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NUCLEAR SAFETY AND RADIATION PROTECTION ACT
(CAP N142 LAWS OF THE FEDERATION OF NIGERIA)

NIGERIAN DESIGN AND CONSTRUCTION OF NUCLEAR POWER PLANT REGULATIONS, 2023

ARRANGEMENT OF SECTIONS

REGULATIONS :

NUCLEAR SAFETY AND RADIATION PROTECTION ACT (CAP N142 LAWS OF THE FEDERATION OF NIGERIA)

NIGERIAN DESIGN AND CONSTRUCTION OF NUCLEAR POWER PLANT REGULATIONS, 2023

[23*rd Day of November,* 2023] Commencement

In exercise of the powers conferred on it by section 47 of the Nuclear Safety and Radiation Protection Act CAP N142 Laws of the Federation of Nigeria, 2004 and all other powers enabling it in that behalf, the Nigerian Nuclear Regulatory Authority, with the approval of the President, makes the following Regulations —

PART I — GENERAL PROVISIONS

Objectives

1. The objectives of these Regulations are to —

(*a*) establish design and construction requirements for the Structures and Systems and Components(SSC) of a Nuclear Power Plant (NPP) ;

(*b*) establish procedures and organisational processes important to safety that are required to be met for safe operation ; and

(*c*) prevent events that compromise safety and mitigate the consequences of such events, where they occur.

Application

2. These Regulations shall apply to —

(*a*) land based stationary NPP with water cooled reactors designed for electricity generation or for heat production applications including district heating or desalination ;

(*b*) other reactor types, with judgement, to determine the requirements to be considered in developing the design ; and

(*c*) organisations involved in design, manufacture, construction, modification, maintenance, operation and decommissioning of NPP, for the purpose of analysis, verification, review, and provision of technical support

Fundamental safety objective

3.—(1) The fundamental safety objective shall be to protect people and the environment from harmful effects of ionizing radiation.

(2) The following measures shall be taken to achieve the fundamental safety objectives referred to in sub regulation (1) of this regulation —

(*a*) control of the radiation exposure of people and the release of radioactive material to the environment during operational states ;

(*b*) restrict the likelihood of events that might lead to loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source, spent nuclear fuel, radioactive waste or any other source of radiation at a NPP ; and

(*c*) prevention of accidents and mitigation of the consequences of such events if they were to occur.

(3) The fundamental safety objective applies to all stages in the lifetime of the NPP, including planning, siting, design, manufacture, construction, commissioning, operation, decommissioning. as well as the associated transport of radioactive material and the management of spent nuclear fuel and radioactive waste.

Radiation protection objective

4. The radiation protection objective shall be to ensure that for all operational states of the NPP and for any associated activities, radiation exposures within the NPP or due to any planned release of radioactive material from the NPP are kept below prescribed limits and as low as reasonably achievable (ALARA).

Technical safety objectives

5. The technical safety objectives shall be to provide all reasonably practicable measures to prevent accidents in the NPP, and to mitigate the consequences of accidents if they occur.

Application of the technical safety objective

6.—(1) The committed whole-body dose for average members of the critical groups who are most at risk, at or beyond the site boundary shall be calculated in the deterministic safety analysis for a period of 30 days after the analysed event, Provided that the dose shall be less than or equal to the dose acceptance criteria of —

(*a*) 0.5 millisievert for any anticipated operational occurrence (AOO) ; or

(*b*) 20 millisieverts for any design basis accident (DBA).

(2) The following qualitative safety goals shall be established —

(*a*) individual members of the public shall be provided a level of protection from the consequences of NPP such that there is no significant additional risk to the life and health of individuals ; and

(*b*) societal risks to life and health from nuclear power plant operation shall be comparable to or less than the risks of generating electricity by viable competing technologies, and shall not significantly add to other societal risks.

(3) The following quantitative safety goals shall be established —

(*a*) core damage frequency which is the sum of frequencies of all event sequences that can lead to significant core degradation is less than 10^{-5} per reactor year ;

(*b*) small release frequency which is the sum of frequencies of all event sequences that can lead to a release to the environment of more than 10^{15} becquerel of iodine-131 is less than 10^{-5} per reactor year, provided that a greater release may require temporary evacuation of the local population ; and

(*c*) large release frequency which is the sum of frequencies of all event sequences that can lead to a release to the environment of more than 10^{14} becquerel of cesium-137 is less than 10^{-6} per reactor year, provided that a greater release may require long term relocation of the local population.

Part II — Management of Safety in Design

Responsibilities in the management of safety in plant design

7. An applicant for a licence to construct or operate a nuclear power plant shall ensure —

(*a*) that the design submitted to the Authority meets all applicable safety requirements ; and

(*b*) engage the services of a qualified design organisation

(*c*) that the NPP design and design process have a clear —

(*i*) division of responsibilities with corresponding lines of authority and communication,

(*ii*) interface between the groups engaged in different parts of the design, and between designers, utilities , suppliers, builders, and contractors as appropriate,

(*iii*) procedures that align with an established quality assurance programme, and

(*iv*) a positive safety culture throughout all levels of the organisation.

Design organisation

8.—(1) The authority to design shall rest with the organisation that has overall responsibility for the design during the design stage, provided that this authority shall be transferred to the operating organisation prior to plant start-up.

(2) The Design Organisation may assign the design of specific parts of the plant to other organisations (responsible designer) .

(3) For the purpose of sub regulation (2) of this regulation formal documentation of the tasks and functions of the design organisation and responsible designer shall be established in conjunction with the Operating Organisation.

(4) The applicant shall confirm that the Design Organisation has achieved the design objectives.

Management system for plant designs

9.—(1) The Design Organisation shall establish and implement a management system for ensuring that all safety requirements established for the design of the plant are considered and implemented in all phases of the design process and that they are met in the final design.

(2) The design management system shall achieve the following objectives —

(*a*) SSCs important to safety meet their respective design requirements ;

(*b*) human capabilities and limitations of personnel are taken into consideration ;

(*c*) the results of the deterministic and probabilistic safety assessment are taken into consideration ;

(*d*) prevention of accident and mitigation of their consequences are given due consideration ;

(*e*) provision of physical protection systems to address design basis threats, verification, validation and approval of plant design, including design tools ; and

(*f*) design inputs and outputs shall be done by groups separate from those who originally performed the design work.

(3) The operating organisation shall establish a formal system for ensuring continuous safety of the plant design throughout the lifetime of the NPP

(4) For the purpose of sub regulation 3 of the regulation, the operating organisation shall ensure that include

(*a*) safety design information necessary for safe operation and maintenance of the plant and any subsequent plant modifications are preserved ; and

(*b*) operational Limits and Conditions (OLC) are provided for incorporation into the plant administrative and operational procedures

(*c*) generation of radioactive waste is limited to minimum practicable levels, in terms of both activities and volumes ;

(*d*) it Establishes a change control process to track design changes in order to provide configuration management during construction commissioning and operation ;

(*e*) the design of the plant including subsequent changes, modifications or safety improvements are in accordance with established procedures that call on appropriate engineering codes and standards which shall incorporate relevant requirements and design basis.

PART III — PRINCIPAL TECHNICAL REQUIREMENTS

Fundamental safety functions

10.—(1) The Operating Organisation shall ensure that the following fundamental safety functions for a NPP are fulfilled for all plant states —

(*a*) control of reactivity ;

(*b*) removal of heat from the reactor and the fuel store ; and

(*c*) confinement of radioactive material, shielding against radiation and control of planned radioactive releases, as well as limitation of accidental radioactive releases.

(2) The Operating Organisation shall ensure that physical separation and independence of safety systems, interference between safety systems or between redundant elements of a system is prevented by physical separation, electrical isolation, functional independence and independence of communication (data transfer), as appropriate.

(3) The Operating Organisation shall ensure that —

(*a*) all items important to safety are identified and classified on the basis of their function and safety significance ;

(*b*) all SSCs are designed, constructed and maintained such that their quality and reliability is commensurate with this classification ;

(*c*) the method for classifying the safety significance of a structure, system or component are primarily based on deterministic methods, complemented where appropriate by probabilistic methods and engineering judgment ;

(*d*) methods for classifying the safety significance of a structure, system or component shall primarily be used on deterministic methods, complemented where appropriate by probabilistic methods and due account taken of the —

(*i*) safety functions to be performed by the item,

(*ii*) consequences of failure to perform a safety function,

(*iii*) frequency with which the item will be called upon to perform SSC function, and

(*iv*) time following a postulated initiating event at which or the period for which the item will be called upon to perform a safety function ;

(*e*) appropriately designed interfaces are provided between structures, systems and components of different classes to ensure that any failure in a system classified in a lower class will not propagate to a system classified in a higher class ; and (*f*) equipment that performs multiple functions are classified in a safety class that is consistent with the most important function performed by the equipment.

Operational limits and conditions for safe operation

11. The Operating Organisation shall ensure that —

(*a*) the design establish a set of operational limits and conditions for safe operation of the nuclear power plant ;

(*b*) the requirement and operational limits and conditions established in the design for NPP shall include :

(*i*) safety limits,

(*ii*) limiting settings for safety systems,

(*iii*) limits and conditions for normal operations,

(*iv*) control system constraint and procedural constraints on process variables and other import parameters,

(*v*) requirement for surveillance, maintenance, testing and inspection of the plant to ensure that structure, systems, and component function as intended in the design to comply with the requirement for optimisation by keeping radiation risks and low as reasonably achievable (ALARA),

(*vi*) specified operational configuration including operational restrictions in the event of the unavailability of safety systems or safety related systems, and

(*vii*) action statement including completion times for actions in response to deviations from the operational limits and conditions ;

(*b*) OLC are established for the plants to operate in accordance with design assumptions and intent (parameters and components), and shall include the limits within which the facility has been shown to be safe ; and

(*c*) the basis on which the OLC are derived are readily available in order to facilitate the ability of plant personnel to interpret, observe, and apply the OLC.

Other design consideration

12.—(1) The Operating Organisation shall ensure that each unit of a multiple unit nuclear power plant shall have its own safety systems and shall have its own safety features for design extension conditions.

(2) The Operating Organisation shall ensure that all systems in the NPP that may contain fissile material or radioactive material are designed to —

(*a*) prevent the occurrence of events that may lead to an uncontrolled radioactive release to the environment ;

(*b*) prevent accidental criticality and overheating ;

(*c*) ensure that radioactive releases are kept below authorised limits on discharges in normal operation and below acceptable limits in accident conditions, and are kept as low as reasonably achievable ; and

(*d*) facilitate mitigation of radiological consequences of accidents.

(3) The Operation Organisation shall ensure that NPP coupled with heat utilisation units, such as for district heating, or water desalination units are designed to prevent processes that transport radionuclides from the nuclear plant to the desalination unit or the district heating unit under conditions of operational states and accidents conditions.

(4) The Operating Organisation shall ensure that the NPP is isolated from its surroundings with a suitable layout of the various structural elements so that access to NPP can be controlled.

(5) The Operating Organisation shall ensure that unauthorised access to, or interference with, items important to safety, including computer hardware and software, are prevented, provided that it shall be ensured in the design that where access is necessary for maintenance, testing or inspection purposes, necessary activities can be performed without significantly reducing the reliability of safety related equipment.

(6) The Operating Organisation shall ensure that the potential for harmful interactions of systems important to safety at the NPP that might be required to operate simultaneously are evaluated, and effects of any harmful interactions are prevented.

(7) The Operating Organisation shall ensure that the functionality of items important to safety at the NPP is not compromised by disturbances in the electrical power grid, including anticipated variations in the voltage and frequency of the grid supply.

PART IV — DESIGN FOR A NUCLEAR POWER PLANT

Design for a nuclear power plant

13.—(1) The Operating Organisation shall ensure that the —

(*a*) design of the plant and items important to safety have the appropriate characteristics to ensure that safety functions can be performed with the necessary reliability ;

(*b*) plant can be operated safely within the OLC for the full duration of its design life and can be safely decommissioned ; and

(*c*) impact of the decommissioning on the environment is minimized.

(2) The Operating Organisation shall ensure that the design basis for

each item important to safety are systematically justified and documented.

(3) The documentation referred to in sub regulation (2) of this regulation shall include the following information —

(*a*) design description ;

(*b*) design requirements ;

(*c*) system classifications ;

(*d*) description of plant states ;

(*e*) security system design, including a description of physical security barriers ;

(*f*) operational limits and conditions ;

(*g*) identification and categorisation of initiating events ;

(*h*) acceptance criteria and derived acceptance criteria ;

(*i*) deterministic safety analysis ;

(*j*) probabilistic safety assessment (PSA) ; and

(*k*) hazards analysis.

Categories of NPP states

14. The Operating Organisation shall ensure that plant states are identified and grouped into a limited number of categories primarily on the basis of their frequency of occurrence at the NPP.

Design basis for items important to safety

15. The Operating Organisation shall ensure that the design basis for items important to safety specify the necessary capability, reliability and functionality for the relevant operational states, for accident conditions and for conditions arising from internal and external hazards, to meet the specific acceptance criteria over the lifetime of the NPP.

Design basis accidents

16. The Operating Organisation shall ensure that accident conditions that are to be considered in the design are derived from Postulated Initiating Events (PIE) for the purpose of establishing the boundary conditions for the NPP to withstand, without exceeding the acceptable limits for radiation protection.

Postulated Initiating events

17. The Operating Organisation shall ensure that the design of the NPP, apply a systematic approach to identifying a comprehensive set of PIE, such that all foreseeable events with the potential for serious consequences and significant frequency of occurrence are anticipated and are considered in the design.

Design extension conditions

18. The Operating Organisation shall ensure that design extension conditions are derived on the basis of engineering judgement, deterministic and probabilistic assessments for the purpose of further improving the safety of the NPP by enhancing the plant's capabilities to withstand, accidents that are either more severe than Design Basis Accidents(DBA) or that involve additional failures, without unacceptable radiological consequences

Combinations of events

19. The Operating Organisation shall ensure that combinations of randomly occurring individual events that could credibly lead to Anticipated Operational Occurrence (AOO) or DBA and the combination of both are considered in the design, Provided that such combinations are identified early in the design phase, and confirmed using a systematic approach.

Internal and external hazards

20.—(1) The Operating Organisation shall ensure that all foreseeable internal and external hazards, including the potential for human induced events directly or indirectly that affect the safety of the NPP, are identified and their effects evaluated.

(2) The Operating Organisation shall ensure that hazards are considered in designing the layout of the plant and in determining the PIE and generated loadings for use in the design of relevant items important to safety of the plant, and the design shall —

(*a*) take due account of internal hazards such as fire, explosion, flooding, missile generation, collapse of structures and falling objects, pipe whip, jet impact and release of fluid from failed systems or from other installations on the site.

(*b*) ensure that appropriate features for prevention and mitigation are provided and that safety is not compromised ;

(*c*) include due consideration of those natural and human induced external events that have been identified in the site evaluation process ;

(*d*) take due account of site specific conditions to determine the maximum delay time by which off-site services need to be available ; and

(*e*) for multiple unit plant sites, take due account of the potential for specific hazards to give rise to impacts on several or even all units on the site simultaneously.

Design rules and limits

21. The Operating Organisation shall ensure that —

(*a*) a set of design limits consistent with the key physical parameters for each item important to safety for the NPP are specified for all operational states and accident conditions ; and

(*b*) the engineering design rules for items important to safety at a NPP are specified and comply with the relevant national or international codes and standards and with proven engineering practices, with due account taken of their relevance to nuclear power technology.

Reliability of items important to safety

22. The Operating Organisation shall ensure that in the design, the reliability of items important to safety is commensurate with their safety significance.

Common-cause failures

23. The Operating Organisation shall ensure that the design of equipment take due account of the potential for common cause failures of items important to safety, to determine how the concepts of diversity, redundancy, physical separation and functional independence are to be applied to achieve the necessary reliability.

Single failure criterion

24. The Operating Organisation shall ensure that the single failure criterion is applied to each safety group incorporated in the plant design and —

(*a*) spurious action shall be considered to be one mode of failure when applying the single failure criterion to a safety group or safety system ; and

(*b*) the design shall take due account of the failure of a passive component, unless it has been justified in the single failure analysis with a high level of confidence that a failure of that component is very unlikely and that its function would remain unaffected by the PIE .

Fail-safe design

25. The Operating Organisation shall ensure that the principle of fail-safe design are applied to the design of SSCs important to safety to enable plant systems to pass into a safe state if a system or component fails, with no necessity for any action to be taken.

Support service systems

26.—(1) The Operating Organisation shall ensure that the —

(*a*) support service systems for operability of equipment forming part of a system important to safety are classified accordingly ; and

(*b*) reliability, redundancy, diversity and independence of support service systems and the provision of features for their isolation and for testing their functional capability are commensurate with the significance to safety of the system being supported.

(2) The Operating Organisation shall ensure that —

(*a*) safety support systems provide services to systems important to safety in all plant states ;

(*b*) the design incorporates emergency safety support systems to cope with the possibility of loss of normal service and, where applicable, concurrent loss of backup systems ; and

(*c*) the emergency support systems —

(*i*) are independent of normal and backup systems, (*ii*) provide continuity of the service until long term (normal or backup) service is re-established,

(*iii*) have a capacity margin that allows for future increases in demand, and

(*iv*) are testable under design load conditions.

(3) The Operating Organisation shall ensure that in cases where a system performs both process and safety functions, the following design considerations applies —

(*a*) the process and safety functions shall not be required or credited at the same time ;

(*b*) if the process function is operating, and a PIE in that system is postulated, it can be shown that all essential safety functions of the system that are required to mitigate the PIE are unaffected ;

(*c*) the system shall be designed to the standards of the function of higher importance with respect to safety ;

(*d*) if the process function shall be used intermittently, the availability of the safety function after each use, and its continued ability to meet expectations, are demonstrated by testing ; and

(*e*) the expectations for instrumentation sharing shall be met.

(4) The Operating Organisation shall ensure that shared instrumentation for safety systems —

(*a*) are not typically shared between safety systems, provided that if justified, there may be sharing between a safety system and a non-safety system (such as a process or control system) ;

(*b*) reliability and effectiveness of a safety system are not impaired by normal operation, by partial or complete failure in other systems, or by any cross-link generated by the proposed sharing ;

(*c*) design include provisions to ensure that the sharing of instruments does not result in an increased frequency in demand on the safety system during operation ;

(*d*) design provide for periodic testing of the entire channel of instrumentation logic, from sensing device to actuating device ; and

(*e*) design that includes sharing of instrumentation between a safety and a non-safety system.

(5) The Operating Organisation shall ensure that SSCs important to safety are not typically shared between two or more reactors, provided that —

(*a*) in exceptional cases when SSCs are shared between two or more reactors, such sharing shall exclude safety systems and turbine generator buildings that contain high-pressure steam and feed water systems ;

(*b*) if sharing of SSCs between reactors is arranged, then the following expectations shall apply —

(*i*) all safety requirements shall be met for all reactors during normal operation, all operational state, and accident conditions.

(*ii*) in the event of an accident involving one of the reactors, orderly shutdown, cool down, and removal of residual heat shall be achievable for the other reactor(s) ; and

(*c*) when an NPP is under construction adjacent to an operating plant, and sharing of SSCs between reactors has been justified, the availability of the SSCs and their capacity to meet all safety requirements for the operating units shall be assessed during the construction phase.

(6) The Operating Organisation shall ensure that —

(*a*) all pressure-retaining SSCs are protected against overpressure conditions, and classified, designed, fabricated, erected, inspected, and tested in accordance with established standards ;

(*b*) all pressure-retaining SSCs of the reactor coolant system and auxiliaries are designed with an appropriate safety margin to ensure that the pressure boundary are not breached, and that fuel design limits are not exceeded in normal operational state, and accident conditions ;

(*c*) consideration shall be given to the characteristics and importance of the isolation and its reliability targets, isolation devices shall be either closed or close automatically on demand, and the response time and speed of closure shall be in accordance with the acceptance criteria defined for PIE ;

(*d*) all pressure boundary piping and vessels shall be separated from electrical and control systems to the greatest extent practicable ; and

(e) pressure-retaining components whose failure shall affect nuclear safety are designed to permit inspection of their pressure boundaries throughout the design life.

(7) The Operating Organisation shall ensure that the design of supporting systems and auxiliary systems shall be such as to ensure that the performance of these systems is consistent with the safety significance of the system or component that they serve at the nuclear power plant.

(8) The Operating Organisation shall ensure that fire protection systems, including fire detection systems and fire extinguishing systems, fire containment barriers and smoke control systems, are provided throughout the NPP, with

due account taken of the results of the fire hazard analysis.

(9) The Operating Organisation shall ensure that items important to safety for a NPP shall be designed to be calibrated, tested, maintained, repaired or replaced, inspected and monitored as required to ensure their capability of performing their functions and to maintain their integrity in all conditions specified in their design basis.

Qualification of items important to safety

27.—(1) The Operating Organisation shall ensure that a qualification programme for items important to safety shall be implemented to verify that items important to safety at a NPP are capable of performing their intended functions when necessary, and in the prevailing environmental conditions, throughout their design life, with due account taken of plant conditions during maintenance and testing.

(2) The Operating Organisation shall ensure that —

(*a*) the design provides an equipment environmental qualification program, and the development and implementation of this program shall ensure that the following functions are carried out in post-accident conditions —

(*i*) the reactor shall be safely shut down and kept in a safe shutdown state during and following all operational state and accident conditions,

(*ii*) residual heat shall be removed from the reactor after shutdown, and also during and following all operational state and accidents conditions,

(*iii*) potential for release of radioactive material from the plant shall be limited, and the resulting dose to the public from all operational state and accidents conditions shall be kept within prescribed limits, and

(*iv*) post-accident conditions shall be monitored to indicate that the functions referred to in sub paragraphs (i)-(iii) of this paragraph are being carried out ;

(*b*) the environmental conditions to be accounted for include those expected during normal operation, and those arising from all operational state and accident conditions and DBA ;

(*c*) operational data and applicable design assist analysis tools, such as the probabilistic safety assessment, shall be used to determine the envelope of environmental conditions ;

(*d*) equipment qualification shall also include consideration of any unusual environmental conditions that can reasonably be anticipated, and that could arise during normal operation or all operational state (such as periodic testing of the containment leak rate) ;

(*e*) equipment credited to operate during DEC (design extension condition) and severe accident states shall be assessed for its capacity to perform its intended function under the expected environmental conditions ; and

(*f*) a justifiable extrapolation of equipment behaviour may be used to provide assurance of operability, and shall be typically based on design specifications, environmental qualification testing, or other considerations.

(3) The Operating Organisation shall ensure that —

(*a*) the seismic qualification of all SSCs align with the requirements of Nigerian or equivalent standards ;

(*b*) the design includes instrumentation for monitoring seismic activity at the site for the life of the plant ; and

(*c*) the design authority identifies SSCs important to safety that are credited to withstand a Design Basis Earthquake (DBE), and they are qualified accordingly.

Overhead lifting equipment

28. The Operating Organisation shall ensure that overhead lifting equipment are provided for lifting and lowering items important to safety at the NPP, and for lifting and lowering other items in the proximity of items important to safety.

Ageing management

29.—(1) The Operating Organisation shall ensure that —

(*a*) the design life of items important to safety at the NPP are determined ; and

(*b*) appropriate margins are provided in the design to take due account of relevant mechanisms of ageing, neutron embrittlement and wear out, and the potential for age related degradation, to ensure the capability of items important to safety perform their necessary safety functions throughout their design life.

(2) The Operating Organisation shall make provisions for monitoring, testing, sampling, and inspecting SSCs to assess ageing mechanisms, verify predictions, and identify unanticipated behaviours or degradation that may occur during operation as a result of ageing and wear.

Escape routes and means of communication

30. The Operating Organisation shall ensure that —

(*a*) the NPP is provided with a sufficient number of escape routes, clearly and durably marked, with reliable emergency lighting, ventilation and other services essential to the safe use of these escape routes consistent with relevant national standards ; and

(*b*) effective means of communication are provided throughout the NPP to facilitate safe operation in all modes of normal operation and to be available for use following all PIE and in accident conditions.

Design for optimal operator performance

31. The Operating Organisation shall ensure systematic consideration of human factors, including the human-machine interface, are included at an early stage in the design process for the NPP and shall be continued throughout the entire design process.

Application of defence in depth

32.—(1) The Operating Organisation shall ensure that the —

(*a*) design of the NPP incorporates defence in depth and the levels of defence in depth shall be independent as far as is practicable ;

(*b*) defence-in-depth is achieved at the design phase through application of design provisions specific to the five levels of defence ; and

(*c*) all levels of defence in depth are kept available at all times, and any relaxation shall be justified for specific modes of operation.

(2) The operating organisation shall ensure that the design shall —

(*a*) provide for multiple physical barriers to the release of radioactive material to the environment ;

(*b*) be conservative, and the construction shall be of high quality to provide assurance that failures and deviations from normal operations are minimized, that accidents are prevented as far as is practicable and that a small deviation in a plant parameter does not lead to a cliff edge effect ;

(*c*) provide for the control of plant behaviour through inherent and engineered features, such that failures and deviations from normal operation requiring actuation of safety systems are minimized or excluded by design, to the extent possible ;

(*d*) provide for supplementing the control of the plant by means of automatic actuation of safety systems, such that failures and deviations from normal operation that exceed the capability of control systems can be controlled with a high level of confidence, and the need for operator actions in the early phase of these failures or deviations, from normal operation is minimized ;

(*e*) provide for systems, structures and components and procedures to control the course of and , as far as practicable, to limit the consequences of failures and deviations from normal operation that exceed the capability of safety systems ; and

(*f*) provide multiple means for ensuring that each of the fundamental safety functions is performed, thereby ensuring the effectiveness of the barriers and mitigating the consequences of any failure or deviation from normal operation.

(3) The Operating Organisation shall ensure that —

(*a*) the design prevents, as far as is practicable —

(*i*) challenges to the integrity of physical barriers,

(*ii*) failure of one or more barriers,

(*iii*) failure of a barrier as a consequence of the failure of another barrier, and

(*iv*) the possibility of harmful consequences of errors in operation and maintenance ;

(*b*) the design shall be such as to ensure, as far as is practicable, that the first, or at most the second, level of defence is capable of preventing an escalation to accident conditions for all failures or deviations from normal operation that are likely to occur over the operating lifetime of the NPP ; and

(*c*) the levels of defence-in-depth shall be independent as far as practicable to avoid the failure of one level reducing the effectiveness of other levels, in particular, safety features for design extension conditions (especially features for mitigating the consequences of accidents involving the melting of fuel) shall as far as is practicable be independent of safety systems.

(4) Defence-in-depth concept shall be achieved at the design phase through application of design provisions specific to the five levels of defence-in-depth.

Interfaces of safety with security and safeguards

33. The Operating Organisation shall ensure that the safety measures, nuclear security measures and arrangements for safeguards for a NPP shall be designed and implemented in an integrated manner so that they do not compromise one another.

Application of proven engineering practices

34. The Operating Organisation shall ensure that —

(*a*) items important to safety for the NPP are designed in accordance with the relevant national and international codes and standards ;

(*b*) the design authority identifies the modern standards and codes that will be used for the plant design, and evaluate those standards and codes for applicability, adequacy, and sufficiency to the design of SSCs important to safety. ;

(*c*) where needed, codes and standards shall be supplemented or modified to ensure that the final quality of the design shall be commensurate with the necessary safety functions ;

(*d*) SSCs important to safety are of proven designs, and designed according to the standards and codes identified for the NPP ;

(*e*) where a new SSC design, feature, or engineering practice is introduced, adequate safety shall be proven by a combination of supporting research and development programs and by examination of relevant experience from similar applications ;

(*f*) the design authority establish an adequate qualification program to verify that the new design meets all applicable safety design requirements and safety expectations, provided that new designs are tested before being brought into service, and monitored in service to verify that the expected behaviour is achieved ;

(*g*) in the selection of equipment, due attention is given to spurious operation and unsafe failure modes ; and

(*h*) where the design has to accommodate an SSC failure, preference shall be given to equipment that exhibits known and predictable modes of failure, and that facilitates repair or replacement.

Safety assessment

35. The Operating Organisation shall ensure that —

(*a*) comprehensive deterministic safety and probabilistic safety assessments are carried out throughout the design process for the NPP to —

(*i*) ensure that all safety requirements on the design of the plant are met throughout all stages of the lifetime of the plant, and

(*ii*) confirm that the design, as delivered, meets requirements for manufacture and for construction, and as built, as operated and as modified ;

(*b*) an independent peer review of the safety assessment are conducted by individuals or groups separate from those carrying out the design before submission.

Features to facilitate radioactive waste management and decommissioning

36. The Operating Organisation shall ensure that —

(*a*) special consideration are given at the design stage of a NPP to incorporate features that facilitates radioactive waste management and the future decommissioning and dismantling of the plant ;

(*b*) the design includes provisions to treat liquid and gaseous effluents in a manner that will keep the quantities and concentrations of discharged contaminants within prescribed limits and supports application of the ALARA principle ; and

Systems for treatment and control of waste systems

37. The Operating Organisation shall ensure that systems for treatment and control of waste Systems are provided for treating solid radioactive waste and liquid radioactive waste at the NPP to keep the amounts and concentrations of radioactive releases below the authorized limits on discharges and as low as reasonably achievable.

PART V — DESIGN OF SPECIFIC PLANT SYSTEMS

Performance of fuel element and assemblies

38. The Operating Organisation shall ensure that the performance of fuel elements and assemblies for the NPP are designed to maintain their structural integrity, and to satisfactorily withstand the anticipated radiation levels and other conditions in the reactor core, in combination with all the processes of deterioration that may occur in operational states.

Fuel elements and assemblies

39. The Operating Organisation shall ensure that —

(*a*) fuel assembly design include all components in the assembly and identify all interfacing systems ;

(*b*) fuel assemblies and the associated components are designed to withstand the anticipated irradiation and environmental conditions in the reactor core, and all processes of deterioration that may occur in normal operation and all operational state, provided that at the design stage, consideration shall be given to long-term storage of irradiated fuel assemblies after discharge from the reactor ;

(*c*) fuel design limits are established to include, as a minimum, limits on fuel power or temperature, limits on fuel burn-up, and limits on the leakage of fission products in the reactor cooling system ;

(*d*) the design limits referred to in paragraph (c) of this regulation reflects the importance of preserving the cladding and fuel matrix ;

(*e*) the design account for all known degradation mechanisms, with allowance for uncertainties in data, calculations, and fuel fabrication ;

(*f*) fuel assemblies are designed to permit adequate inspection of their structures and component parts prior to and following irradiation ;

(*g*) in accident condition other than severe accident, the fuel assembly and its component parts remain in position and not suffer distortion to an extent that would prevent effective post-accident core cooling or interfere with the actions of reactivity control devices or mechanisms, provided that the acceptance criteria for the fuel for accident condition shall be consistent with these expectations ;

(*h*) the expectations for reactor and fuel assembly design apply in the event of changes in fuel management strategy or in operating conditions over the lifetime of the plant are maintained ;

(*i*) fuel design and design limits reflect a verifiable and auditable knowledge base ; and

(*j*) the fuel is qualified for operation, either through experience with the same type of fuel in other reactor or through a programme of experimental testing and analysis, to ensure that fuel assembly requirements are met.

Structural capability of the reactor core

40. The Operating Organisation shall ensure that —

(*a*) the fuel elements and fuel assemblies and their supporting structures for the NPP are designed so that, in operational states and in accident conditions other than severe accidents, a geometry that allows for adequate cooling is maintained and the insertion of control rods is not impeded ;

(*b*) the reactor core design facilitates the application of a guaranteed shutdown state as described in the Guaranteed Shutdown State (GSS) ;

(*c*) the core are designed and mounted such that the —

(*i*) fission chain reaction is controlled during normal operation and AOO, and

(*ii*) maximum degree of positive reactivity and its maximum rate of increase by insertion in normal operation, AOO, and DBA are limited so that no resultant failure of the reactor pressure boundary shall occur, cooling capability are maintained, and no significant damage will occur to the reactor core ;

(*d*) the shutdown margin for all shutdown states allows for the core to remain subcritical for any credible changes in the core configuration and reactivity addition ; and

(*e*) if operator intervention is required to keep the reactor in a shutdown state, the feasibility, timeliness, and effectiveness of such intervention are demonstrated.

Control of the reactor core

41. The Operating Organisation shall ensure that —

(*a*) the distributions of neutron flux that can arise in any state of the reactor core in the NPP, including states arising after shutdown and during or after refuelling, and states arising from anticipated operational occurrences and from accident conditions not involving degradation of the reactor core, are inherently stable ;

(*b*) the demands made on the control system for maintaining the shapes, levels and stability of the neutron flux within specified design limits in all operational states are minimized ;

(*c*) adequate means are provided to maintain both bulk and spatial power distributions within a predetermined range ;

(*d*) provision is made for the removal of non radioactive substances including corrosion product that may compromise the safety of the system.

Reactor shutdown

42.—(1) The Operating Organisation shall ensure that —

(*a*) means are provided to ensure that —

(*i*) there is a capability to shut down the reactor of the NPP in operational states and in accident conditions, and (*ii*) the shutdown condition can be maintained even for the most reactive conditions of the reactor core ;

(*b*) the design provides means of reactor shutdown capable of reducing reactor power to a low value and maintaining that power for the required duration, when the reactor power control system and the inherent characteristics are insufficient or incapable of maintaining reactor power within the requirements of the OLC ;

(*c*) the design includes at least two separate, independent, and diverse means of shutting down the reactor ;

(*d*) at least one means of shutdown is independently capable of quickly rendering the nuclear reactor subcritical from normal operation, AOO, and DBA by an adequate margin, on the assumption of a single failure, provided that for this means of shutdown, a transient recriticality may be permitted in exceptional circumstances if the specified fuel and component limits are not exceeded ;

(*e*) at least one means of shutdown independently capable of rendering the reactor subcritical from normal operation, in AOO, and in DBA, and maintaining the reactor subcritical by an adequate margin on the assumption of a single failure ;

(*f*) the means of shutdown shall be independently capable of rendering the reactor core subcritical in all operational states and accident condition and maintaining the reactore subcritical by an adequate margin and with high reliability for even the most reactive condition of the core ;

(*g*) redundancy is provided in the fast-acting means of shutdown if, in the event that the credited means of reactivity control fails during any AOO or DBA, inherent core characteristics are unable to maintain the reactor within specified limits ;

(*h*) while resetting the means of shutdown, the maximum degree of positive reactivity and the maximum rate of increase are within the capacity of the reactor control system ; and

(*i*) stored energy is used in shutdown actuation, to improve reliability.

(2) The Operating Organisation shall ensure that the design authority specify derived acceptance criteria for reactor trip parameter effectiveness for all operational states and accidents condition, and performs a safety analysis to demonstrate the effectiveness of the means of shutdown ;

(*a*) the design specifies a direct trip parameter to initiate reactor shutdown for all AOO and DBA in time to meet the respective derived acceptance criteria for each credited means of shutdown, provided that where a direct trip parameter does not exist for a given credited means, there shall be two diverse trip parameters specified for that means ;

(*b*) for all Operational states and accident conditions, there are at least two diverse trip parameters unless it can be shown that failure to trip will not lead to unacceptable consequences ;

(*c*) there are gap in trip coverage for any operating condition within the OLC, by providing additional trip parameters. if necessary ;

(d) the extent of trip coverage provided by all available parameters are documented for the entire spectrum of failures for each set of PIE ; and

(*e*) an assessment of the accuracy and potential failure modes of the trip parameters are provided in the design documentation.

(3) The Operating Organisation shall ensure that the —

(*a*) design permits ongoing demonstration that each means of shutdown is being operated and maintained in a manner that ensures continued adherence to reliability and effectiveness requirements ; and

(b) periodic testing of the systems and their components are scheduled at a frequency commensurate with applicable requirements.

(4) The Operating Organisation shall ensure that —

(*a*) in the design, once automatic shutdown is initiated, it shall be impossible for an operator to prevent its actuation ;

(*b*) in the design, manual shutdown actuation is minimized; and

(*c*) the means for monitoring shutdown status and manual actuation are provided in the main control room.

Guaranteed shutdown state

43. The Operating Organisation shall ensure that the —

(*a*) design authority defines the GSS that will support safe maintenance activities of the NPP ;

(*b*) design provides two independent means of preventing recriticality from any pathway or mechanism during the GSS ; and

(*c*) shutdown margin for GSS is such that the core will remain subcritical for any credible changes in the core configuration and reactivity addition and where possible, this shall be achieved without operator's intervention.

Reactor coolant systems

44. The Operating Organisation shall ensure that the components of the reactor coolant systems for the NPP are designed and constructed so that the risk of faults due to inadequate quality of materials, inadequate design standards, insufficient capability for inspection or inadequate quality of manufacture is minimized.

Design of reactor coolant systems

45. The Operating Organisation shall ensure that —

(*a*) the design provides the reactor coolant system and its associated components and auxiliary systems with sufficient margin to ensure that the appropriate design limits of the reactor coolant pressure boundary are not exceeded in normal operation, all operational states or accident conditions ;

(*b*) in the design the operation of pressure relief devices will not lead to unacceptable releases of radioactive material from the plant, even in DBA ;

(*c*) the reactor coolant system is fitted with isolation devices to limit any loss of radioactive coolant outside containment ;

(*d*) the material used in the fabrication of the component parts are selected so as to minimize activation of the material ;

(*e*) plant states in which components of the pressure boundary could exhibit embrittlement are avoided ;

(*f*) the design reflects consideration of all conditions of the boundary material in normal operation (including maintenance and testing), all operational states and accident conditions AOO, and DBA, as well as expected end-of-life properties affected by ageing mechanisms, the rate of deterioration, and the initial state of the components ;

(*g*) the design of the moving components contained inside the reactor coolant pressure boundary are able to minimize the likelihood of failure and associated consequential damage to other items of the reactor coolant system in normal operation, all operational states and accident conditions AOO, and DBA, with allowance for deterioration that may occur in service ; and

(*h*) the design provides a system capable of detecting and monitoring leakage from the reactor coolant system.

Overpressure protection of the reactor coolant pressure boundary

46. The Operating Organisation shall ensure that —

(*a*) provision is made to ensure that the operation of pressure relief devices will protect the pressure boundary of the reactor coolant systems against overpressure and will not lead to the release of radioactive material from the NPP directly to the environment ;

(*b*) the components of the reactor coolant pressure boundary are designed, manufactured, and arranged in a manner that permits adequate inspections and tests of the boundary throughout the lifetime of the plant ; and

(*c*) the design facilitates surveillance in order to determine the metallurgical conditions of materials for which metallurgical changes are anticipated.

Inventory of reactor coolant

47. The Operating Organisation shall ensure that —

(*a*) provision is made for controlling the inventory, temperature and pressure of the reactor coolant such that specified design limits are not exceeded in any operational state of the NPP, with due account taken of volumetric changes and leakage ;

(*b*) in taking volumetric changes and leakage into account, the design shall provide control of coolant inventory and pressure such that specified design limits are not exceeded in normal operation and this expectation shall extend to the provision of adequate capacity (flow rate and storage volumes) in the systems performing this function ; and

(*c*) the inventory in the reactor coolant system and its associated systems are sufficient to support cool down from hot operating conditions to zero power cold conditions without the need for transfer from any other systems.

Clean up of reactor coolant

48. The Operating Organisation shall ensure that —

(*a*) adequate facilities are provided at the NPP for the removal from the reactor coolant of radioactive substances, including activated corrosion products and fission products deriving from the fuel, and non-radioactive substances ; and

(*b*) the capability of the necessary plant systems are based on the specified design limit on permissible leakage of the fuel, with a conservative margin to ensure that the plant can be operated with a level of circuit activity that is as low as reasonably practicable, and to ensure that the requirements for radioactive releases complies with the ALARA principle and below the authorised limits on discharges.

Removal of residual heat from the reactor core

49. The Operating Organisation shall ensure that —

(*a*) means are provided for the removal of residual heat from the reactor core in the shutdown state of the NPP such that the design limits for fuel, the reactor coolant pressure boundary and structures important to safety are not exceeded ;

(*b*) the design provides a means of removing residual heat from the reactor for all conditions of the Reactor Coolant System (RCS), provided that the means are independent of the configuration in use ;

(*c*) the means of removing residual heat meets reliability requirements on the assumptions of a single failure and the loss of off-site power, by incorporating suitable redundancy, diversity, and independence ;

(*d*) interconnections and isolation capabilities have a degree of reliability that is commensurate with system design requirements ;

(*e*) heat removal is at a rate that prevents the specified design limits of the fuel and the reactor coolant pressure boundary from being exceeded ; and

(*f*) if a residual heat removal system is required when the RCS is hot and pressurized, it shall be initiated at the normal operating conditions of the RCS.

Emergency cooling of the reactor core

50. The Operating Organisation shall ensure that —

(*a*) means of cooling the reactor core is provided to restore and maintain cooling of the fuel under accident conditions at the NPP, even if the integrity of the pressure boundary of the primary coolant system is not maintained ;

(*b*) all water-cooled nuclear power reactors shall be equipped with an emergency core cooling system (ECCS) ;

(*c*) the design considers the effect on core reactivity of the mixing of ECCS water with reactor coolant water, including possible mixing due to in-leakage ;

(*d*) the ECCS meets the following criteria for all accident conditions involving loss of coolant —

(*i*) all fuel in the reactor and all fuel assemblies are kept in a configuration such that continued removal of the residual heat produced by the fuel can be maintained, and

(*ii*) a continued cooling flow (recovery flow) is supplied to prevent further damage to the fuel after adequate cooling of the fuel is re-established by the ECCS ;

(*e*) the ECCS recovery flow path are such that impediment to the recovery of coolant following a loss of coolant accident by debris or other material is avoided ;

(*f*) maintenance and reliability testing that is conducted when ECCS availability is required are carried out without a reduction in the effectiveness of the system below the OLC ;

(*g*) in the event of an accident when injection of emergency coolant is required, it is impossible for an operator to prevent the injection from taking place ;

(*h*) all ECCS components that may contain radioactive material are located inside containment or in an extension of containment ;

(*i*) ECCS piping in an extension of containment that could contain radioactivity from the reactor core are subject to the following expectations —

(*i*) as a piping extension to containment, it meets the requirements for metal penetrations of containment, (*ii*) all piping and components of the ECCS recovery flow path piping that are open to the containment atmosphere are designed for a pressure greater than the containment design pressure,

(*iii*) all ECCS recovery flow paths are housed in a confinement structure that prevents leakage of radioactivity to the environment and to adjacent structures, and

(*iv*) the housing referred to in sub-paragraph (iii) of this paragraph includes detection capability for leakage of radioactivity, and the capability to either return the radioactivity to the flow path, or to collect the radioactivity and store or process it in a system designed for this purpose ;

(*j*) intermediate or secondary cooling piping loops have leak detection, whether the ECCS recovery system is inside or outside of containment, with the leak detection being such that on detection of radioactivity from the ECCS recovery flow, the loops are isolated as per the requirements for containment isolation ;

(*k*) inadvertent operation of all or part of the ECCS have no detrimental effect on plant safety ; and

(*l*) the means provided for cooling of the reactor core are such as to ensure that possible chemical reactions are kept to an acceptable level.

Heat transfer to an ultimate heat sink

51. The Operating Organisation shall ensure that the capability to transfer heat to an ultimate heat sink is ensured for all plant states ;

Containment structure and containment system

52. The Operating Organisation shall ensure that a containment system is provided to ensure, or to contribute to, the fulfilment of the following safety functions at the NPP —

(*a*) confinement of radioactive substances in operational states and in accident conditions ;

(*b*) protection of the reactor against natural external events and human induced events ; and

(c) radiation shielding in operational states and in accident conditions.

Containment system for the reactor

53. The Operating Organisation shall ensure that —

(*a*) the strength of the containment structure provides sufficient margins of safety based on potential internal overpressures, under-pressures, temperatures, dynamic effects such as missile generation, and reaction-forces anticipated to result in the event of DBA, provided that application of strength margins applies to access openings, penetrations, isolation valves, and to the containment heat removal system ;

(*b*) the effects of other potential energy sources, such as possible chemical reactions and radiolytic reactions are considered.

(*c*) in calculating the necessary strength of the containment structure, natural phenomena and human induced events are taken into consideration ;

(*d*) the positive and negative design pressures within each part of the containment boundary include the highest and lowest pressures that could be generated in the respective parts as a result of any accident condition are considered ;

(*e*) the containment structure protects systems and equipment important to safety in order to preserve safety functions for the plant ;

(*f*) the design supports maintenance of full functionality following a DBE of all parts of the containment system credited in the safety analysis ; and

(*g*) the seismic design of the concrete containment structure have an elastic response when subjected to seismic ground motions.

(3) The Operating Organisation shall ensure that the containment structure is designed and constructed to perform a pressure test at a specified pressure to demonstrate structural integrity before plant operation commences and throughout the plant's lifetime.

Control of radioactive releases from the containment

54.—(1) The Operating Organisation shall ensure that the design of the containment is such that any radioactive release from the NPP to the environment is as low as reasonably achievable, is below the authorised limits on discharges in operational states and is below acceptable limits in accident conditions.

(2) The Operating Organisation shall ensure the following —

(*a*) the safety leakage rate limit shall assure that normal operation release limits are met, and operational states and accident conditions will not result in exceeding dose acceptance criteria ;

(*b*) the design leakage rate limit shall be below the safety leakage rate limit, as low as practicably achievable and consistent with design practices ;

(*c*) the test acceptance leakage rate shall provide the maximum rate acceptable under actual measurement tests, provided that the test acceptance leakage rate limits shall be established for the entire containment system, and for individual components that can contribute significantly to leakage;

(*d*) the containment structure and the equipment and components affecting the leak tightness of the containment system shall be designed to allow leak rate testing for commissioning, at the containment design pressure; and over the service lifetime of the reactor, either at the containment design pressure or at reduced pressures that permit estimation of the leakage rate at the containment design pressure ;

(*e*) to the extent practicable, penetrations shall be designed to allow individual testing of each penetration ; and

(*f*) the design shall be expected to provide for ready and reliable detection of any significant breach of the containment envelope.

Reactor coolant system auxillaries that penetrates containment

55. The Operating Organisation shall ensure that —

(1) lines that penetrates the containment as part of the reactor coolant pressure boundary and lines that are connected directly to the containment atmosphere shall —

(*i*)be fitted with at least two adequate containment isolation valves arranged in series,

(*ii*) and shall be provided with suitable leak detection systems. Containment as is practicable, and

(*iii*) each valve shall be capable of reliable and independent actuation and of being periodically tested ;

(*b*) each line that connects directly to the containment atmosphere, that penetrates the containment structure and is not part of a closed system, is provided with two isolation barriers that meet the following expectations —

(*i*) two automatic isolation valves in series for lines that may be open to the containment atmosphere,

(*ii*) two closed isolation valves in series for lines that are normally closed to the containment atmosphere, and

(*iii*) the line up to and including the second valve is part of the containment envelope.

(2) The Operating Organisation shall ensure that —

(*a*) all closed piping service systems have at least one single isolation valve on each line penetrating the containment, this valve shall be located outside of, but as close as practicable to, the containment structure ;

(*b*) where failure of a closed loop is assumed to be a PIE or the result of a PIE, the isolations for reactor coolant system auxiliaries apply ; and

(*c*) closed piping service systems inside or outside the containment structure that form part of the containment envelope needs no further isolation if they meet the applicable service piping standards and codes, and they can be continuously monitored for leaks.

Access to the containment

56. The Operating Organisation shall ensure that —

(*a*) access to the containment Access by operating personnel to the containment at the NPP shall be through airlocks equipped with doors that are interlocked to ensure that at least one of the doors is closed during reactor power operation and in accident conditions ;

Internal structures of the containment

57. The Operating Organisation shall ensure that —

(*a*) the design provides for ample flow routes between separate compartments inside the containment and the openings between compartments shall be large enough to prevent significant pressure differentials that may cause damage to load bearing and safety systems during accident conditions ; and

(*b*) the design of internal structures considers any hydrogen control strategy, and assists in the effectiveness of that strategy.

Containment pressure and energy management

58. The Operating Organisation shall ensure that —

(*a*) the design enables heat removal and pressure reduction in the reactor containment in all plant states ; and

(*b*) systems designed for this purpose are considered part of the containment system, and shall be capable of —

(*i*) minimizing the pressure-assisted release of fission products to the environment,

(*ii*) preserving containment integrity, and

(*iii*) preserving required leak tightness.

Control and cleanup of the containment atmosphere

59. The Operating Organisation shall ensure that —

(*a*) provision are made to control —

(*i*) the pressure and temperature in the containment at an NPP, and

(*ii*) control any build up of fission products or other gaseous liquid or solid substance that might be released inside the containment and that may affect the operation of systems important to safety ; and

(*b*) the design provides systems to control the release of fission products, hydrogen, oxygen, and other substances into the reactor containment as necessary to —

(*i*) reduce the amount of fission products that could be released to the environment in accident conditions, and (*ii*) control the concentration of hydrogen. Oxygen and other substances in the containment atmosphere in accident conditions so as to prevent deflagration or detonation loads that could challenge the integrity of the containment.

Coverings, coatings, and materials

60. The Operating Organisation shall ensure that the coverings, thermal insulations and coatings for components and structures within the containment system are carefully selected, and their methods of application specified to ensure fulfilment of their safety functions and to minimize interference with other safety functions in the event of deterioration of coverings, thermal insulations and coatings.

Severe accidents

61. The Operating Organisation shall ensure that —

(*a*) following onset of core damage, the containment boundary is capable of contributing to the reduction of radioactivity releases to allow sufficient time for the implementation of off-site emergency procedures ;

(*b*) damage to the containment structure is limited to prevent uncontrolled releases of radioactivity, and to maintain the integrity of structures that support internal components ;

(*c*) the ability of the containment system to withstand loads associated with severe accidents is demonstrated in design documentation ; and

(*d*) the design shall provide means of retaining the molten core and preventing it from sinking into the Earth crust in the event of a meltdown.

Instrumentation and control systems

62. The Operating Organisation shall ensure that instrumentation is provided for —

(*a*) determining the values of all the main variables that can affect the fission process, the integrity of the reactor core, the reactor coolant systems and the containment at the NPP ;

(*b*) obtaining essential information on the plant that is necessary for its safe and reliable operation ;

(*c*) determining the status of the plant in accident conditions ; and

(*d*) making decisions for the purposes of accident management.

Control systems

63. The Operating Organisation shall ensure that appropriate and reliable control systems are provided at the NPP to maintain and limit the relevant process variables within the specified operational ranges.

Protection system

64.—(1) The Operating Organisation shall ensure that a protection system is provided at the NPP that has the capability to detect unsafe plant conditions and to initiate safety actions automatically to actuate the safety systems necessary for achieving and maintaining safe plant conditions.

(2) The protection system referred to in sub-regulation (1) of this regulation shall be designed to —

(*a*) initiate automatically the operation of appropriate systems including, as necessary, the reactor shutdown systems, in order to ensure that specified design limits are not exceeded as a result of AOO ;

(*b*) detect accident conditions and initiate the operation of systems necessary to limit the consequences of such accidents within the design basis ; and

(*c*) be capable of overriding unsafe actions of the control system.

Reliability and testability of instrumentation and control systems

65.—(1) The Operating Organisation shall ensure that instrumentation and control of systems for items important to safety at the NPP are designed for high functional reliability and periodic testability commensurate with the safety function (s) to be performed.

(2) The Operating Organisation shall ensure that —

(*a*) redundancy and independence designed into the protection system are sufficient at least to ensure that —

(*i*) no single failure results in loss of protection function, and

(*ii*) the removal from service of any component or channel does not result in loss of the necessary minimum redundancy, unless the acceptable reliability of operation of the protection system can be otherwise demonstrated ;

(*b*) the protection system is designed to ensure that the effects of operational states, and accident conditions on redundant channels do not result in loss of its function ;

(*c*) design techniques such as testability, including a self-checking capability where necessary, fail-safe behaviour, functional diversity and diversity in component design or principles of operation are used to the extent practicable to prevent loss of a protection function ;

(*d*) except its adequate reliability is ensured by some other means, the protection system shall be designed to permit periodic testing of its functioning dependently to determine failures and losses of redundancy that may have occurred ;

(*e*) the design permits all aspects of functionality from the sensor to the input signal to the final actuator to be tested in operation ; and

(*f*) the design is such as to minimize the likelihood that operator action could defeat the effectiveness of the protection system in normal operation and expected operational occurrences, but not to negate correct operational actions in accident conditions.

66. The Operating Organisation shall ensure that —

Use of computer based equipment in systems important to safety

(*a*) if a system important to safety at the NPP is dependent upon computer based equipment, appropriate standards and practices for the development and testing of computer hardware and software are established and implemented throughout the service life of the system, and in particular throughout the software development cycle, provided that the entire development is subject to a quality management system ;

(*b*) an assessment of the equipment are undertaken by experts who are independent of the design and the supplier team to provide assurance of its high reliability ;

(*c*) common cause failure deriving from software are taken into consideration ; and

(*d*) protections are provided against accidental disruption of, or deliberate interference with, system operation.

Separation of protection and control systems

67.—(1) The Operating Organisation shall ensure that interference between protection and control systems at the NPP are prevented by means of separation, by avoiding interconnections or by suitable functional independence.

(2) The Operating Organisation shall ensure that —

(*a*) a control room is provided at the NPP from which the plant can be safely operated in all operational states, either automatically or manually, and from which measures can be taken to maintain the plant in a safe state or to bring it back into a safe state after AOO and accident conditions ;

(*b*) the design identifies events both internal and external to the CR that may pose a direct threat to its continued operation, and shall provide practicable measures to minimize the effects of these events ;

(*c*) the safety functions initiated by automatic control logic in response to an accident can also be initiated manually from the main and secondary control rooms ; and

(*d*) appropriate measures shall be taken, including the provision of barriers between the control room at the nuclear power plant and the external environment, and adequate information shall be provided for the protection of occupants of the control room, for a protracted period of time, against hazards such as high radiation levels resulting from accident conditions, releases of radioactive material, fire or explosive or toxic gases.

Supplementary control room

68. The Operating Organisation shall ensure that —

(*a*) instrumentation and control equipment are kept available, preferably at a single location (a supplementary control room) that is physically, electrically and functionally separate from the control room at the NPP ;

(*b*) the supplementary control room is so equipped that the reactor can be placed and maintained in a shutdown state, residual heat can be removed, and essential plant variables can be monitored if there is a loss of ability to perform these essential safety functions in the control room ; and

(*c*) barriers between the supplementary control room at the NPP and the external environment and adequate information at all times are provided.

Emergency response facilities on the site

69. The Operating Organisation shall ensure that —

(*a*) the NPP includes the necessary emergency response facilities on the site and their design shall be such that personnel will be able to perform expected tasks for managing an emergency under conditions generated by accidents and hazards ;

(*b*) information about important plant parameters and radiological conditions at the NPP and in its immediate surroundings shall be provided to the relevant emergency response facilities ; and

(*c*) each facility is provided with a secure means of communication with the control room, the supplementary control room and other important locations at the plant, and with on-site and off-site emergency response organisations .

Emergency Power Supply

70. The Operating Organisation shall ensure that —

(*a*) the design of the NPP includes an emergency power supply capable of supplying the necessary power in AOO and DBA , in the event of a loss of off-site power ;

(*b*) the design includes an alternate power source to supply the necessary power in design extension conditions ;

(*c*) the design specifications for the emergency power supply and for the alternate power source at the NPP includes the requirements for capability, availability, duration of the required power supply, capacity and continuity ;

(*d*) the combined means to provide emergency power, such as water, steam or gas turbines, diesel engines or batteries shall have a reliability and type that are consistent with all the requirements of the safety systems to be supplied with power, and their functional capabilities are testable ;

(*e*) the EPS system includes appropriate control, monitoring and testing facilities ; and

(*f*) the emergency power supply is initiated either automatically or manually following the accident conditions as determined by the nuclear safety requirements of the plant; and can be tested under load conditions representing full load demand.

Support and heat transport systems

71.—(1) The design of supporting systems and auxiliary systems shall be such as to ensure that the performance of these systems is consistent with the safety significance of the systems or component that they serve at the NPP.

(2) The Operating Organisation shall ensure that heat transport systems are provided as appropriate to remove heat from systems and components at the NPP that are required to function in operational states and in accident conditions.

Process sampling systems and post-accident sampling systems

72. The Operating Organisation shall ensure that process and post-accident sampling systems are provided for determining, in a timely manner, the concentration of specified radionuclides in fluid process systems, and in gas and liquid samples taken from systems or from the environment, in all operational states and in accident conditions at the NPP.

Compressed air systems

73. The Operating Organisation shall ensure that the design basis for any compressed air system that serves an item important to safety at the NPP specifies the quality, flow rate and cleanness of the air to be provided.

Air conditioning systems and ventilation systems

74. The Operating Organisation shall ensure that —

(*a*) systems for air conditioning, air heating, air cooling and ventilation are provided as appropriate in auxiliary rooms or other areas at the NPP to maintain the required environmental conditions for systems and components important to safety in all plant states ;

(*b*) it provides systems for the ventilation of buildings at the NPP with the appropriate capability for the cleaning of air to —

(*i*) prevent unacceptable dispersion of airborne radioactive substances within the plant,

(*ii*) reduce the concentration of airborne radioactive substances to levels compatible with the need for access by personnel to the area,

(*iii*) keep the levels of airborne radioactive substances in the plant below authorized limits and as low as reasonably achievable,

(*iv*) ventilate rooms containing inert gases or noxious gases without impairing the capability to control radioactive effluents, and

(*v*) to control gaseous radioactive releases to the environment below the authorised limits on discharges and to keep them as low as reasonably achievable ; and

(c) areas of higher contamination at the plant are maintained at a negative pressure differential (partial vacuum) with respect to areas of lower contamination and other accessible areas.

Lighting systems

75. The Operating Organisation shall ensure that adequate lighting are provided in all operational areas of the NPP in operational states and in accident conditions.

Steam supply system, feed-water system and turbine generators

76. The Operating Organisation shall ensure that the —

(*a*) design of the steam supply system, feed water system and turbine generators of the NPP shall be such as to ensure that the appropriate design limits of the reactor coolant pressure boundary are not exceeded in operational states or in accident conditions ;

(*b*) steam supply system and the feed water systems are of sufficient capacity and designed to prevent anticipated operational occurrences from escalating to accident conditions ; and

(*c*) turbine generators are provided with appropriate protection Such as over speed protection and vibration protection, and measures are taken to minimize the possible effects of turbine generated missiles on items important to safety.

Fuel handling and storage systems

77. The Operating Organisation shall ensure that —

(*a*) fuel handling and storage systems are provided at the NPP to ensure that the integrity and properties of the fuel are maintained at all times during fuel handling and storage ; and

(*b*) the design of the plant shall incorporate appropriate features to facilitate the lifting, movement and handling of fresh fuel and spent fuel.

Handling and storage of non-irradiated fuel

78. The Operating Organisation shall ensure that the design of the fuel handling and storage systems for non-irradiated fuel shall —

(*a*) ensure nuclear criticality safety ;

(*b*) permit appropriate maintenance, periodic inspection, testing of components important to safety and inspection of non-irradiated fuel; and

(*c*) prevents loss of or damage to the fuel ;

(*d*) meet NNRA safeguards requirements for recording and reporting accountancy data, and for monitoring flows and inventories related to non-irradiated fuel containing fissile material ; and

(*e*) prevent criticality by a specified margin, by physical means or by means of physical process and preferably by use of geometrically safe configurations, even under conditions of optimum moderation.

79. The Operating Organisation shall ensure that —

Handling and storage of irradiated fuel

(*a*) the design of the handling and storage systems for irradiated fuel shall —

(*i*) ensure nuclear criticality safety,

(*ii*) permit adequate heat removal under normal operation, AOO, and DBA,

(*iii*) permit inspection of irradiated fuel,

(*iv*) permit periodic inspection and testing of components important to safety,

(*v*) prevent the dropping of used fuel in transit,

(*vi*) prevent unacceptable handling stresses on fuel elements or fuel assemblies,

(*vii*) prevent the inadvertent dropping of heavy objects and equipment on fuel assemblies,

(*viii*) permit inspection and safe storage of suspect or damaged fuel elements or fuel assemblies,

(*ix*) provide proper means for radiation protection,

(*x*) adequately identify individual fuel modules,

(*xi*) facilitate maintenance and decommissioning of the fuel storage and handling facilities,

(*xii*) facilitate decontamination of fuel handling and storage areas and equipment when necessary,

(*xiii*) ensure implementation of adequate operating and accounting procedures to prevent loss of fuel,

(*xiv*) include measures to prevent a direct threat or sabotage to irradiated fuel,

(*xv*) comply with the Authority's safeguards requirements for recording and reporting accountancy data and for monitoring flows and inventories related to irradiated fuel containing fissile material, and

(*xvi*) prevent criticality by a specified margin, by physical means or by means of physical process and preferably by use of geometrically safe configurations, even under conditions of optimum moderation ;

(*b*) for reactors using a water pool system for fuel storage, the design prevents the uncovering of fuel assemblies in all operational states and accident conditions that are of relevance for the spent fuel pool so that the possibility of conditions arising that could lead to an early radioactive release or a large radioactive release is practically eliminated and so as to avoid high radiation fields on the site ; and

(*c*) the design of the plant shall provide —

(*i*) the necessary fuel cooling capabilities,

(*ii*) features to prevent the uncovering of fuel assemblies in the event of a leak or a pipe break, and

(*iii*) a capability to restore the water inventory.

Detection of failed fuel

80. The Operating Organisation shall ensure that the design provides a means for allowing reliable detection of fuel defects in the reactor, and subsequent removal of failed fuel if action levels are exceeded.

Design for radiation protection

81. The Operating Organisation shall ensure that —

(*a*) design for radiation protection provision is made for ensuring that doses to operating personnel at the NPP will be maintained below the dose limits and will be kept as low as reasonably achievable, and that the relevant dose constraints will be taken into consideration ;

(*b*) the shielding design prevents radiation levels in operating areas from exceeding the prescribed limits and includes provision of appropriate permanent layout and shielding of SSCs containing radioactive materials, and the use of temporary shielding for maintenance and inspection work ;

(*c*) to minimize radiation exposure, the plant layout provides for efficient operation, inspection, maintenance, and replacement, in addition, the design shall limit the amount of activated material and its build-up ;

(*d*) the design accounts for frequently occupied locations, and supports the need for human access to locations and equipment ;

(*e*) access routes are shielded where needed ;

(*f*) the design enables operator access for actions credited for post-accident conditions ; and

(*g*) adequate protection is provided against exposure to radiation and radioactive contamination in accident conditions in those parts of the facility to which access is required.

Access and movement control

82. The Operating Organisation shall ensure that —

(*a*) the plant layout and procedures control access to controlled and supervised radiation areas as well as areas of potential contamination ; and

(*b*) the design minimizes the movement of radioactive materials and the spread of contamination, and provides appropriate decontamination facilities for personnel.

83. The Operating Organisation shall ensure that means of radiation monitoring equipment are provided at the NPP to ensure that there is adequate radiation monitoring in operational states and design basis accident conditions and, as far as is practicable, in design extension conditions. Means of radiation monitoring

84. The Operating Organisation shall ensure that the design provides for — Handling of radioactive material

(*a*) appropriate disposal of radioactive materials, either to on-site storage or through removal from the site ;

(*b*) reduction in the quantity and concentration of radioactive materials produced ;

(*c*) control of dispersal within the plant ;

(*d*) control of releases to the environment ;

(*e*) decontamination facilities for equipment, and for handling any radioactive waste arising from decontamination activities ; and

(*f*) minimisation of radioactive waste generation.

85. The Operating Organisation shall ensure that the design provides the means for monitoring radiological releases to the environment in the vicinity of the plant, with particular reference to — Monitoring environmental impact

(*a*) pathways to the human population, including the food-chain ;

(*b*) the radiological impact, if any, on local ecosystems ;

(*c*) the possible accumulation of radioactive materials in the environment ; and

(*d*) the possibility of any unauthorised discharge routes.

86. The Operating Organisation shall ensure that — Safety analysis of the plant design

(*a*) a safety analysis of the design for the NPP be conducted in which methods of both deterministic and probabilistic analysis are applied to enable the challenges to safety in the various categories of plant states to be evaluated and assessed ;

(*b*) on the basis of a safety analysis, the design basis for items important to safety and their links to initiating events and event sequences are confirmed ;

(*c*) the safety analysis provides assurance that defence in depth has been implemented in the design of the plant ;

(*d*) the safety analysis provides assurance that uncertainties have been given adequate consideration in the design of the plant and in particular that adequate margins are available to avoid cliff-edge effects and early radioactive releases or large radioactive releases ; and (*e*) the applicability of the analytical assumptions, methods and degree of conservatism used in the design of the plant is updated and verified for the current or as built design.

PART VI — CONSTRUCTION FOR NUCLEAR POWER PLANT

Responsibilities of operating organisation

87. The Operating Organisation shall have —

(*a*) primary responsibility for the safety and security of all construction activities , including responsibility for activities carried out on its behalf by contractors ;

(*b*) within its organisation the knowledge, expertise and resources to maintain control and oversight of safety at all times ;

(*c*) a comprehensive process established to address non-conformances in design, manufacturing, construction and operation ; and

(*d*) resolutions to correct differences from the initial design and non-conformance shall be documented.

Management system

88. The Operating Organisation shall ensure that all construction and related activities are developed and implemented in line with the requirements of its management system regulation.

Construction management

89.—(1) The Operating Organisation shall —

(*a*) identify health and safety, environmental, and other requirements applicable to construction activities ;

(*b*) communicate relevant requirements to all parties and take into account when establishing, implementing and maintaining management practices and controls and identify and resolve conflicting requirements ;

(*c*) put in place arrangements with vendors, contractors and suppliers for specifying and managing the supply to it of items, products and services that may influence safety ;

(*d*) ensure that individuals in the organisation, from senior managers downwards, foster a strong safety culture, and the management system and leadership for safety are to be such as to foster and sustain a strong safety culture ;

(e) establish measures to resolve conflicts and misunderstandings between organizations; such as conflicts related to construction schedules, activities, tools and work spaces ;

(*f*) develop measures to ensure that contractors and sub-contractors meet their respective contractual obligations in accordance with an appropriate safety management system ; and (*g*) maintain records of its oversight activities and report to the Authority relevant contractor performance that has affected, or has the potential to affect the quality of construction and future operational safety.

(2) the promoting organisation shall ensure that interfaces between the operating organisation ,reactor designer ,manufacturers, construction organizations, contractors, the Authority and other regulatory bodies shall be agreed upon and understood before construction starts.

Readiness review

90. The Operating Organisation shall ensure that a readiness review is performed before construction starts to confirm that the operating organisation and contractors are prepared to successfully manage and carryout construction activities.

Personnel qualification and training

91. The Operating Organisation shall ensure that personnel engaged in construction activities have appropriate training, qualifications and competence to perform their assigned task effectively and safely.

Security and safeguards

92. The Operating Organisation shall ensure that —

(*a*) site security measures include the actions to be taken during the construction phase, measures to protect SSCs under construction and to detect and deter conditions that would otherwise impair site security ;

(*b*) the security program for the construction site and cyber security measures are integrated ; and

(*c*) inspectors are provided access (in compliance with IAEA safeguard requirements) to the site and information about site buildings and structures, operational parameters, flow and storage of nuclear material, and installation of safeguards surveillance and monitoring equipment.

Emergency preparedness

93. The Operating Organisation shall ensure that —

(*a*) appropriate plan is in place for managing emergencies during construction ; and

(*b*) for sites at existing nuclear installations, arrangements for emergency preparedness and response are put in place to ensure the safety of workers and the public in the case of an accident occurring at or affecting the construction.

Effect on and from existing facilities

94. The Operating Organisation shall ensure that —

(*a*) assessment of safety and security is performed during construction and consider all hazards from, or to, nearby site facilities and any interdependence of their safety systems ;

(*b*) the consequences of potential contamination (nuclear and hazardous substances) from a construction site to operating units, as well as from operating site to construction site, shall be assessed and its contamination monitored if necessary ;

(*c*) all other potential risks is assessed (excavation, accidental fall of cranes, collapse of items, use of explosives) and such consideration shall include an impact assessment of cumulative environmental discharges for all facilities on a site ;

(*d*) the responsibilities of other relevant licensee(s) and the construction organisation for safety and security are agreed upon before the start of construction activities at the site ;

(*e*) close communication and cooperation between the parties are established ;

(*f*) all steps are taken to ensure that the existing facility can be operated safely and securely during construction activities ;

(*g*) for adjacent installations or those with common buildings or services, the following boundaries are to be identified —

(*i*) controlled areas,

(*ii*) physical system,

(*iii*) security access boundaries, and

(*iv*) clean zones ;

(*h*) when using the resources of existing nuclear installations (such as water, electric power, fire protection, emergency medical services, and security), clear interfaces are defined so as not to jeopardize operating installations ;

(*i*) emergency plans take full account of the presence of other parties in the area ; and

(*j*) procedures are implemented to ensure the licensee of an existing facility or facilities endorses a change of status for those common buildings or services before the construction organisation puts such plans in place.

Fire protection

95. The Operating Organisation shall ensure the availability of fire protection controls until final systems for plant fire detection, protection and suppression are installed and operational, and details of these controls are to be included in the emergency preparedness arrangements.

Environmental measures

96. The Operating Organisation shall put in place environmental monitoring and protection controls to ensure adequate mitigation of potential environmental effects related to construction activities are in accordance with relevant National Regulations.

Ageing management

97. The Operating Organisation shall establish and implement programs to ensure that manufacturing, construction and installation processes do not adversely affect ageing performance of SSCs and such programs include chemical control, Inspection, examination and testing, baseline data collection and material surveillance.

Construction programme

98. The Operating Organisation shall ensure —

(*a*) a construction schedule is submitted to the Authority prior to commencement of construction ;

(*b*) a proper planning, scheduling and work sequencing including provisions for Items with long-lead times, onsite manufacturing, modular assembly and testing activities, and hold and witness points by various parties ;

(*c*) in the provision for construction and operation, due account is taken of relevant experience that has been gained in the construction of other similar plants and associated structures, systems and components ; and

(*d*) where best practices from other relevant industries are adopted, such practices shall be shown to be appropriate to the specific nuclear application.

Onsite manufacturing, installation and testing

99. Onsite manufacturing shall be located where it will not affect SSCs important to safety or construction activities. The Operating Organisation shall ensure that rules and procedures are established for onsite testing facilities to ensure that industry codes and standards are met.

Long-lead items

100. The Operating Organisation shall ensure that any differences between the original purchasing requirements, the licence-to-construct design basis and the as-built items are evaluated, reconciled and reported to authorised agencies and the Authority.

Manufacture and assembly

101. The Operating Organisation shall ensure right of access to facilities and records for witness points or audit by the Authority.

Protection of structures, system and components important to safety

102.—(1)The Operating Organisation shall put in place measures to ensure that SSCs important to safety are protected from construction activities which include —

(*a*) conducting preventative and corrective maintenance to maintain the functionality of SSCs important to safety, as required by the design, until operational maintenance programs are initiated ;

(*b*) ensuring that fabrication or manufacturing, construction and installation processes do not adversely affect ageing performance of SSCs important to safety or adjacent reactor units ;

(*c*) performing periodic monitoring of environmental conditions to confirm that they remain within allowable limits throughout construction ; and (*d*) implementing housekeeping, cleanliness and foreign material exclusion measures as necessary to protect sensitive mechanical, electrical and control equipment from internal and external contamination.

(2) The temporary use of SSCs important to safety that are to become part of the completed facility shall be authorised by the responsible organisation.

(3) The temporary use shall not subject the SSCs important to safety to conditions for which they were not designed.

Transportation of components to the construction site

103. The Operating Organisation shall ensure that transportation routes are planned with consideration given to —

(*a*) type of transport and lifting equipment for large, heavy or awkwardly shaped components ;

(*b*) assessments of roads, rail, waterways, bridges ,docks and wharfs, to ensure transport is possible without posing hazards or causing damage to the components, or harm to persons or anything on the routes ; and

(c) structures, systems and components important to safety which shall be transported in accordance with relevant national requirements.

Onsite construction activities

104. The Operating Organisation shall ensure that —

(*a*) initial check when components are received at the construction site are carried out to ensure they are in order and have not been obviously damaged during transport and components are controlled to prevent inadvertent installation or use ;

(*b*) equipment such as special cartons, containers, protective devices, cranes, hoists, manipulators and transport vehicles are qualified ;

(*c*) equipment for handling components are used and maintained in accordance with National Regulations and Standards and Operators and handlers of such equipment shall be trained and qualified in their use ;

(*d*) components and consumables are clearly identifiable by using appropriate marks specified by the designer or manufacturer and controlled at all locations, including offsite manufacturing facilities, to prevent their misuse, damage, deterioration or loss of identification ;

(*e*) storage is provided as specified by the designers and manufacturers to protect components prior to their installation and use ;

(*f*) installed SSCs from personnel traffic, temporary structures, weather, and adjacent construction activities that would adversely affect the quality of the SSCs or any test results are protected ;

(*g*) temporary use of SSCs shall not subject the SSCs to conditions for which they were not designed ; and (*h*) during the entire construction phase, the SSCs are subjected to an appropriate preventive or corrective maintenance plan to maintain their functionality as required by the design and this shall be continued until operational maintenance programs are initiated.

Transfers during construction to commissioning

105. The Operating Organisation shall ensure that —

(*a*) a process for turnover of SSCs important to safety is established ; and

(*b*) rules and procedures are established to control and coordinate the handover from construction to commissioning.

Configuration control

106.—(1) The Operating Organisation shall ensure that all recorded information that describes, specifies, certifies, or provides data or results created during construction, as part of the facility configuration information, are agreed to, planned and processed so as to facilitate its turnover to commissioning and operations in the agreed form, format and required quality.

(2) The Operating Organisation shall ensure that changes that occur in the course of construction are processed to maintain conformance among the design requirements, the physical configuration and the facility configuration information.

(3) The Authority shall be notified where configuration changes have an impact on the submitted design and licensing basis information.

Construction records

107. The Operating Organisation shall ensure that —

(*a*) the control of construction records are established and consistent with the schedule for accomplishing construction activities ;

(*b*) construction records furnish documentary evidence that SSCs meet specified requirements forming part of the facility configuration information and that the construction records are identified, generated, authenticated, maintained and transferred to it prior to operation and shall be maintained throughout the lifetime of the facility ;

(*c*) photographic and, where appropriate, video records and computer simulations shall be compiled, particularly in areas that will eventually be inaccessible or will be subject to intense radiation especially in facilitating the planning of work in this area during commissioning, operation and decommissioning ;

(*d*) the visual construction records of as-built conditions referred to in paragraph (c) of this regulation show identification marks and are catalogued with descriptive captions to ensure that visual records made during subsequent inspections or maintenance work can be easily compared, and will help in any work preparation ; and

(*e*) it submits the construction report to the Authority prior to commissioning.

PART VII — OFFENCES AND PENALTIES

Offences and penalties

108.—(1) A person who contravenes any of the provision of these regulations commits an offence and is liable on conviction to the penalties stipulated under the Act and any other extant law or guidelines made pursuant to the Act.

(2) Notwithstanding the provisions of sub regulation (1) of this regulation, the Authority may impose penalties such as administrative fine, suspension, revocation of authorisation, sealing of facility or any combination of these.

PART VIII — MISCELLANEOUS PROVISIONS

Enforcement procedure

109.—(1) Any person or organisation who —

(*a*) without reasonable excuse, fails to produce a licence which he is required by these Regulations to have ;

(*b*) willfully obstructs a radiation protection or safety officer or any other authorized officer in the exercise of his duties under these Regulations; or

(*c*) contravenes any other provisions of these Regulations,

commits an offence under these Regulations.

(2) A persons responsible for notified or authorised practices or sources within practices are subject to administrative fines for non-compliance with applicable regulations and regulatory requirements commensurate with the nature of the infraction, in line with the Enforcement Policy of the Authority.

(3) Where the infractions referred to in subregulation (2) of this regulation persists, the violator shall be referred to the Nuclear Security Committee established by the Authority for appropriate sanction.

(4) Where the offence under these Regulations is committed by a body corporate, the body corporate is liable to a fine or penalty prescribed in the Enforcement Policy of the Authority and every director, secretary or manager of the body corporate shall be proceeded against accordingly unless he proves that the offence is committed without his consent or connivance and that he exercised due diligence to prevent the commission of the offence having regards to the nature of his functions and the circumstances of the case.

Appeal

110. Any person or organisation may appeal to the Governing Board of the Authority against any decision made by the Authority pursuant to these Regulations.

111. In these Regulations — Interpretations

"Abbreviations" means the list of abbreviations specified in the Schedule to these Regulations ;

"Acceptable limit" as defined under *"limit"* ;

"Accident" means any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety, and for the purposes of these Regulations, accidents —

(*a*) include design basis accidents and beyond design basis accidents ; and

(*b*) exclude anticipated operational occurrences, which have negligible consequences from the perspective of protection or safety ;

"Accident conditions" means deviations from normal operation that are less frequent and more severe than anticipated operational occurrences, including design basis accidents and design extension conditions ;

"Accident management" means the taking of a set of actions during the evolution of a beyond design basis accident to —

(*a*) prevent the escalation of the event into a severe accident ;

(*b*) mitigate the consequences of a severe accident ; and

(*c*) achieve a long term safe stable state.

"Action level" means the level of dose rate or activity concentration above which remedial actions or protective actions should be carried out in chronic exposure or emergency exposure situations ;

"Activities" means —

(*a*) the production, use , import and export of radiation sources for industrial, research and medical purposes ;

(*b*) the transport of radioactive material ;

(*c*) the decommissioning and dismantling of facilities and the closure of disposal facilities for radioactive waste ;

(*d*) the close-out of facilities where the mining and processing of radioactive ore was carried out ;

(*e*) activities for radioactive waste management such as the discharge of effluents ; and

(*f*) the remediation of sites affected by residual radioactive material from past activities ;

"Anticipated Operational Occurrence" means an operational process deviating from normal operation which is expected to occur at least once

during the operating lifetime of a facility but which, in view of the appropriate design provisions, does not cause any significant damage to items important to safety or lead to accident conditions ;

"Applicant" means a person who applies to the regulatory authority for authorisation to undertake specified activities ;

"Authority" means Nigerian Nuclear Regulatory Authority (NNRA), having legal authority for conducting the regulatory process, including issuing authorisations, and thereby regulating nuclear, radiation, radioactive waste and transport safety ;

"Authorisation" means the granting by the regulatory authority or other governmental body of written permission for an operator to perform specified activities, which may include licensing, certification, registration, etc ;

"Authorised limit" see *"limit"* ;

"Best estimate" means unbiased estimate obtained by the use of a mathematical model or calculation method to realistically predict plant behaviour and important parameters ;

"Beyond design basis accident (BDBA)*"* means accident conditions less frequent and more severe than a design basis accident, which may or may not involve core degradation ;

"Combustion" means a chemical process that involves oxidation sufficient to produce heat or light ;

"Common-cause failure" means a concurrent failure of two or more structures, systems or components due to a single specific event or cause, such as natural phenomena (earthquakes, tornadoes, floods, etc.), design deficiency, manufacturing flaws, operation and maintenance errors, human-induced destructive events and others ;

"Commissioning" means a process of activities intended to demonstrate that installed systems, structures, and components and equipment perform in accordance with their specifications and design intent before they are put into service ;

"Complementary design feature" means a design feature outside of the design basis envelope that is introduced to cope with beyond design basis accidents, including severe accidents ;

"Confinement" means a continuous boundary without openings or penetrations (such as windows) that prevents the transport of gases or particulates out of the enclosed space ;

"Containment" means a confinement structure designed to maintain confinement at both high temperature and pressures and for which isolation valving on penetrations is permitted ;

"Controlled area" means defined area in which specific protection measures and safety provisions are or could be required for controlling normal exposures or preventing the spread of contamination during normal working conditions, and preventing or limiting the extent of potential exposures ;

"Conservatism" means use of assumptions, based on experience or indirect information, about a phenomena or behaviour of a system being at or near the limit of expectation, which increases safety margins or makes predictions regarding consequences more severe than if best-estimate assumptions had been made ;

"Construction" means the process of procuring, manufacturing and assembling the components, carrying out civil work, installing and maintaining components and systems, and performing associated tests ;

"Construction organisation" means the entity managing the procurement, manufacture and assembly of components, carrying out of civil work, instalment and maintenance of components and systems, and performance of associated tests, and they maybe part of the licensee's organisation or a contracted entity ;

"Construction safety case" means the information provided with the licence application for a licence to construct, including the documents to which the application makes reference, once approved by the NNRA ;

"Core damage" means the core degradation resulting from event sequences more severe than design basis accidents ;

"Core Damage Frequency" means the sum of frequencies of all event sequences that can lead to significant core degradation is less than 10^{-5} per reactor year ;

"Decommissioning" means administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility ;

"Design" means the overall planning and philosophies that go into ensuring that every aspect of the physical design will consider safety, security and safeguards under all scenarios it may encounter during its lifecycle ;

"Design basis" means the range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorised limits by the planned operation of safety systems ;

"Design basis accident" means accident conditions against which a nuclear power plant is designed according to established design criteria, and for which the damage to the fuel and the release of radioactive materials

are kept within authorised limits ;

"Design basis threat" means a set of malevolent acts that the NNRA considers possible ;

"Design extension conditions" means postulated accident conditions that are not considered for design basis accidents but that are considered in the design process of the facility in accordance with best estimate methodology and for which releases of radioactive materials are kept within acceptable limits ;

"Design Organisation" means the organisation responsible for preparation of the final detailed design of the plant to be built ;

"Deterministic safety analysis" means analysis of plant responses to an event performed using predetermined rules and assumptions (such as those concerning the initial plant state, availability and performance of the plant systems, and operator actions) and Deterministic analyses can use either conservative or best estimate methods ;

"Direct trip parameter" means a value based on direct measurement of a specific challenge to the derived acceptance criteria and, if applicable, a direct measure of the event ;

"Disposal" means emplacement of waste in an appropriate facility without the intention of retrieval ;

"Diversity" means the presence of two or more redundant systems or components to perform an identified function, where the different systems or components have different attributes so as to reduce the possibility of common-cause failure ;

"Environment" means the components of the Earth, including —

(*a*) land, water, and air, including all layers of the atmosphere,

(*b*) all organic and inorganic matter and living organisms ; and

(*c*) interacting natural systems that include components referred to in (a) and (b) ;

"Exclusion zone" means a parcel of land within or surrounding a nuclear facility on which there is no permanent dwelling and over which a licensee has the legal authority to exercise control ;

"External event" means any event that proceeds from the environment external to a nuclear power plant, and can cause failure of structures, systems and components. which include, but are not limited to, earthquakes, floods, and hurricanes ;

"Facility configuration information" means recorded information that describes, specifies reports, certifies, or provides data or results regarding

the design requirements or design basis, or that pertains to other information attributes associated with the facility and its structures, systems and components ;

"Facility" means a reactor, a critical facility, a conversion plant, a fabrication plant, a reprocessing plant, an isotope separation plant or a separate storage installation; or any location where nuclear material in amounts greater than one effective kilogram is customarily used ;

"Fail-safe design" means design whose most probable failure modes do not result in a reduction of safety ;

"Failure" means an event during which a component's or structure's functional deficiency or structural weakness has exceeded established limit values or has brought about a deviation from the components or structure's designed functioning ;

"Fire" means a process of combustion characterized by heat emission and accompanied by smoke or flame, or both ;

"Fuel assembly" means a set of fuel elements and associated components which are loaded into and subsequently removed from a reactor core as a single unit ;

"Fuel element" means a rod [or other form] of nuclear fuel, its cladding and any associated components necessary to form a structural entity ;

"Fuel handling" means the movement, storage, transfer, packaging and transport of fresh and irradiated fuel ;

"Heat sink" means a system or component that provides a path for heat-transfer from a source such as heat generated in the fuel, to a large heat absorbing medium ;

"Human factors" means factors that influence human performance as it relates to the safety of the nuclear power plant, including activities during design, construction, and commissioning, operation, maintenance and decommissioning phases ;

"Independent systems" means systems that do not share any components ;

"Internal event" means an event internal to the nuclear power plant that result from human error or failure in a system, structure, or component ;

"Large release frequency" means the sum of frequencies of all event sequences that can lead to a release to the environment of more than1014 Becquerel of Cesium- 137 is less than 106 per reactor year, and a greater release may require long term relocation of the total population.

"Licence" means a legal document issued by the regulatory authority

granting authorisation to perform specified activities related to a facility or activity ;

"Licensee" means the holder of a current licence. The licensee is the person or organisation having overall responsibility for a facility or activity ;

"Licensing basis" means a set of requirements and documents for a regulated facility or activity comprising the —

(*a*) regulatory requirements set out in the applicable laws and regulations,

(*b*) conditions and safety and control measures described in the facility's or activity's licence and the documents directly referenced in that licence, and

(*c*) safety and control measures described in the licence application and the documents needed to support that licence application ;

"Limit" means the value of a quantity used in certain specified activities or circumstances that must not be exceeded, and —

(a)"Acceptable limit" means a limit acceptable to the regulatory authority ; and

(b)"Authorized limit" means a limit on a measurable quantity established or formally accepted by the regulatory authority ;

"Management system" means a set of interrelated or interacting elements (system) for establishing an organization's policies and objectives and enabling the objectives to be achieved efficiently and effectively, which include the structure, resources, processes, personnel, equipment, organisational culture, as well as the documented policies and processes, and the organisation's processes have to address the totality of organisation's requirements as established in, for example, IAEA safety standards and other international codes and standards ;

"Maintenance" means the organised activity, both administrative and technical, of keeping structures, systems and components (SSC's) in good operating condition, including both preventive and corrective aspects ;

"Mission time" means the duration of time within which a system or component is required to operate or be available to operate and fulfil its function following an event ;

"Modification" means the alteration of a system, component or structure in such a way that it no longer meets all the requirements set for earlier designs ;

"Monitoring" means continuous or periodic measurement of radiological or other parameters or determination of the status of a system, which may include sampling as a preliminary step to measurement ;

"Normal operation" means operation of a nuclear power plant within specified operational limits and conditions including start-up, power operation, shutting down, shutdown, maintenance, testing and refuelling ;

"Nuclear power plant" means any fission reactor installation constructed to generate electricity on a commercial scale and it is a Class IA nuclear facility ;

"Nuclear safety" means the achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards ;

"Operations area" means a geographical area that contains an authorised facility and enclosed by a physical barrier to prevent unauthorised access and by means of which the management of the authorised facility can exercise direct authority ;

"Operating Organisation" means the organisation authorised by the regulatory authority to operate a facility ;

"Operational limits and conditions (OLC)" means a set of rules setting up parameter limits, the functional capability and the performance of equipment and personnel approved by the Authority for safe operation ;

"Operation" means all activities performed to achieve the purpose for which a facility was constructed, and for reactor facilities, this includes maintenance, refuelling, in-service inspection and other associated activities ;

"Operational states" means states defined under normal operation and anticipated operational occurrences ;

"Peer reviews" means an evaluation, examination of review of commercial, professional or academic efficiency, competence etc by experts in the relevant field ;

"Periodic testing" means inspections, operability checks and calibrations carried out on parameter values, structures, systems and components to verify compliance with operational limits and conditions and to ensure adequacy of the safety status of the reactor ;

"Plant" means a nuclear power plant ;

"Plant state" means a configuration of nuclear power plant components, including the physical and thermodynamic states of the materials and the process fluids in them, and for the purpose of these Regulations, a plant is said to be in one of the following states: normal operation, anticipated operational occurrence, design basis accident, or beyond design basis accident (severe accidents are a subset of the beyond design basis state) ;

"Postulated initiating event" means an event identified in the design as leading to either an anticipated operational occurrence or accident conditions, which means that a postulated initiating event is not necessarily an accident itself, rather it is the event that initiates a sequence that may lead to an operational occurrence, a design basis accident, or a beyond design basis accident, depending on the additional failures that occur ;

"Practicable" means technically feasible and justifiable while taking cost-benefit considerations into account ;

"Practically eliminated" means the possibility of certain conditions arising may be considered to have been 'practically eliminated' if it would be physically impossible for the conditions to arise or if these conditions could be consider with a high level of confidence to be extremely unlikely to arise ;

"Pressure boundary" means a boundary of any pressure-retaining vessel, system, or component of a nuclear or non-nuclear system ;

"Preventive maintenance" means measures carried out according to a pre-determined maintenance programme which are aimed at preventing any operational incidents or failures of a component or a structure ;

"Probabilistic safety assessment" means a comprehensive and integrated assessment of the safety of the nuclear power plant that, by considering the initial plant state and the probability, progression, and consequences of equipment failures and operator response, derives numerical estimates of a consistent measure of the safety of the plant, and such assessments are most useful in assessing the relative level of safety ;

"Process " means set of interrelated activities that transform inputs into outputs ;

"Process system" means a system whose primary function is to support (or contribute to) the production of steam or electricity ;

"Protection system" means system which monitors the operation of a reactor and which, on sensing an abnormal condition, automatically initiates actions to prevent an unsafe or potentially unsafe condition, and the 'system' in this case encompasses all electrical and mechanical devices and circuitry, from sensors to actuation device input terminals ;

"Proven design" means the proving of a design of a component(s) by either showing compliance with accepted engineering standards, or by a history of experience, or by test, or some combination of these ; and new component(s) are *"proven"* by performing a number of acceptance and demonstration tests that show the component(s) meets pre-defined criteria ;

"Radiation protection" means the protection of people from the effects of exposure to ionizing radiation, and the means for achieving this ;

"Quality assurance" means planned and systematic actions necessary to provide adequate confidence that an item, process or service will satisfy given requirements for quality, for example, those specified in the licence ;

"Redundancy" means provision of alternative identical or diverse structures, systems or components, so that anyone can perform the required function regardless of the state of operation or failure of any other ;

"Repair" means making a failed component or structure aperable by restoring it to a state which conforms to original design ;

"Residual heat" means the sum of heat originating from radioactive decay, fission in the fuel in the shutdown state, and the heat stored in reactor related structures, systems and components ;

"Safeguards" means a system of international inspections and other verification activities undertaken by the IAEA in order to evaluate, on an annual basis, Nigeria's compliance with its obligations pursuant to the safeguards agreements between Nigeria and the IAEA ;

"Safety analysis" means analysis by means of appropriate analytical tools that establishes and confirms the design basis for the items important to safety; and ensures that the overall plant design is capable of meeting the acceptance criteria for each plant state ;

"Safety case" means an integrated collection of arguments and evidence to demonstrate the safety of a facility, which typically include a safety assessment, but could also include information (including supporting evidence and reasoning) on the robustness and reliability of the safety assessment and the assumptions made therein ;

"Safety culture" means the assembly of characteristics and attitude in organisations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance ;

"Safety function" means a specific purpose that must be accomplished for safety ;

"Safety group" means assembly of structures, systems and components designated to perform all actions required for a particular postulated initiating event to ensure that the specified limits for AOOs and DBAs are not exceeded, and it may include certain safety and safety support systems, and any interacting process system ;

"Safety limits" means limits on operational parameters within which an authorized facility has been shown to be safe, and they are operational

limits and conditions beyond those for normal operation ;

"Safety support system" means a system designed to support the operation of one or more safety systems ;

"Safety system" means a system provided to ensure the safe shutdown of the reactor or the residual heat removal from the core, or to limit the consequences of anticipated operational occurrences and design basis accidents ;

"Safety system support features" means the collection of equipment that provides services such as cooling, lubrication and energy supply required by the protection system and the safety actuation systems ;

"Safety system settings" means the levels at which protective devices are automatically actuated in the event of anticipated operational occurrences or accident conditions, to prevent safety limits being exceeded ;

"Severe accident" means a beyond design basis accident that involves significant core degradation ;

"Shutdown state" means a designated operational mode where the reactor is subcritical, and fundamental safety functions (cooling, reactivity control, confinement) are maintained following power operation, anticipated operational occurrences, or accident conditions, and it ensures the plant remains safe, often categorized as hot or cold shutdown or refueling ;

"Single failure" means a failure that results in the loss of capability of a system or component to perform its intended function(s) and any consequential failure(s) that result from it ;

"Single failure criterion" means a criterion (or requirement) applied to a system such that it must be capable of performing its task in the presence of any single failure ;

"Site area" means a geographical area that contains an authorised facility, and within which the management of the authorised facility may directly initiate emergency actions, and this area is often identical to the operations area, except in situations (such as Research Reactors, irradiation installations) where the authorised facility is on a site where other activities are being carried out beyond the operations area, but where the management of the authorised facility can be given some degree of authority over the whole site area ;

"Site boundary" means the boundary of the site area ;

"Siting" means the process of selecting a suitable site for a facility, including appropriate assessment and definition of the related design basis ;

"Small Releases Frequency" means the sum of frequencies of all event sequences that can lead to release to the environment of more than 10^{15} Becquerel of iodine-131 in less than 10^{-5} per reactor year, and a greater release may require a temporary evacuation of the local population ;

"Supervised area" means a defined area not designated a controlled area but for which occupational exposure conditions are kept under review, even though specific protection measures and safety provisions are not normally needed ;

"Structures, systems and components" means a general term encompassing all of the elements (items) of a facility or activity which contribute to protection and safety, except human factors ; Structures are the passive elements: buildings, vessels, shielding, etc ; A system comprises several components, assembled in such a way as to perform a specific (active) function ; and a component is a discrete element of a system, it includes wires, transistors, integrated circuits, motors, relays, solenoids, pipes, fittings, pumps, tanks and valves ;

"Trip parameter" means a measurement of a variable that is used to trigger a safety system action when the trip parameter set point is reached ;

"Trip parameter set point" means trip parameter value at which activation of a safety system is triggered ; and

"Ultimate heat sink" means a medium to which the residual heat can always be transferred, even if all other means of removing the heat have been lost or are insufficient, and this medium is normally a body of water or the atmosphere.

112. These regulations may be cited as the Nigerian Design and Construction of Nuclear Power Plants Regulations 2023. Citation

SCHEDULE

[Regulation 111]

LIST OF ABBREVIATIONS

ALARA	As low as reasonably achievable
AOO	Anticipated operational occurrence
BDBA	Beyond design basis accident
BDBT	Beyond design basis threat
CR	Control room
DBA	Design basis accident
DBE	Design basis earthquake
DBT	Design basis threat
ECCS	Emergency core cooling system
EHRS	Emergency heat removal system
EPS	Emergency power supply
GSS	Guaranteed shutdown state
IAEA	International Atomic Energy Agency
MCR	Main control room
MSIV	Main steam isolation valve
NPP	Nuclear power plant
NSRPA	Nuclear Safety and Radiation Protection Act
OLC	Operational limits and conditions
PIE	Postulated initiating event
PSA	Probabilistic safety assessment
RCS	Reactor coolant system
SCR	Secondary control room
SSC	Structures, systems, and components

Made at Abuja this 23rd day of November 2023

Bola Ahmed Tinubu, GCFR
President, Federal Republic of Nigeria