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1. IDENTIFICATION

Document Category: Specific Safety Guides

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Proposed Title: Design of Nuclear Installations Against External Events Excluding Earthquakes

Proposed Action: Revision of Specific Safety Guide SSG-68, Design of Nuclear Installations Against External Events Excluding Earthquakes (2021)

Review Committee(s) or Group: NUSSC, WASSC

Technical Officer(s): Hyun Woo Lee (EESS/NSNI)

2. BACKGROUND

The current edition of IAEA Safety Standards Series No. SSG-68, published in 2021, provides recommendations for the design of nuclear installations against external events excluding earthquakes. It was developed in response to evolving international safety requirements following the Fukushima Daiichi accident, with particular emphasis on addressing design extension conditions and enhancing resilience to extreme external hazards. However, since the major drafting in 2016-2017, there have been changes in both the external risk landscape, such as increasing climate change impacts, space weather (e.g. geomagnetic storms), and innovative designs leading to non-traditional site environments, and the broader framework of IAEA Safety Standards, which prompts a revision of SSG-68.

Especially, a number of relevant IAEA Safety Standards have been recently revised or are undergoing revision to reflect lessons learned, technological advancements, and new safety practices, such as IAEA Safety Standards Series No. SSR-1 (DS557), SSG-9 (Rev. 1), SSG-18 (DS541), SSG-79, SSG-35 (DS559), NS-G-3.2 (DS529), and NS-G-3.6 (DS531). In addition, the Safety Standards ~~on~~ for external events design ~~needs~~ should~~to~~ be aligned not only with the external events-related IAEA Safety Standards Series ~~No. SSR-2/1 (Rev.1), which is under preparation for review,~~ but also with other applicable safety requirements (e.g. IAEA Safety Standards Series No. SSR-2/1 (Rev.1) (DS562), SSR-2/2 (Rev. 1) (DS532), SSR-3 and SSR-4). Therefore, this revision will also extend the scope to include all nuclear installations and fusion facilities. ~~.~~ For the same purpose, IAEA Safety Standards Series No. SSG-67, Seismic Design for Nuclear Installations is under revision as well.

These developments reflect a coordinated effort by the IAEA and Member States to update the safety requirements and recommendations pertaining to~~framework for external hazards,~~ expand the applicability to new reactor technologies, and to respond to combined hazard scenarios including climate-driven and human-induced events. The revision of SSG-68 will align it with this evolving set of standards, ensure consistency in terminology and methodology, and reflect best practices ~~for current and next generation nuclear installations.~~ in the design and operation of current installations, as well as in the design of the next-generation of nuclear installations.

3. JUSTIFICATION FOR THE PRODUCTION OF THE PUBLICATION

The revision of SSG-68 will be undertaken to ensure full compatibility with the updated Safety Requirements, particularly SSR-1, and with interfacing Safety Guides and technical documents listed in Section 6. The latest advances in hazard identification, assessment methodologies, and risk-informed performance-based design practices for external events excluding earthquakes need to be addressed in the revision of SSG-68.

This revision is also needed to update SSG-68 to reflect newly emerging or intensified external hazard conditions that can affect the design of nuclear installations. In recent years, several new dimensions of external risk, such as increasing climate change impacts, space weather, and innovative designs leading to non-traditional site environments, have become increasingly relevant to the siting, design, and safety assessment of both current and advanced nuclear technologies.

Key drivers for the revision include:

- The escalation of combined climate-driven events, such as concurrent flooding, wildfires, and prolonged blackouts, posing challenges to existing safety margins and emergency preparedness strategies.
- The possibility for siting nuclear installations in non-traditional or higher-risk environments, including remote regions with limited infrastructure, post-industrial areas that may have legacy contamination or outdated facilities, underground sites, and zones with complex logistical constraints due to difficult terrain or transportation challenges.
- The potential deployment of mobile reactors and ~~microreactors~~, including floating reactors and microreactors~~and underground designs~~, which pose unique challenges in terms of adaptability to external hazards.

The revision is intended to ensure that SSG-68 remains technically up-to-date, inclusive of a broad range of reactor types, and siting conditions, consistent with relevant IAEA Safety Standards, and implementable by Member States seeking to maintain high standards of nuclear safety in a rapidly evolving external environment.

4. OBJECTIVE

The objective of this revision is to update and expand the guidance provided in SSG-68 on the design of nuclear installations against external events excluding earthquakes. 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 revision will address recommendations on the design provisions to address new external hazard conditions arising from evolving siting environments, such as remote, underground, or repurposed industrial sites, and from increased deployment of innovative reactor technologies, including small modular reactors (SMRs), floating reactors, and other types of advanced design reactors. It will also take into account the growing frequency and severity of combined climate-related events that may challenge the performance of ~~safety related~~ structures, systems, and components (SSCs) important to the safety of nuclear installations.

The revised Safety Guide is intended to support Member States in the application of the Safety Requirements by providing clear, practical, and up-to-date recommendations for ensuring the safety of nuclear installations against a broad range of external events and combinations of external events.

The revised Safety Guide will provide structured and practical recommendations to support implementation by regulatory bodies, designers, ~~and~~ operating organizations and technical supporting organizations.

5. SCOPE

This revision of SSG-68 will maintain the existing scope of providing recommendations on the design of nuclear installations to withstand external events excluding earthquakes. 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.

The update will enhance the existing recommendations by incorporating recent developments in external hazard characterization, safety assessment methodologies, and design provisions for evolving conditions. In particular, the revised Safety Guide will provide expanded guidance for addressing:

- **Combined events and cascading aspects ~~events~~**, such as extreme precipitation combined with flooding, wildfires coupled with infrastructure failure, and long-duration severe weather scenarios.
- **New siting contexts**, including remote locations, post-industrial (brownfield) areas, and co-location with existing infrastructures, such as former coal- or gas-fired power stations, and associated hazard spectra, which may differ significantly from those of conventional sites~~.~~.
- **Advanced reactor technologies**, including SMRs, non-light water reactors (NWLRs), floating nuclear power plants (FNPPs), transportable nuclear power plants (TNPPs), fusion facilities, and other innovative designs that require updated design considerations for protection against external hazards.

The revised Safety Guide will continue to focus on the protection of ~~safety-related~~ SSCs important to the safety of nuclear installations against external events (and combinations of external events) and will maintain consistency with the applicable Safety Requirements and interfacing Safety Guides.

It is recognized that for existing nuclear installations, including cases where the design has already been approved by regulatory bodies, the practical implementation of newly introduced recommendations may need to be considered in a graded manner, taking into account feasibility aspects such as those assessed during periodic safety review processes.~~The revised Safety Guide will provide structured and practical recommendations to support implementation by regulatory bodies, designers, and operating organizations.~~

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

This Safety Guide falls within the thematic area of Facilities and Activities~~Site Evaluation~~ and will interface with the following IAEA Safety Standards and other publications (this is not, and cannot be, regarded as an exclusive or exhaustive list):

1. INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSR-1, IAEA, Vienna (2019).
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), IAEA, Vienna (2016).
3. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Commissioning and Operation, IAEA Safety Standards Series No. SSR-2/2 (Rev. 1), IAEA, Vienna (2016).
4. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, IAEA Safety Standards Series No. SSR-3, IAEA, Vienna (2016).
5. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. SSR-4, IAEA, Vienna (2017).
6. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Classification of Structures, Systems and Components in Nuclear Power Plants, IAEA Safety Standards Series No. SSG-30, IAEA, Vienna (2014).
7. INTERNATIONAL ATOMIC ENERGY AGENCY, Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-9 (Rev.1), IAEA, Vienna (2022).

8. INTERNATIONAL ATOMIC ENERGY AGENCY, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-18, IAEA, Vienna (2011) (DS541, 2025).

9. INTERNATIONAL ATOMIC ENERGY AGENCY, Volcanic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-21, IAEA, Vienna (2012).

10. INTERNATIONAL ATOMIC ENERGY AGENCY, Hazards Associated with Human Induced External Events in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-79, IAEA, Vienna (2023).

11. INTERNATIONAL ATOMIC ENERGY AGENCY, Investigation of Site Characteristics and Evaluation of Radiation Risks to the Public and the Environment in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-92, IAEA, Vienna (in preparation, DS529).

12. INTERNATIONAL ATOMIC ENERGY AGENCY, Geotechnical Aspects in Site Evaluation and Design of Nuclear Installations, IAEA Safety Standards Series No. SSG-93, IAEA, Vienna (in preparation, DS531) (DS531, 2025).

13. INTERNATIONAL ATOMIC ENERGY AGENCY, Design of the Reactor Containment and Associated Systems for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-53, IAEA, Vienna (2019).

14. INTERNATIONAL ATOMIC ENERGY AGENCY, Protection Against Internal and External Hazards in the Operation of Nuclear Power Plants, IAEA Safety Standards Series No. SSG-77, IAEA, Vienna (2022).

15. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR OFFICE, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-2, IAEA, Vienna (2011).

16. INTERNATIONAL ATOMIC ENERGY AGENCY, Protection against Internal Hazards in the Design of Nuclear Power Plants, IAEA Safety Standards Series No. SSG-64, IAEA, Vienna (2021).

All sections of NSNI including the Operational Safety Section (OSS), Regulatory Activities Section (RAS), Research Reactor Safety Section (RRSS) and Safety Assessment Section (SAS) were consulted for the development of this DPP. Close cooperation during the whole process will be needed among the coordinators of the relevant Safety Standards, including SSR-1, SSR~~G~~-2/1, SSG-67, which are currently under review, as well as all relevant sections of NSNI, as needed.

7. OVERVIEW

The planned table of contents includes the following sections (similar to table of contents of the present SSG-68 (2021)):

1. INTRODUCTION
   Background
   Objective
   Scope
   Structure
2. GENERAL CONSIDERATIONS FOR THE DESIGN OF NUCLEAR INSTALLATIONS AGAINST EXTERNAL EVENTS
   Requirements for site evaluation
   Design principles for nuclear installations
   Additional design considerations for external events
   Structures, systems and components (SSCs) to be protected against external events
   Design and evaluation for design basis external events and beyond design basis external events
   Design safety features for design basis external events and beyond design basis external events

Design considerations for non-traditional site environments
Administrative measures

3. DESIGN BASIS FOR EXTERNAL EVENTS
   Derivation of the design basis from the site hazard evaluation
   Overall design approach
   Derivation of loading conditions for design basis and beyond design basis external events
   Evaluation of beyond design basis external events and cliff edge effects
4. INSTALLATION LAYOUT AND DESIGN APPROACH
   Installation layout
   Approach to design of structures, systems and components important to safety against external events
   Approach to assessment of structures, systems and components for beyond design basis external events
   Approach to additional design considerations for emerging external hazard challenges

5. DESIGN PROVISIONS AGAINST EXTERNAL EVENTS
   External floods, including tsunamis
   Extreme winds
   Other extreme meteorological conditions
   Volcanic events
   External fire
   External explosions
   Chemical release events (e.g. toxic, flammable, corrosive, and asphyxiant substances and their mixtures)
   Radiological events at nearby or collocated installations
   Aircraft crash
   Electromagnetic interference
   Biological events
   Hazardous events caused by~~F~~ floating objects ~~impact~~ and ~~hazardous~~ oil~~liquid~~ spills ~~events~~
   Other hazardous external events
   Combination of external events
6. APPLICATION OF A GRADED APPROACH TO THE DESIGN OF NUCLEAR INSTALLATIONS AGAINST EXTERNAL EVENTS
7. APPLICATION OF THE MANAGEMENT SYSTEM TO THE DESIGN OF NUCLEAR INSTALLATIONS AGAINST EXTERNAL EVENTS

REFERENCES
GLOSSARY
CONTRIBUTORS TO DRAFTING AND REVIEW

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 identified as part of the review process.

8. PRODUCTION SCHEDULE:

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STEP 1: Preparing a DPP	DONE
STEP 2: Internal review of the DPP (Approval by the Coordination Committee)	Q3 2025
STEP 3: Review of the DPP by the review Committee(s) (Approval by review Committee(s))	Q4 2025
STEP 4: Review of the DPP by the CSS (approval by CSS) or information of the CSS on the DPP	Q2 2026
STEP 5: Preparing the draft publication	Q2 2027
STEP 6: First internal review of the draft publication (Approval by the Coordination Committee)	Q3 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 resources needed for proposed publication are estimated as follows:

— Secretariat: 30-person weeks by IAEA staff;
— HBAs: 20 weeks by selected experts for drafting the publication;
— Meetings (CM, WS, and TM): 24 person-weeks for reviewing and finalizing the publication.

ANNEX: FEEDBACK ANALYSIS REPORT

The current SSG-68 was published in 2021. Since the major drafting in 2016-2017, significant developments have occurred in both external hazard assessment and nuclear installation design. Feedback was obtained through technical meetings, where experts from Member States contributed to identifying areas of improvement.

Technical and Expert Meetings Providing Input:

- Technical Meeting on the Protection of Nuclear Installations Against External Hazards (October 2024)
- Technical Meeting on the Optimization of Protection of Small Modular Reactors in Relation to External Events (May 2025)

During these meetings, experts discussed how to reflect recent trends, technologies, and safety challenges in the guidance, including the emergence of combined hazards, deployment of advanced reactor designs (e.g. SMRs, FNPPs, TNPPs), and updated IAEA safety standards. The following key themes emerged:

Key Themes Identified from Feedback and Gap Analysis:

1. Expansion of Scope and Applicability
   - The revision will incorporate design provisions for protection against external events, excluding earthquakes, applicable to all types of nuclear installations, including advanced reactor designs, such as small modular reactors (SMRs), floating nuclear power plants (FNPPs), transportable reactors (TNPPs), and non-water-cooled designs, which present unique design and siting challenges.
   - Attention will be given to installations located in non-traditional environments, such as underground, offshore, or remote areas, which require site-specific external hazard considerations.

2. Combined, Cascade-type ~~, Cascading,~~ and Emerging Hazards
   - The revised guide will provide expanded guidance on the design of nuclear installations to withstand combinations of external events, such as flooding and fire, or external explosions with loss of off-site power.
   - It will address the impact of climate change on the frequency, intensity, and interaction of hazards, including sea-level rise, low-flow conditions, prolonged heatwaves, rising seawater/river-water temperatures that may affect the ultimate heat sink extreme weather patterns, and long-duration events.
   - Emerging and previously underrepresented hazards, such as space weather, permafrost degradation, drought, and biological hazards, will be considered in the context of their impact on ~~safety-related~~ SSCs important to safety.

3. Alignment with IAEA Safety Standards and Terminology
   - SSG-68 will be updated to ensure consistency with other IAEA Safety Standards under revision or recently published, including SSR-1, SSR-2/1 (Rev. 1), SSG-9 (Rev. 1), SSG-18 (DS541), SSG-21, SSG-64, SSG-77, and SSG-79.
   - It will reflect coherent terminology and methodology in hazard assessment, classification, and event scenario development, particularly for design basis and beyond design basis external events.
   - Interfaces with site evaluation guidance and updated defence-in-depth strategies will be strengthened.

4. Application of Graded Approach and Risk-Informed Performance-Based Design ~~Approaches~~Principles
   - The guide will emphasize the graded approach to design against external events, enabling the proportional application of safety measures based on the likelihood and severity of hazards, safety functions, and facility characteristics.
   - The integration of risk-informed ~~and~~ performance-based design principles~~approaches~~ will support balanced and technically justified decisions in defining design bases and evaluating protective features against postulated risks from external events.

- Special focus will be given to explaining the relationships between design basis, particularly design extension conditions, and beyond design basis external events, especially ~~design extension conditions~~ for extreme or low-frequency events.

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5. Design Provisions for Innovative Reactor Technologies and Site Environments
   - The updated Safety Guide will provide practical recommendations for the design of installations with innovative features, including modular construction, floating platforms, and transportable units, ensuring resilience to risks from evolving environmental and human-induced external events.
   - It will strengthen layout and SSC protection strategies for installations in confined, shared, or repurposed sites, including co-location with industrial facilities (e.g., hydrogen plants, desalination units).
   - Considerations for site access, boundary definition, and the design of safety features to withstand rare but high-consequence events will be strengthened, including provisions for long-term monitoring and hazard reassessment.

The revision of SSG-68 is a timely and necessary update that will ensure alignment with current international safety expectations, technological advancements, and the evolving hazard landscape. It will strengthen the applicability of IAEA guidance across a broad spectrum of nuclear installations and site conditions, assisting Member States in applying high safety standards for protection against external events excluding earthquakes.

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

Section #	Section Title	Existing gaps and possible revisions
1	Introduction	— Update background and objective to reflect the evolution of external hazards (e.g. climate change effects on site design parameters, human-induced risks), including potential effects on ultimate heat sink temperature and long-duration heatwaves. — Incorporate the applicability to new design contexts and reactor types.
2	General Considerations for the Design of Nuclear Installations Against External Events	— Emphasize integration with IAEA Safety Standards with interfaces. — Update for advanced technologies and complex environments. — Add a new subsection for design considerations for nuclear installations in non-traditional site environments (e.g. brown site, remote region, underground, additional considerations due to advanced reactor types, and climate change effects).
3	Design Basis for External Events	— Expand on compound and cascade-type~~ing~~ hazards, taking into consideration emerging hazards. — Derive design bases considering risk-informed performance-based design ~~concepts~~concept — Integrate loading combinations and scenarios relevant to new site types.
4	Installation Layout and Design Approach	— Address layout principles in constrained sites (e.g., repurposed industrial zones, underground) — Emphasize adequate separation and redundancy under emerging and cascading external events — Add a new subsection for approach to additional design considerations for emerging external hazard challenges
5	Design Provisions Against External Events	— Update design provisions for specific external events, reflecting changes in related Safety Guides. — Ensure technology neutrality and applicability, as far as possible/relevant, to all installation types, including large NPPs, SMRs, FNPPs, TNPPs, advanced and non-water-

		cooled reactors, research reactors, fuel cycle facilities, and fusion facilities. — Expand applicability to external event scenarios arising from emerging site safety issues, including the effects of climate change and associated uncertainty, non-traditional siting, and combined or previously unaddressed hazards, if any.
6	Application of a Graded Approach to the Design of Nuclear Installations Against External Events	— Clarify graded approach principles across different external events and installation types — Update the contents to incorporate recent developments in MS practices and other IAEA documentation.
7	Application of the Management System to the Design of Nuclear Installations Against External Events	— Update for integration of feedback, records management, and hazard monitoring over the facility lifetime in line with relevant IAEA documents.