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1. IDENTIFICATION

Document Category: Specific Safety Guides

Working ID: **DS563**

Proposed Title: **Seismic Design for Nuclear Installations**

Proposed Action: **Revision of a publication**

IAEA Safety Standard Series No. SSG-67, Seismic Design for Nuclear Installations (2021)

Review Committee(s) or Group: NUSSC, WASSC

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2. BACKGROUND

This revised Specific Safety Guide will supersede the IAEA Specific Safety Guide SSG-67, "Seismic Design for Nuclear Installations," which has been used in IAEA safety review services since its publication. SSG-67 was published in 2021 to supplement and provide recommendations on meeting the requirements of the IAEA Safety Requirements publications SSR-2/1 (Rev. 1), "Safety of Nuclear Power Plants: Design," SSR-3, "Safety of Research Reactors," and SSR-4, "Safety of Nuclear Fuel Cycle Facilities," regarding the seismic design of nuclear installations. It is based on general practices in Member States for concepts such as design basis earthquakes, seismic categorization of structures, systems, and components (SSCs), and guidance on seismic design, analysis, qualification, and seismic instrumentation. The Safety Guide includes recommendations for plant layout, required geotechnical parameters, and seismic design rules for civil structures, piping, and equipment, as well as qualification methods including analysis, testing, and earthquake experience.

It is recognized that there are steady advances in technology, scientific knowledge, regulations, and events that prompt the update and revision of IAEA Safety Standards. The following are some of the issues that have emerged since the publication of the current Safety Guide in 2021 and prompt an update: the rapid development of small modular reactors (SMRs) and advanced nuclear technologies, including non-water cooled reactors (non-WCRs), has introduced novel structural types and configurations that require updated seismic design recommendations to ensure safety while accommodating innovative reactor designs; there is a growing need for clearer recommendations on applying a graded approach to seismic design, tailored to the specific hazards and characteristics of diverse nuclear installations, to optimize safety measures without over-conservatism; trends toward risk-informed and performance-based principles and practices in seismic design have evolved, enabling better understanding of seismic risks, more balanced designs, and quantifiable safety goals that align with probabilistic safety assessments; advancements in computational techniques and increased computing capacity have enhanced capabilities for complex seismic analyses, such as nonlinear soil-structure interaction and site

response modelling, allowing for more accurate and efficient design processes; the accumulation of seismic experience from past events, including the Chūetsu offshore earthquake (2007) and the Tohoku earthquake (2011), continues to provide valuable lessons on building responses, sloshing effects in pools, and the effectiveness of good practice design rules, even under motions exceeding design levels.

The Safety Guide should address the requirements in the higher-level documents, which emphasize avoiding cliff-edge effects, ensuring seismic margins beyond the design basis earthquake, and considering multi-unit site impacts. These topics are related to achieving realistic seismic margins and will be addressed in the revised Safety Guide.

3. JUSTIFICATION FOR THE PRODUCTION OF THE PUBLICATION

This revision aims to update IAEA Safety Standards Series No. SSG-67, "Seismic Design for Nuclear Installations," to ensure compatibility with Safety Requirements (e.g., SSR-2/1 (Rev. 1), which is under preparation for review, and SSR-3 and SSR-4) and supporting technical documents, incorporating lessons learned and advancements since its 2021 publication.

Furthermore, this revision will be developed in close coordination with IAEA Safety Standards Series No. SSG-68, “Design of Nuclear Installations Against External Events Excluding Earthquakes.” Owing to the differing modes of impact on structures, systems and components, it is considered necessary that SSG-67 and SSG-68 be revised as separate safety guides. However, close coordination remains essential, in particular with respect to the consistency of design approaches and criteria, as well as the consideration of the combination of external events.

The revision is driven by the need to address evolving nuclear safety practices, technological developments, and feedback from Member States.

Based on the result of this analysis, key drivers for this revision include the following themes, which are elaborated further in the Annex. The results of the analysis revealed that there is a growing expectation for these items to be incorporated into this Safety Guide.

- Development of advanced nuclear technologies such as small modular reactors (SMRs), non-water cooled reactors (non-WCRs), floating nuclear power plants (FNPPs), transportable nuclear power plants (TNPPs), and fuel cycle installations.
- Emphasis on the application of a graded approach.
- Evolution of methods for performing beyond design basis evaluations.
- Experience-based qualification methods.
- Incorporation of risk-informed performance-based design principles for enhanced risk understanding and balanced design.

4. OBJECTIVE

The objective of this revision is to update and expand the guidance provided in SSG-67 on the seismic design of nuclear installations. The revised Safety Guide will incorporate the latest technical developments, feedback from operating experience, and lessons learned from international review services and Member State practices.

The Safety Guide provides recommendations on how to meet the safety requirements established in SSR-2/1 (Rev. 1), SSR-3, and SSR-4 in relation to the design aspects of nuclear installations subjected to seismic hazards defined in accordance with SSG-9 (Rev. 1).

These recommendations focus on the consistent application of methods and procedures in accordance with best practice for seismic analysis, design, testing, and qualification of SSCs in order that they meet the applicable safety requirements.

The revision will address recommendations on the design provisions to address new seismic design concept arising from evolving siting environments, such as increased deployment of innovative reactor technologies, including small modular reactors (SMRs), floating reactors, and other types of advanced design reactors.

In addition, the revision aims to further enhance seismic safety by providing recommendations for design extension conditions and measures beyond the design basis.

The revised Safety Guide is intended to support Member States in implementing the Safety Requirements by providing clear, practical, and up-to-date recommendations to ensure the safety of nuclear installations against seismic hazards. The revised Safety Guide will provide structured and practical recommendations to support implementation by regulatory bodies, designers, and operating organizations.

5. SCOPE

This revision of SSG-67 will maintain the existing scope of providing recommendations on the seismic design of nuclear installations to withstand seismic hazards. The revised Safety Guide will address all nuclear installations, as defined in the IAEA Nuclear Safety and Security Glossary, 2022 (Interim) Edition, that are subject to regulatory oversight under IAEA Safety Standards. This revised Safety Guide is intended to be applied to the design and construction of new nuclear installations. Assessment of the seismic safety of an existing nuclear installation is beyond the scope of this Safety Guide.

The update will enhance the existing recommendations by incorporating recent developments in seismic design and qualification methodologies, and design provisions for evolving conditions. In particular, the revision will provide expanded guidance for addressing development of advanced nuclear technologies, the application of a graded approach, design extension condition and beyond design basis evaluations, experience-based qualification methods, and incorporation of risk-informed performance-based design principles.

6. PLACE IN THE OVERALL STRUCTURE OF THE RELEVANT SERIES AND INTERFACES WITH EXISTING AND/OR PLANNED PUBLICATIONS

The revised Safety Guide will maintain its place within the IAEA Safety Standards Series. The Safety Guide is applicable to all types of nuclear installations, including research reactors and nuclear fuel cycle facilities. Accordingly, its revision is expected to be undertaken in coordination with other Divisions such as WES/NSRW. Moreover, since seismic design is closely related to operational safety and safety assessment from the perspective of configuration management, close coordination will also be pursued with the relevant sections within NSNI. Particularly, the Safety Guide interfaces with the following publications (this is not an exhaustive list):

- IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety (2016)
- IAEA Safety Standards Series No. GSR Part 5, Predisposal Management of Radioactive Waste (2009), (Under revision as DS548)

- IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), Safety of Nuclear Power Plants: Design (2016)
- IAEA Safety Standards Series No. SSR-2/2 (Rev. 1), Safety of Nuclear Power Plants: Commissioning and Operation (2016)
- IAEA Safety Standards Series No. SSR-3, Safety of Research Reactors (2016)
- IAEA Safety Standards Series No. SSR-4, Safety of Nuclear Fuel Cycle Facilities (2017)
- IAEA Safety Standards Series No.GSG-10, Prospective Radiological Environmental Impact Assessment for Facilities and Activities (2018)
- IAEA Safety Standards Series No. SSG-9 (Rev. 1), Seismic Hazards in Site Evaluation for Nuclear Installations (2022)
- IAEA Safety Standards Series No. SSG-15 (Rev.1), Storage of Spent Nuclear Fuel (2020)
- IAEA Safety Standards Series No. SSG-30, Safety Classification of Structures, Systems and Components in Nuclear Power Plants (2014)
- IAEA Safety Standards Series No. SSG-53, Design of the Reactor Containment and Associated Systems for Nuclear Power Plants (2019)
- IAEA Safety Standards Series No. SSG-77, Protection Against Internal and External Hazards in the Operation of Nuclear Power Plants (2022)
- IAEA Safety Standards Series No. SSG-89, Evaluation of Seismic Safety for Nuclear Installations (2024)
- IAEA Safety Standards Series No. NS-G-3.6, Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants (2004).

7. OVERVIEW

The planned table of contents includes the following sections—similar to those in the current SSG-67 (2021)—which may be modified, combined, or expanded (including, as appropriate, the addition of appendices or annexes) during the review process by the Safety Standards Committees, Member States, and the Commission on Safety Standards:

CONTENTS

1. INTRODUCTION

Background
Objective
Scope
Structure

2. GENERAL CONSIDERATIONS FOR SEISMIC DESIGN OF NUCLEAR INSTALLATIONS

External hazards
Seismic design principles
Design extension condition
Beyond design basis considerations
Other seismic design aspects

3. INPUT FOR SEISMIC DESIGN OF NUCLEAR INSTALLATIONS

General concept of seismic design
Design basis earthquake

Combination of earthquake loads with other loads
Combination of other external events
Beyond design basis earthquake
Seismic categorization for structures, systems and components
Selection of seismic design and qualification standards

4. SEISMIC DESIGN PRINCIPLES FOR STRUCTURES, SYSTEMS, AND COMPONENTS OF NUCLEAR INSTALLATIONS

Layout of the installations
Structures
Seismically isolated structures
Building and civil structures
Systems and components
Seismic capacity
Design extension conditions

5. SEISMIC ANALYSIS AND DESIGN OF STRUCTURES FOR NUCLEAR INSTALLATIONS

Site response analysis
Structural response
Dynamic soil-structure interaction
Design of structures

6. SEISMIC DESIGN AND QUALIFICATION OF SYSTEMS AND COMPONENTS FOR NUCLEAR INSTALLATIONS

Design of systems and components
Seismic qualifications

7. BEYOND DESIGN BASIS EVALUATION OF SEISMIC DESIGN OF NUCLEAR INSTALLATIONS

Adequate considerations on beyond design basis conditions
Seismic margin considerations

8. SEISMIC INSTRUMENTATION AND POST-EARTHQUAKE ACTIONS FOR NUCLEAR INSTALLATIONS

Seismic instrumentation
Post-earthquake actions

9. APPLICATION OF A GRADED APPROACH TO SEISMIC DESIGN FOR NUCLEAR INSTALLATIONS

10. MANAGEMENT SYSTEM FOR SEISMIC DESIGN

REFERENCES

GLOSSARY

The planned revision for each section is provided in the Feedback Analysis Report attached as an Annex. This plan is not exhaustive and will incorporate other areas of update identified as part of the review process.

8. PRODUCTION SCHEDULE: Provisional schedule for preparation of the publication, outlining realistic expected dates for each step.

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STEP 1: Preparing a DPP	July 2025
STEP 2: Internal review of the DPP (Approval by the Coordination Committee)	July 2025
STEP 3: Review of the DPP by the review Committee(s) (Approval by review Committee(s))	November 2025
STEP 4: Review of the DPP by the CSS (approval by CSS) or information of the CSS on the DPP	Q1 2026
STEP 5: Preparing the draft publication	Q1 2027
STEP 6: First internal review of the draft publication (Approval by the Coordination Committee)	Q2 2027
STEP 7: First review of the draft publication by the review Committee(s) (Approval for submission to Member States for comments)	Q4 2027
STEP 8: Soliciting comments by Member States	Q2 2028
STEP 9: Addressing comments by Member States	Q3 2028
STEP 10: Second internal review of the draft publication (Approval by the Coordination Committee)	Q3 2028
STEP 11: Second review of the draft publication by the review Committee(s) (Approval of the draft)	Q4 2028
STEP 12: (For Safety Standards) Editing of the draft publication in MTCD and endorsement of the draft publication by the CSS (For nuclear security guidance) DDG's decision on whether additional consultation is needed, establishment by the Publications Committee and editing	Q2 2029
STEP 13: Approval by the Board of Governors (for SF and SR only)	-
STEP 14: Target publication date	Q3 2029

9. RESOURCES

The development of the Safety Reports Series involves the following resources:

- Secretariat: 30-person weeks by IAEA staff;
- HBAs: 10 weeks by selected experts for drafting;
- Meetings (CM, WS, and TM): 24 person-weeks for reviewing and finalizing the publication.

ANNEX: Feedback Analysis Report.

The current SSG-67 was published in 2021. During the four years since its publication, feedback has been gathered from experts of Member States during Technical Meetings:

- Technical Meeting on the Optimization of Protection of Small Modular Reactors in Relation to External Events, 6 to 9 May 2025.
- Technical Meeting on the Protection of Nuclear Installations Against External Hazards, 7 to 11 October 2024.

In addition, a Consultancy Meeting was held from 14 to 18 July 2025, during which experts involved in seismic design from major countries shared recent trends and the latest technological developments in relevant areas. The experts also discussed technical topics that may need to be added or updated in the current SSG-67 to reflect these developments. The gaps identified in the current SSG-67 are summarized in Table A.1. Following are key themes emerging from the feedback analysis:

- **Development of Advanced Nuclear Technologies**: With increasing global demand for energy and plans for new NPPs, including SMRs, FNPP, TNPP and non-WCRs, the updated SSG-67 will provide recommendations to accommodate novel structural types and seismic design solutions tailored to these innovative reactor designs.
- **Integration of Hazard Information**: The revision will improve integration of seismic hazard information into the design process, ensuring consistency with SSG-9 (Rev. 1) for site evaluation and reducing overlap with related standards such as SSG-77 and SSG-89.
- **Emphasis on Graded Approach**: The update will clarify and emphasize the application of a graded approach to seismic design, making it applicable across all nuclear installations to align safety measures with hazard levels and facility characteristics.
- **Evolution of Methods for Performing Beyond Design Basis Evaluations**: Advances in beyond design basis earthquake evaluation practices, including seismic margin assessments and probabilistic safety assessments, will be incorporated to enhance assessment safety margins and address cliff-edge effects.
- **Experience-Based Qualification Methods**: The revision will include recommendations on experience-based seismic qualification methods, leveraging data from past earthquakes (e.g., Niigata-ken Chuetsu Oki Earthquake (NCOE), 2007, Great East Japan Earthquake (GEJE), 2011) to validate designs and improve qualification processes.
- **Integration with other IAEA safety standards**: The update will align SSG-67 with SSG-77, SSG-89, and SSG-9 (Rev. 1) to eliminate redundancies, enhance coherence across the IAEA safety standards, and reflect Member State experiences and best practices in seismic design.
- **Incorporation of Risk-Informed Performance-Based Design Principles for Enhanced Risk Understanding and Balanced Design**: The revision will incorporate risk-informed, performance-based design principles to improve understanding of seismic risks and produce more balanced, efficient designs that meet safety objectives without unnecessary conservatism.

Table A.1. Existing gaps and possible revisions in each section

Section #	Section Title (Proposed New)	Existing gaps and possible revisions
1	Introduction	• Update background and objectives to reflect new safety publications (e.g., SSR 2/1 (Rev. 1), SSG 89, SSG 77). • Expand scope to explicitly include small modular reactors (SMRs) and other advanced nuclear technologies (e.g., floating NPPs (FNPPs), and transportable NPPs (TNPPs)), with relevant provisions added or modified.
2	General Considerations for Seismic Design of Nuclear Installations	• Enhance consistency with SSR-2/1 (Rev.1) and emphasize the graded approach for all nuclear installations. • Review seismic design principles for completeness and consistency with current state of practice, including new structural materials, configurations, systems (e.g., steel-plate composite walls, precast concrete, deeply embedded structures), and aging effects. • Highlight risk analyses (link to SSG-89) connection with graded approaches and risk-informed performance based (RIPB) design.
3	Input for Seismic Design of Nuclear Installations	• Address combinations of other external events. • Explain relationships between design basis, design extension conditions, and beyond design basis earthquakes. • Address plant seismic design standardization considerations such as enveloping seismic design. • Address RIPB methods to inform selection of design basis and beyond design basis earthquakes.
4	Seismic Design Principles for Structures, Systems, and Components of Nuclear Installations	• Add sections for nuclear-specific components (e.g., reactor internals and control rod insertion, fuel handling equipment). • Emphasize early integration of seismic design principles in plant layout. • Update seismic isolation contents to include other vibration control systems (e.g., tuned mass dampers) and address qualification.
5	Seismic Analysis and Design of Structures for Nuclear Installations	• Address potential for compounding conservatisms in multi-stage analyses. • Introduce concept of overall planning for coherent modelling and analysis approaches, address ground motion characterization, and include provisions for nonlinear time-domain SSI analysis. • Clarify when structure-soil-structure interaction (SSSI) analysis is appropriate • Incorporate recent developments in characterizing site response uncertainty and coordinate with SSG-9 (Rev. 1) to avoid gaps and overlap.
6	Seismic Design and Qualification of Systems and Components for Nuclear Installations	• Include information regarding for qualification by seismic experience.

Section #	Section Title (Proposed New)	Existing gaps and possible revisions
		• Include principles for qualification of novel seismic solutions for systems and components (e.g., tuned mass dampers) with enhanced analysis/testing to address uncertainty.
7	Beyond Design Basis Evaluations of Seismic Design of Nuclear Installations	• Review for consistency with SSG-89 considering insights from TECDOC 2043. • Clarify the connection between the seismic margin and Beyond Design Basis Earthquake. • Ensure terminology is sufficiently general to apply to non-WCR NPPs and nuclear installations other than NPPs.
8	Seismic Instrumentation and Post-Earthquake Actions for Nuclear Installations	• Review recommendations for minimum number of instruments considering current practice among MS. • Highlight instrumentation's role in validating site response/SSI analyses.
9	Application of a Graded Approach to Seismic Design for Nuclear Installations	Rewrite section to incorporate recent developments in MS practice and throughout other IAEA documentation.
10	Management System for Seismic Design	Review and update as necessary, establishing consistency with other relevant safety standards.