NRRC Technical Regulations

Safety Assessment of Nuclear Facilities

NRRC-R-07 Rev. 0.1

2024

هيئة الرقابة النووية والإشعاعية
Nuclear and Radiological Regulatory Commission

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Regulation

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Preamble

In accordance with the provisions of the Law of Nuclear and Radiological Control issued by Royal Decree No. (M/82) dated 25/7/1439 AH, and NRRC's Statute issued by the Ministers' Cabinet Resolution No. (334) dated 25/6/1439 AH, the NRRC prepared regulations that ensure control over radiological activities and practices as well as nuclear and radiological facilities.

This regulation has been prepared on the basis of International Atomic Energy Agency (IAEA) standards, international best practices, and in accordance with the Kingdom's international commitments. This regulation has been presented in "the Public Consultation Platform" for the public review, comments, and feedback.

This regulation has been approved by the NRRC's Board of Directors Resolution No. (R/1/1/2022) dated 20/04/2022.

This edition, NRRC-R-07 Rev. 0.1 (2024), of the regulation is revised and takes precedence over the previous publication, NRRC-R-07 (2022). In addition, the changes within this revision are editorial.

Table of Contents

Related Regulations

Chapter 1: Objective, Scope, and Definitions

Section 1: Objective

1. The objective of this regulation is to establish the regulatory requirements for the safety assessment of nuclear facilities to ensure the fulfillment of nuclear safety requirements for each nuclear facility.

Section 2: Scope

2. This regulation applies to the safety assessment of a nuclear facility throughout its lifetime. All established requirements herein apply directly to nuclear power plants and other types of nuclear facilities, except for the reactor-oriented terminology that may need to be replaced by equivalent terminology to cover the primary purpose of a specific requirement.

3. The regulation establishes the requirements for managing the safety assessment efforts and performing the assessments themselves. The requirements cover the design-oriented assessments and the periodic safety reviews to incorporate a life cycle approach.

4. The requirements of this regulation apply to an applicant for or a holder of a construction or operating license and, to an appropriate extent, to vendors, suppliers, designers, and those supporting the aforementioned organizations in safety assessments.

5. This regulation is focused on the safety assessment of nuclear facilities and is supplemented by the Regulation on Radiation Safety (NRRC-R-01 Rev. 0.1), the Regulation on Licensing and Regulatory Oversight of Nuclear Facilities (NRRC-R-03 Rev. 0.1), the Regulation on Leadership and Management for Safety (NRRC-R-04 Rev. 0.1), the Regulation on Site Evaluation of Nuclear Facilities (NRRC-R-05 Rev. 0.1), the Regulation on Design of Nuclear Facilities (NRRC-R-06 Rev. 0.1), the Regulation on Construction and Commissioning of Nuclear Facilities

(NRRC-R-08 Rev. 0.1), and the Regulation on Operations of Nuclear Facilities (NRRC-R-09 Rev. 0.1).

Section 3: Definitions

Failure

This refers to a failure of a system, structure, or component (item) to maintain its capability or perform its function as intended in the design by any of the relevant failure modes, including inadvertent or spurious operation.

Initiating event

This refers to an identified internal or external event, as potentially caused by a malfunction, failure, error, hazard, or their combinations, that affects any normal operational mode of a nuclear facility and leads to an anticipated operational occurrence or accident condition.

Chapter 2: Management of Safety Assessments

Section 4: Safety Assessment

6. A safety assessment shall be carried out for a nuclear facility and related activities that give rise to radiation risks to determine whether adequate measures are in place to protect the people and the environment. The safety assessment shall cover the lifetime of the nuclear facility and shall be kept up-to-date at all stages of the facility's lifetime.

7. An applicant for, or a holder of, a license for constructing or operating a nuclear facility shall be responsible for the safety assessment to ensure the fulfillment of all applicable safety requirements. An independent verification shall be carried out by individuals or teams of the operating organization not performing the safety assessment to examine the assessment at an appropriate level of detail to ensure quality prior to submission to the NRRC.

8. The safety assessment shall be based on design assessments related to the design of the nuclear facility and shall be complemented by periodic safety reviews throughout the lifetime of the facility.

9. The processes and projects through which the safety assessment is resourced, produced, documented, and reviewed shall be prepared, planned, organized, and audited to ensure competence, quality, consistency, and completeness of all safety assessment-related activities. Interfaces with responsible vendors, suppliers, designers, and consultants engaged in the safety assessment work shall be identified and controlled.

10. A graded approach shall be used to determine the scope and level of detail of the safety assessment, which is commensurate with the potential radiation risks arising from the nuclear facility or related activity. Confidence in the safety assessment results shall be strengthened by independent verification, analysis, or review exercises covering the full assessment or specific parts with safety-significant uncertainties.

Section 5: Design Assessments

11. The primary purpose of the design assessments shall be to determine whether an adequate level of safety has been achieved in the design in relation to the safety objectives and criteria, as stipulated by the Regulation on Design of Nuclear Facilities (NRRC-R-06 Rev. 0.1).

12. The design assessments shall be performed using a combination of deterministic safety analysis, probabilistic risk assessment, and reviews of the safety classification schemes, operating procedures, postulated accidents, and initiating events.

13. The results of the design assessments of a nuclear facility shall be used in order to:

a. Finalize the design solutions and operational procedures for the nuclear facility and items;

b. Specify the operational limits and conditions for the facility and items;

c. Specify the conditions for qualifying items important to safety;

d. Prepare the maintenance, surveillance, and inspection programs;

e. Outline the procedures for abnormal conditions and emergency response;

f. Increase the competence of the staff in nuclear and radiological safety issues;

g. Make decisions that ensure the safety of and minimize the risks to the facility and related activities.

14. The design assessments shall be updated throughout the lifetime of the nuclear facility whenever a design modification, operational experience, or new knowledge makes it necessary to revise the assumptions, models, or data used in the assessments.

Section 6: Periodic Safety Reviews

15. The safety of the nuclear facility shall be periodically reviewed to determine whether an adequate level of safety is maintained during operation, with due account taken of operating experience and significant new safety-related information from all relevant sources.

16. The periodic safety reviews shall be performed with a broad scope covering the design and development, condition and aging, operational performance, radiological effects, and management of the nuclear facility.

17. The results of the periodic safety review of the nuclear facility shall be used in order to:

a. Create an integrated view of the facility safety status and necessary improvements;

b. Steer the allocation of resources for issues and actions of safety significance;

c. Proactively support the safe use of the facility throughout its lifetime.

18. The periodic safety reviews shall be performed based on an interval of ten (10) years or as prescribed by the NRRC, to follow the development of the nuclear facility, the operating organization, and the nuclear field in general.

Chapter 3: Main Elements of Design Assessments

Section 7: Deterministic Safety Analysis

19. A deterministic safety analysis of the design of the nuclear facility shall be made to predict the behavior of the facility during and following all operational states and accident conditions to ensure that the safety criteria are met.

20. Acceptance criteria shall be specified for the deterministic safety analyses to evaluate safety based on the key facility design parameters and the radiological impact, as analyzed for normal operation, anticipated operational occurrences, and accident conditions.

21. A comprehensive listing of postulated initiating events (PIEs) shall be prepared so that the analysis of the facility response envelops all foreseeable events challenging the integrity of physical barriers and the performance of safety functions.

22. Calculational methods and computer codes used in the safety analysis shall undergo verification and validation with appropriate experimental data and research. Uncertainty and sensitivity analyses shall be performed and accounted for when applying the results.

23. The facility's response to postulated initiating events shall be analyzed to determine whether the acceptance criteria and the safety criteria are met even with unfavorable combinations of initial conditions, equipment failures, and operator actions, as specified for the design basis and features as well as the operational limits and conditions of the nuclear facility.

Section 8: Probabilistic Risk Assessment

24. A probabilistic risk assessment of the nuclear facility shall be made to determine whether the radiation risks are as low as reasonably achievable (ALARA) and guide the decisions to improve the safety of the nuclear facility design and management throughout its lifetime.

25. All initiating events caused by failures, errors, or hazards that could challenge normal operation and require mitigation or events that could lead directly to severe damage to fuel, the reactor core, or other radiologically risk-significant items of the nuclear facility shall be identified and grouped to establish the starting point for the probabilistic risk assessment.

26. The response of the nuclear facility to each group of initiating events shall be analyzed to model alternative sequences in which the initiating events could develop further, as such events are affected by the reliability of items performing their safety functions and operators taking corrective actions.

27. Based on initiating event identification, accident sequence modeling, and detailed reliability analyses, the probabilistic risk assessment shall present the quantitative results in the form of different facility damage states and their frequencies. The total frequency of damage states involving severe damage, with appropriate uncertainty considerations, shall be viewed as a quantitative estimate of the effectiveness of the defense-in-depth levels and the safety functions in preventing severe accidents. The results shall be used to identify the most significant contributors to the severe damage frequency and the subsequent opportunities for safety improvements and a more balanced design.

28. The probabilistic risk assessment shall be completed by further analyzing the progress and management of severe accidents, the effectiveness of the confinement of radioactive materials released, and the consequences in terms of radioactive releases into the environment. The frequencies and characteristics of these radioactive source terms and their radiological impact, with appropriate uncertainty considerations, shall be viewed as quantitative estimates of the radiation risks associated with the nuclear facility. The assessment results shall be factored to identify the largest risk contributors and opportunities for risk reduction.

Section 9: Design Reviews and Analyses

29. The design of the nuclear facility, items important to safety, and human interactions shall be reviewed and analyzed to identify and correct design deficiencies, to assess and justify the final design solutions, and to ensure the fulfillment of the safety objectives and design basis requirements for operational states, accident conditions, design extension conditions, and hazard conditions.

30. The defense-in-depth features of the nuclear facility shall be reviewed, analyzed, and assessed to determine whether adequate provisions have been made at each level of defense-in-depth, whether there exist such dependencies between the levels that several levels of defense could be coincidentally or consequentially lost, and whether the final design can be considered compliant with the defense-in-depth principle.

31. The site characteristics relating to the safety of the nuclear facility shall be analyzed to ensure that the radiological impact assumptions made in the design assessments are correct, the facility is sufficiently protected against external hazards, and the potential effects on a nuclear facility with multiple units, if relevant, are appropriately covered by the facility design and emergency measures.

32. The safety functions shall be reviewed, analyzed, and assessed to determine whether their failure tolerance and reliability are at a level commensurate with

their importance for the defense-in-depth and the fundamental safety function objectives of the nuclear facility. The reviews, analyses, and assessments performed for a specific safety function shall cover the relevant operational states and the accident conditions, design extension conditions, and hazard conditions.

33. The design of items important to the safety of a nuclear facility shall be reviewed to determine whether such items are robust, reliably designed, and suitable for their purpose. Thorough analyses and assessments shall be performed for structures, systems, and components whose safety significance, design complexity, technological novelty, or potential exposure to challenging conditions make their qualification, verification, and validation particularly demanding.

34. Human interactions with the nuclear facility or a specific activity shall be addressed to determine whether the procedures and measures for operational states and accident conditions, design extension conditions, and hazard conditions ensure an adequate level of safety and whether sufficient design features, administrative procedures, and control measures have been provided to prevent and mitigate the influence of human errors on the safety of the nuclear facility.

Chapter 4: Main Elements of Periodic Safety Reviews

Section 10: Facility Design and Development

35. The design of the nuclear facility shall be reviewed to determine the adequacy of the current design and documentation against the current licensing basis of the facility and national and international codes, standards, requirements, and practices.

36. The deterministic safety analysis shall be reviewed to determine to what extent the existing analyses are complete and remain valid when considering the current design, condition, and operation of the nuclear facility, the development in safety

analysis methods, research, and standards, and the existence and adequacy of safety margins.

37. The probabilistic risk assessment shall be reviewed to determine to what extent the existing risk assessment remains valid for the current design and operational characteristics of the nuclear facility, whether the assessment is in accordance with current standards and good practices, and whether the assessment results show that the risks are sufficiently low and well balanced.

38. The hazard analyses shall be reviewed to determine the adequacy of protection of the nuclear facility against internal and external hazards, with account taken of the facility design and condition, site characteristics, and the development in analysis methods, safety standards, and knowledge.

39. Human factors shall be examined to determine their effect on the safe operation of the nuclear facility and to identify improvements that are reasonable and practicable.

Section 11: Condition, Aging, and Lifetime

40. Equipment qualifications shall be reviewed to determine whether items important to safety have been properly qualified and whether this qualification is being maintained through an adequate program of maintenance, inspection, and testing with respect to safety function performance.

41. The actual conditions and associated documents for items important to safety shall be reviewed to consider whether they are adequate for meeting the design requirements, validating the results of the current design assessments, and ensuring the ongoing maintenance, surveillance, and inspection programs are effective in this regard.

42. The aging effects on items important to safety shall be reviewed to determine whether they are being effectively managed and whether an effective aging

management program is in place to ensure safety function performance for the planned lifetime of the nuclear facility.

Section 12: Operational Performance and Experience

43. The safety performance indicators, records of operating experience, and evaluation of the root causes of events shall be reviewed to determine whether the operating organization systematically collects and evaluates such information and whether the results indicate any need for safety improvements.

44. The use of relevant experience from other nuclear facilities and research shall be reviewed to determine whether the operating organization utilizes such feedback to introduce reasonable and practicable safety improvements in the design and operation of the nuclear facility.

Section 13: Radiation Protection and the Environment

45. The radiation protection arrangements for the workers and the monitoring program for the radiological impact on the environment shall be reviewed to determine whether the operating organization is carrying out adequate and effective measures to ensure that the subsequent doses and emissions are appropriately controlled and kept as low as reasonably achievable as required by Regulation on Radiation Safety (NRRC-R-01 Rev. 0.1).

Section 14: Management and Leadership

46. The operating organization and management system, as well as the feedback associated with safety culture and leadership, shall be reviewed to assess their adequacy and effectiveness in prioritizing safety when operating the nuclear facility.

47. The processes for managing, implementing, and adhering to operating and working procedures and for complying with safety requirements and operational limits shall be reviewed to assess their adequacy and effectiveness in ensuring the safe operation of the nuclear facility.

48. Emergency planning shall be reviewed to determine whether the operating organization has adequate staff, facilities, and equipment in place for dealing with emergencies and whether the arrangements have been adequately coordinated with other arrangements of relevant agencies and response organizations and are being regularly exercised.

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