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1. IDENTIFICATION

Document Category: Specific Safety Guides

Working ID: DS567

Proposed Title: Volcanic Hazards in Site Evaluation for Nuclear Facilities

Proposed Action: Revision of Specific Safety Guide SSG-21, Volcanic Hazards in Site Evaluation for Nuclear Installations (2012)

Review Committee(s) or Group: NUSSC, WASSC, EPreSC

Technical Officer(s): Stephen McDuffie (EESS/NSNI)

2. BACKGROUND

The IAEA has a number of Safety Guides that provide recommendations on the characterization of external hazards that can affect nuclear facilities and support designs to withstand those hazards. These Safety Guides assist Member States to comply with Safety Requirements in IAEA Safety Standards Series No. SSR-1, Site Evaluation for Nuclear Installations. SSG-21 is devoted to meeting especially SSR-1 Requirement 17, Evaluation of volcanic hazards. SSG-21 provides recommendations on assessment of volcanic hazards, considering the many volcanic phenomena that can affect a nuclear facility. It also provides recommendations on the data necessary to properly assess the hazards, and the process for screening hazards that require further assessment.

Volcanic hazard assessment has advanced significantly in recent years. In particular, the process for screening volcanic phenomena at a site has evolved, and screening decisions can now rely on conservative numerical modelling of volcanic phenomena. In addition, certain volcanic phenomena can be grouped to simplify the hazard assessment process. Multiple phenomena that occur near a volcanic vent, for example, can be assessed with a single hazard probability. It is now also possible to recommend site-specific hazard assessment rather than volcano-specific approaches. Some Member States have recently developed new volcanic hazard guidance documents, and completed rigorous volcanic hazard assessments for nuclear installations, that can help inform the Safety Guide revision.

SSG-21 does not adequately consider the impact of igneous intrusions on radioactive waste disposal facilities and other subsurface facilities. The frequency and characteristics of such intrusions are highly uncertain, therefore the revision can provide recommendations on including such hazards in a volcanic hazards assessment. Finally, new knowledge on the impacts of volcanic phenomena on engineered systems is available, and this needs to be reflected in recommendations in relation to component design.

3. JUSTIFICATION FOR THE PRODUCTION OF THE PUBLICATION

SSG-21 was published in 2012; however, much of the information on which it is based represents the state of volcanology knowledge in the late 1990s. Volcanic hazards are complex and unique among the natural hazards that can affect the safety of nuclear facilities. Volcanic activity can produce several

phenomena, many of which are exclusionary siting criteria for nuclear facilities. Thus, a standalone Safety Guide devoted to characterizing and assessing these hazards is appropriate. Updating the Safety Guide to incorporate recommendations on modern approaches and computational techniques for volcanic hazard assessment will allow users to be aware of the most modern, efficient methods for screening volcanic hazards at a site, and for conducting rigorous hazard assessments at the sites where volcanic phenomena are credible.

This revision has been requested by the IAEA's Nuclear Safety Standards Committee (NUSSC) and added to its medium term plan as a priority (for details please refer to the Feedback Analysis Report provided in the Annex).

4. OBJECTIVE

The objective of the revised Safety Guide is to provide recommendations on the identification, characterization, and assessment of volcanic hazards that could affect a nuclear installation or radioactive waste disposal facility. This identification, characterization and assessment of volcanic hazards is necessary to comply with Requirements 1, 5 and 17 in SSR-1.

This Safety Guide is intended for use by regulatory bodies, designers of nuclear facilities and operating organizations directly responsible for the assessment and mitigation of volcanic hazards at a nuclear facility site.

5. SCOPE

The revised Safety Guide will have a scope slightly larger than SSG-21, as it will add recommendations on the nature of impacts of certain volcanic phenomena on engineered systems. Volcanic phenomena that may not disqualify a site from consideration may need to be considered in facility design, and the Safety Guide will provide information on potential impacts to systems. The expansion of scope to explicitly consider the impact of igneous intrusions on radioactive waste disposal facilities and other subsurface facilities leads to the replacement of nuclear "installations" with "facilities" in the Safety Guide title.

The scope will include recommendations for the collection of data on volcanic sources and phenomena, the screening of volcanic hazards, and the assessment of volcanic hazards at a site. The recommendations can be applied to a new location as well as existing nuclear installations. The recommendations will most commonly apply to the site survey, site selection and site assessment stages. The recommendations can also be used during the operational stages if necessary for periodic safety review.

The recommendations apply to any type of nuclear installation or radioactive waste disposal facility, using a graded approach commensurate with the hazard posed by the facility.

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 Site Evaluation and will interface with the following IAEA Safety Standards and other publications (this is not an exclusive or exhaustive list):

1. EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH

- ORGANIZATION, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006), <https://doi.org/10.61092/iaea.hmxn-vw0a>.
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, IAEA Safety Standards Series No. GSR Part 2, IAEA, Vienna (2016), <https://doi.org/10.61092/iaea.cq1k-j5z3>.
 3. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4 (Rev. 1), IAEA, Vienna (2016).
 4. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015), <https://doi.org/10.61092/iaea.3dbe-055p>.
 5. INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSR-1, IAEA, Vienna (2019).
 6. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), IAEA, Vienna (2016).
 7. 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).
 8. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, IAEA Safety Standards Series No. SSR-3, IAEA, Vienna (2016).
 9. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. SSR-4, IAEA, Vienna (2017).
 10. INTERNATIONAL ATOMIC ENERGY AGENCY, Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSR-5, IAEA, Vienna (2011).
 11. INTERNATIONAL ATOMIC ENERGY AGENCY, Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-9 (Rev. 1) (2022).
 12. INTERNATIONAL ATOMIC ENERGY AGENCY, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-18 (DS541), IAEA, Vienna (2011).
 13. INTERNATIONAL ATOMIC ENERGY AGENCY, The Safety Case and Safety Assessment for the Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSG-23, IAEA, Vienna (2012).
 14. INTERNATIONAL ATOMIC ENERGY AGENCY, Site Survey and Site Selection for Nuclear Installations, IAEA Safety Standards Series No. SSG-35 (DS559), IAEA, Vienna (2015).
 15. 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 (2025).

16. INTERNATIONAL ATOMIC ENERGY AGENCY, Geotechnical Aspects in the Siting and Design of Nuclear Installations, IAEA Safety Standards Series No. 93, IAEA, Vienna (2026).
17. INTERNATIONAL ATOMIC ENERGY AGENCY, Evaluation of the Status of National Nuclear Infrastructure Development (Rev. 2), IAEA Nuclear Energy Series No. NG-T-3.2 (Rev. 2), IAEA, Vienna (2022).
18. INTERNATIONAL ATOMIC ENERGY AGENCY, Managing Siting Activities for Nuclear Power Plants, NG-T-3.7 (Rev. 1), IAEA, Vienna (2022).
19. 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).
20. INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-25 (2013) (DS535, 2025).
21. INTERNATIONAL ATOMIC ENERGY AGENCY, Management of Site Investigations for Radioactive Waste Disposal Facilities, IAEA Nuclear Energy Series No. NW-T-1.40, IAEA, Vienna (2024), <https://doi.org/10.61092/iaea.jy3v-m5p4>.

This revision of SSG-21 is not expected to affect other Agency publications, with the possible exception of portions of SSG-35, Site Survey and Site Selection for Nuclear Installations, that mention volcanic hazard data collection. SSG-35 is also undergoing revision, and the Technical Officer managing the SSG-21 revision also serves on the team revising SSG-35. This will help ensure continued agreement among the two Safety Guides. SSR-1 is currently under revision, which could potentially impact SSG-21 as well as SSG-35. The SSG-21 team will closely follow the changes to SSR-1 to ensure SSG-21 remain consistent. The SSG-21 revision will be managed by the External Events Safety Section within the Division of Nuclear Installation Safety (NSNI). During development of this DPP, the other sections of NSNI were consulted: the Operational Safety Section (OSS), Regulatory Activities Section (RAS), Research Reactor Safety Section (RRSS) and Safety Assessment Section (SAS). These sections and the Waste and Environmental Safety Section within the Division of Radiation, Transport and Waste Safety (NSRW) will be consulted during the drafting process.

7. OVERVIEW

The overall structure of SSG-21 is expected to be as follows:

Section 1 will be the introduction, with the background, objective, scope, and structure.

Section 2 will be an overview of volcanic hazard assessment. It will be revised to reflect updates to the deterministic and probabilistic approaches to volcanic hazard assessment.

Section 3, recommendations on the hazard assessment process, will update the discussion of stage 1 of the general hazard assessment procedure to clarify a vague reference to “geographic region.” Stage 3 on screening will also be updated to reflect new, more efficient screening techniques.

Section 4, on necessary information and investigations, will be updated to include the latest geophysical and geochemical data collection methods.

Section 5 on screening of volcanic hazards will have significant changes to discuss screening through conservative numerical modelling. As appropriate, distance-based screening values for certain phenomena will be added.

Section 6 will be devoted to site-specific volcanic hazards assessment. It will be updated to discuss simplified hazard assessment techniques by grouping volcanic phenomena at a location and assessing a single hazard probability.

Section 7, on nuclear facilities other than nuclear power plants, will be enhanced to discuss radioactive waste disposal facilities and the potential impact on them and other underground facilities from igneous intrusions.

Section 8 will be a new section discussing the effects of certain volcanic phenomena on engineered systems. Some systems can be engineered to withstand certain volcanic phenomena, so this new section will explore this topic.

Section 9 (former section 8) will be on monitoring and preparation for response to volcanic events. This may be slightly changed to reflect advancements in volcano monitoring.

Section 10 (former section 9) on the management system for volcanic hazard assessment should see little change.

The appendix describing various volcanic phenomena and the two annexes will likely be deleted. Such supplemental material in Safety Guides is disfavoured by the Commission on Safety Standards.

8. PRODUCTION SCHEDULE

Provisional schedule for preparation of the publication, outlining realistic expected dates for each step

STEP 1: Preparing a DPP	DONE
STEP 2: Internal review of the DPP (Approval by the Coordination Committee)	Q1 2026
STEP 3: Review of the DPP by the review Committee(s) (Approval by review Committee(s))	Q2 2026
STEP 4: Review of the DPP by the CSS (approval by CSS) or information of the CSS on the DPP	Q4 2026
STEP 5: Preparing the draft publication	Q1 2028
STEP 6: First internal review of the draft publication (Approval by the Coordination Committee)	Q2 2028
STEP 7: First review of the draft publication by the review Committee(s) (Approval for submission to Member States for comments)	Q4 2028
STEP 8: Soliciting comments by Member States	Q2 2029
STEP 9: Addressing comments by Member States	Q3 2029
STEP 10: Second internal review of the draft publication (Approval by the Coordination Committee)	Q3 2029
STEP 11: Second review of the draft publication by the review Committee(s) (Approval of the draft)	Q4 2029
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 2030
STEP 13: Approval by the Board of Governors (for SF and SR only)	N/A
STEP 14: Target publication date	Q3 2030

9. RESOURCES

The resources for development are estimated as follows:

- Two in-person consultancy meetings (Q4 – 2026; Q2 – 2027) each involving six experts, for a total of 12 person-weeks;
- Ten weeks of home-based assignments for selected experts;
- IAEA Secretariat: 20 person-weeks of professional staff time.

ANNEX: FEEDBACK ANALYSIS REPORT

During its 57th meeting held 4-6 June 2024, the Nuclear Safety Standards Committee (NUSSC) formed an e-Working Group (e-WG) to collect inputs from the NUSSC members to create its medium-term plan. The e-WG, in assistance with the NUSSC Secretariat, circulated a survey questionnaire to the NUSSC members and collected 31 responses, which were reported and discussed during the 57th NUSSC meeting to develop the medium-term plan. [Survey results](#) indicated that NUSSC members believe that SSG-21 needs revision in the next five years, and the e-WG report listed it as one of the priorities of the medium-term plan. Potential topics to be addressed during the revision included revision to a vague statement about “geographic area,” and development of distance-based screening criteria for the most severe volcanic phenomena that can occur near a volcano.

Volcanic hazard investigation has not played a major role in many SEED missions since SSG-21 was published. However, in one recent SEED mission, the importance of variable screening distances for volcanic phenomena became apparent. One Member State suggested a uniform, small screening distance from active volcanoes during the site survey process. Such a selected distance could be inadequate for protection against some severe phenomena, such as lava flows and pyroclastic density current. This highlighted the need for improved guidance on screening distances.

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

Section #	Section Title	Existing gaps and possible revisions
1	Introduction	— Scope and structure will be updated.
2	Overview of Volcanic Hazard Assessment	— Discuss grouping of phenomena to assess them with a single hazard probability. — Update discussion of deterministic and probabilistic approaches, considering advances in probabilistic modelling techniques.
3	General Recommendations	— Clarification of stage 1, initial assessment. Rather than beginning with a poorly defined “geographic region,” the first stage of assessment will likely focus on a discussion of the volcano-tectonic setting. — Minor revision to stage 3, screening of hazards, to mention more efficient screening techniques.
4	Necessary Information and Investigations (Database)	— Updates to the section on geophysical and geochemical survey data to mention the utility of newer data collection techniques.
5	Screening of Volcanic Hazards	— Revisions to the recommended screening process. Some phenomena can be screened based on conservative numerical modelling of the phenomena. — Distance-based screening criteria for certain phenomena will be added.
6	Site Specific Volcanic Hazard Assessment	— Updates to hazard modelling methods, such as grouping certain phenomena (e.g. opening of a new vent, ground deformation, ballistics) and assessing a single hazard probability. — Discuss use of site-specific hazard approaches rather than volcano-specific hazard analyses.

7	Nuclear Facilities Other Than Nuclear Power Plants	— Expansion of the discussion currently in paragraph 7.7 on effects on subsurface facilities. — Add information about assessing volcanic hazard over much longer time scale for radioactive waste disposal facilities.
8	Effects of Volcanic Phenomena on Engineered Systems	— A new section to discuss the effects of certain phenomena, especially gases and tephra, on engineered systems. — Developing design parameters for engineered systems to withstand volcanic phenomena that are not site-exclusion phenomena.
9	Monitoring and Preparation for Response	— Former section 8, this may have minor updates to reflect advancements in volcano monitoring technology.
10	Management System for Volcanic Hazard Assessment	— Former section 9, this may have minor updates to reflect any lessons learned from recent volcanic hazard assessment projects.
Appendix	Description of Types of Volcanic Phenomena	— Likely to be deleted.
Annex I	Volcanic Hazard Scenarios	— Likely to be deleted.
Annex II	Worldwide Sources of Information	— Likely to be deleted.
Definitions of Volcanological Terms		— Update as appropriate.