

Feasibility Study for Developing a Safety Review Guide on Nigeria's Proposed Maiden Nuclear Power Plant

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1. Introduction

Safety Analysis Report (SAR), produced by an applicant, is a mandatory document required to be submitted to and approved by the Regulatory Body (RB) before constructing and operating a Nuclear Power Plant (NPP). The SAR can comprise 19 or 21 chapters [1,2], depending on the national-specific format. The lack of technical knowledge and appropriate national-specific regulatory requirements for these chapters of the SAR can cause difficulty in providing a standardized, high-quality review by the regulatory staff.

Nigeria is embarking on a Nuclear Power Program and is proposing a light-water nuclear reactor. The Nigerian Nuclear Regulatory Authority (NNRA) adopts standards from the International Atomic Energy Agency (IAEA) to develop regulations peculiar to the country's needs. These standards can be used to develop regulatory review guides to attain a more precise, uniform, and standard review. On the other hand, the United States Nuclear Regulatory Commission (USNRC) has developed a review guide, which is titled "Standard Review Plan (SRP)" [3], based on USNRC regulations such as the Code of Federal Regulations (CFR), Regulatory Guides (RG), etc.

This research proposes a new approach for developing Nigerian regulatory review guides for reviewing SAR with IAEA standards based on the SRP format. The IAEA standards equivalent to US regulations are first identified and applied to develop a regulatory review guide. In the following sections, more detailed methods for developing review guides on Safety Analysis, Chapter 15 of the SAR, are described with comparisons and insights from this research.

This proposed approach for developing the review guide would benefit the NNRA and other developing regulatory bodies that want to adopt IAEA standards to develop a comprehensive guide for reviewing SARs.

2. Methods and Results

This section describes the methodology and materials used to propose this new approach for developing a regulatory review guide for Safety Analysis using IAEA standards. Chapter 15 of the SRP (NUREG-0800) has a well-defined structure covering six major review areas, including the categorization of transients

and accidents, analysis acceptance criteria, plant characteristics analyzed in the evaluation of safety, event evaluation, evaluation of individual initiating events and, assumed protection and safety systems actions [4]. Based on the USNRC regulations used in developing the standard review plan for chapter 15 of the SAR, the equivalent IAEA safety standards are compiled and described in this paper.

The IAEA safety standards consist of three categories: Safety Fundamentals, Requirements, and Guides, arranged in descending order of hierarchy [5]. The Safety Fundamentals consist of ten Fundamental Safety Principles, which serve as a foundation for the Safety Requirements. The Safety Requirements are divided into General Safety Requirements (GSR) and Specific Safety Requirements (SSR), which consist of seven and six broad sections of requirements that must be fulfilled to achieve the safety of NPPs. The Safety Guides are several nonmandatory documents that include technical recommendations to achieve the required level of safety [5].

The identified IAEA standards adopted by the NNRA in its requirements for the SAR can further be used in drafting its review guide based on the NUREG 0800 format.

2.1 Comparison between USNRC Regulation and IAEA General Safety Requirement (GSR) Related to Safety Analysis Review

To narrow the search for equivalence between NUREG-0800 and IAEA standards, the IAEA GSR with only seven sections is reviewed to find the corresponding USNRC regulations. The most applicable part identified of the IAEA GSRs is the GSR Part 3 [6]. The equivalent USNRC regulation is then determined from the 53 parts of Title 10, Chapter I of the CFR. Table I below shows one of the findings from this section.

Table I: USNRC Regulation and Equivalent IAEA GSR Applicable to Safety Analysis Review

USNRC: 10 CFR Part 20
IAEA: GSR Part 3
Comparisons: Both documents are highly similar and contain the acceptance criteria for protecting the people and the environment against radiation.

- 10 CFR Part 20: Standards for Protection Against Radiation
- GSR Part 3: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

2.2 Comparison between USNRC Regulations and IAEA Specific Safety Requirements (SSRs) Related to Safety Analysis Review

From the IAEA SSRs, the most applicable requirements for Safety Analysis are SSR-1 and SSR-2/1. The equivalent USNRC regulations are obtained from the 53 parts of the 10 CFR. Table II below shows some findings from the comparison in this section.

Table II: USNRC Regulation and Equivalent IAEA SSRs Applicable to Safety Analysis Review

USNRC	IAEA	Comparisons
10 CFR Part 100	SSR-1	10 CFR Part 100 and SSR-1 are highly similar and contain criteria that must be fulfilled in siting NPPs.
10 CFR Part 50, Appendix A	SSR-2/1	These two documents are highly similar and consist of the requirements that shall be fulfilled for the design of NPPs. Examples of the application of both documents are shown in subsection 2.2.1.

- 10 CFR Part 100: Reactor Site Criteria
- 10 CFR Part 50, Appendix A: General Design Criteria (GDC) for NPPs
- SSR-1: Site Evaluation for Nuclear Installations
- SSR-2/1: Safety of Nuclear Power Plants: Design

2.2.1. Comparison between 10 CFR Part 50, Appendix A and SSR-2/1.

The 10 CFR Part 50 Appendix A and SSR-2/1 have 55 General Design Criteria (GDC) and 82 Requirements, respectively. These GDCs are matched to their corresponding SSR-2/1 requirements; some examples are shown in Table III below.

Table III: Examples of Equivalent GDC and SSRs Related to Safety Analysis Review

10 CFR Part 50, Appendix A	SSR-2/1
GDC 20: Protection System Functions	Requirement 61: Protection system
GDC 35: Emergency Core Cooling	Requirement 52: Emergency Cooling of the Reactor Core

2.3 Comparison between USNRC Regulation and IAEA Specific Safety Guide (SSG) Related to Safety Analysis Review

The USNRC has an extensive collection of Regulatory Guides (RG) available on its website for easy accessibility. Several RGs are identified to be related to the safety analysis review. Therefore, the equivalent SSGs to RGs are extracted from the IAEA collection of SSGs. Table IV below shows an example of these equivalent guides and the results obtained from their comparison.

Table IV: USNRC Regulation and Equivalent IAEA SSG Applicable to Safety Analysis Review

USNRC: RG 1.206
IAEA: SSG-12
<p>Comparisons: RG 1.206 provides recommendations on how to fulfill USNRC requirements on licensing, including early site permits, standard design certification, and combined licenses. SSG-12 provides an overview of the different types of licensing methods for NPPs. The NNRA may adopt any of these techniques recommended by the IAEA.</p>

- Regulatory Guide 1.206: Applications for Nuclear Power Plants
- SSG-12: Licensing Process for Nuclear Installations

2.4 Examples of how to Develop Review Guides Based on the New Approach using IAEA Standards

The examples in this section include excerpts from the NUREG 0800 and the IAEA equivalence resulting from this research using the new approach in developing a regulatory review guide for safety analysis.

Example 1

i) USNRC-based review guide (NUREG 0800)

The following is a specific criterion necessary to meet the requirements of GDC for Anticipated Operational Occurrences (AOOs):

Pressure in the Reactor Coolant System (RCS) and main steam systems should be maintained below 110 percent of the design values in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code [4].

ii) IAEA-based review guide (new approach)

For AOOs (or transients), the following requirement is mandatory to fulfill the requirements of SSR-2/1 to demonstrate that the NPP design is adequate to ensure:

The pressure in the RCS and main steam systems is maintained below a prescribed value (typically 110% of the design pressure) [7].

Example 2

i) USNRC-based review guide (NUREG 0800)

For loss-of-coolant-accidents (LOCAs), the following acceptance criterion should be met:

The calculated total oxidation of the cladding shall nowhere exceed 0.17 times the total cladding thickness before oxidation [4].

ii) IAEA-based review guide (new approach)

For LOCAs, the following acceptance criterion should be met:

The maximum local cladding oxidation should not exceed a prescribed value (typically 17-18% of the initial cladding thickness before oxidation) [7].

3. Conclusion

Upon the identification and comparison between the USNRC regulations and IAEA standards applicable to the Safety Analysis review, it is observed that high similarities exist between these documents. Therefore, these IAEA standards can be used as the basis for a regulatory review guide for Safety Analysis review by using the NUREG 0800 format as described in this paper. Although some differences, such as the unit of dose criteria, exist between USNRC and IAEA regulations, these can be resolved accordingly to suit the national criteria established by the NNRA.

The NNRA is in the process of drafting regulations to license its first nuclear power plant. The IAEA standards and other regulations of experienced countries in nuclear power programs would play a key role in developing Nigeria's regulations. This research shows that it is feasible to adopt standards from different organizations. This research also serves as a basis for how adopting these regulations can be accomplished by recommending an approach for developing safety review guides in Nigeria from IAEA standards.

The primary difficulty in achieving this approach for the new regulatory review guide is collating and identifying the equivalence between USNRC and IAEA documents. This process is very valuable but may require much time due to the vast pool of nuclear safety-related documents available from both organizations.

This proposed approach and experiences for developing the review guide would benefit the embarking countries trying to adopt IAEA standards as their national regulatory requirements and guides. The regulatory review guide can also be extended to other chapters of the SAR for future research. This research can be further developed for different applications beyond the development of regulatory review guides.

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