating rules (GORs); and

   d) Physical security design (preliminary).

6) The preparatory phase should focus on the following main activities:

   a) Assessment by the NNR of the design against the regulatory requirements, proven technology, generic safety issues (e.g. severe accidents), etc.

   b) Identification of potential licensing issues, i.e. technical issues which could require considerable time and effort to resolve.

   c) Identification of long-term items (e.g. the research, tests and qualifications required).

   d) Inspection of design documents and design/manufacturer/supplier organisations.

   e) Investigating and securing arrangements for technical support.

   f) Compilation of the NNR preliminary safety evaluation report (PSER)

   g) Staff recruitment and training on proposed technologies and licensing.

   h) Development of the review plan, including acceptance criteria as appropriate, and CCAP.

   i) Follow up on issues identified.

14.3 Review of the Safety Case for Construction

1) For a nuclear licence to construct a nuclear facility, the NNR should be provided with a safety case containing sufficient information covering the full technical safety basis. This will enable the NNR to perform a detailed assessment and therefore determine whether the proposed design

will likely meet the requirements and that all safety issues identified during the safety case review will be mitigated at the appropriate stage of the licensing process.

2) The safety case submitted in support of the application for a construction licence should cover siting, design, construction, manufacturing, commissioning, operation and decommissioning.

3) The specification of the scope and the structure of the safety case should be agreed to with the NNR prior to submission and should be based on international standards.

4) Once the decision is made to grant a nuclear licence to construct, the NNR may impose in terms of section 23 of the Act specific conditions related to the respective licensing stage such as mandatory hold and/or witness points beyond which work must not proceed without the approval of the Regulator. Depending on the type of nuclear facility, the associated nuclear risk and the completeness of the safety assessment, these hold and/or witness points could be for important steps such as:

   a) Site establishment;

   b) Early site activities;

   c) Component manufacturing (otherwise authorised under an authorisation to manufacture);

   d) Carrying out of civil works;

   e) Installation of components and equipment;

   f) Performance of pre-commissioning or functional tests of individual subsystems of components;

   g) Non-nuclear commissioning testing up to and including non-nuclear integrated tests; and

   h) Nuclear commissioning testing (including nuclear material on site, loading of nuclear material, initial criticality, low power testing and full power testing).

5) For subsequent licensing stages the applicant will request a variation (amendments to the conditions) to this nuclear licence supported by the relevant information. Subject to the regulatory review of the submitted documents, the conditions of the nuclear licence will be amended for the specific stage of licensing and a variation of the nuclear licence will be issued to the applicant.

14.4 Construction Compliance Assurance Programme

1) After the construction licence application has been submitted, the NNR assesses the functionality of the applicant's management system and the adequacy of the procedures as part of the

Construction Compliance Assurance Programme (CCAP) relating to the review of the construction licence application.

2) After the construction licence has been granted, the Regulator assesses the functionality of the licensee's management system and the adequacy of the procedures to evaluate, guide and approve design operations as part of the CCAP.

3) The CCAP for nuclear power plants will include, amongst others, audits and inspections relating to:

   a) Control of design information;

   b) Manufacturing;

   c) Construction and installation;

   d) Commissioning;

   e) Reporting;

   f) Quality assurance and quality control;

   g) Design and as-built verification;

   h) Geotechnical and foundation activities;

   i) Structural concrete, including anchors;

   j) Structural steel and supports;

   k) Reactor coolant system pressure boundary piping;

   l) Safety-related piping;

   m) Mechanical components;

   n) Electrical and instrumentation and control;

   o) Containment penetrations;

   p) Welding and non-destructive examination;

   q) Containment structural integrity test;

   r) Radiation waste management and storage;

   s) In-service inspection; and

   t) Environmental protection.

15 REFERENCES

The following references were consulted during the compilation of this document:

[1] National Nuclear Regulator Act (Act No. 47 of 1999).

[2] Regulations in terms of section 36 of the National Nuclear Regulator Act (Act No. 47 of 1999), on Safety Standards and Regulatory Practices (GN R388).

[3] RG-0005: Guidance on Testing, Qualification and Commissioning of the Pebble Bed Modular Reactor Demonstration Power Plant (PBMR DPP), 9 March 2010.

[4] RG-0007: Regulatory Guide on Management of Safety, March 2015.

[5] IAEA Safety Guide SSG-38, Construction of Nuclear Installations.

[6] IAEA Nuclear Energy Series NP-T-2.7, Project Management in Nuclear Power Plant Construction: Guidelines and Experience.

[7] Occupational Health and Safety Act (Act No. 85 of 1993).

[8] Regulation 734 of 2009, Pressure Equipment Regulations. Published in the Republic of South Africa Government Gazette, No. 32395, 15 July 2009.

[9] Regulation 735 of 2009, Incorporation of Health and Safety Standards into the Pressure Equipment Regulations. Published in the Republic of South Africa Government Gazette, No. 32395, 15 July 2009.

[10] SANS 347, Categorisation and Conformity Assessment Criteria for all Pressure Equipment, Standards South Africa, 2007.

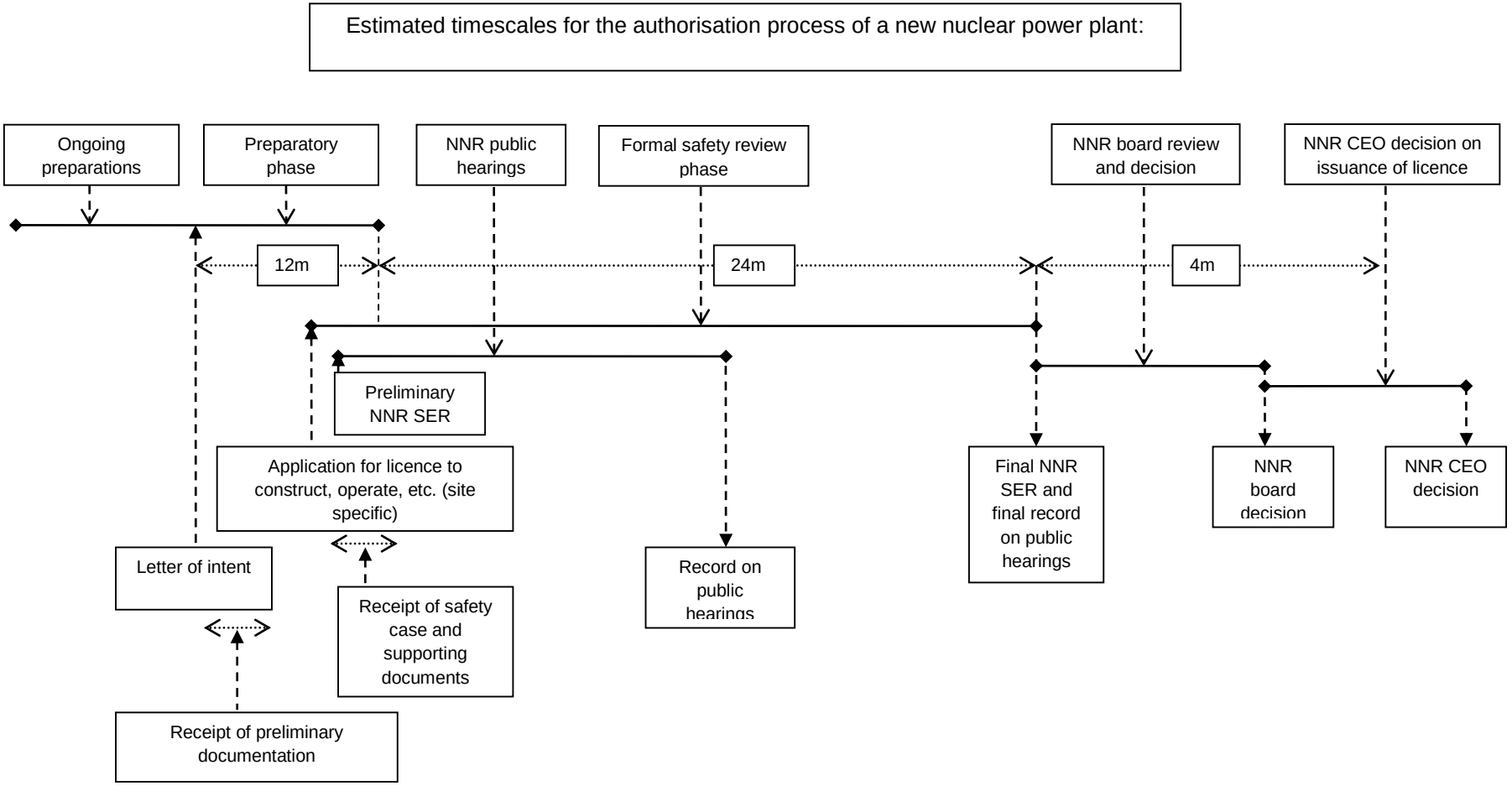
[11] SANS 10227, Criteria for the Operation of Inspection Authorities Performing Inspection in Terms of the Pressure Equipment Regulations, Standards South Africa, 2007.

[12] PP-0016: Conformity Assessment of Pressure Equipment in Nuclear Service.

[13] PP-0017: Design and Implementation of Digital Instrumentation and Control for Nuclear Installation.

[14] RD-0034: Quality and Safety Management Requirements for Nuclear Installations.

ATTACHMENT A: TYPICAL CONSTRUCTION LICENSING SCHEDULE



Note: The timescales indicated in this document are typical for the licensing of a technology that has been licensed in another country, where information is readily available in English and which meets internationally recognised standards.