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1. IDENTIFICATION

Document Category:	**Specific Safety Guide**
Working ID:	**DS573**
Proposed Title:	**Design of the Containment and Associated Systems for Nuclear Power Plants**
Proposed Action:	**Revision of IAEA Specific Safety Guide No. SSG-53 "Design of the Reactor Containment and Associated Systems for Nuclear Power Plants" (2019)**
Review Committee:	**NUSSC, NSGC**
Technical Officer(s):	**TIBERI Vincenzo (NSNI/SAS), LUIS HERNANDEZ Jorge (NSNI/SAS)**

2. BACKGROUND

IAEA Safety Standards Series No. SSG-53, Design of the Reactor Containment and Associated Systems for Nuclear Power Plants, (hereinafter referred to as SSG-53) was published in 2019 to provide recommendations for meeting the associated requirements established in the IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), Safety of Nuclear Power Plants: Design.

Consistent with SSR-2/1 (Rev. 1) and based on the significant operating experience of water cooled reactor (WCR) technologies, the recommendations provided in SSG-53 were intended to be primarily applicable to land-based stationary nuclear power plants (NPPs) with water cooled reactors. This is explicitly stated in the scope section of SSG-53.

Advancements in nuclear reactor technologies have led to the deployment and growing interest in non-water-cooled reactor (NWCR) design, such as high temperature gas cooled reactors (HTGRs), liquid metal fast reactors (LMFRs) and molten salt reactors (MSRs), as well as small modular reactors (SMRs) and microreactors. These technologies are being considered for a wide range of civil applications, including electricity generation, process heat and desalination. Their increasing relevance highlights the need to revisit and expand existing safety guidance to ensure it remains applicable across evolving reactor technologies.

In typical land-based stationary WCRs, the containment system which ensures or contributes to the fulfilment of the following safety functions at the nuclear power plant: (i) confinement of radioactive substances in operational states and in accident conditions; (ii) protection of the reactor against natural external events and human induced events; and (iii) radiation shielding in operational states and in accident conditions", corresponds to the reactor containment and its associated systems[1].

In advanced reactor technologies[2], including NWCRs, these same three safety functions are preserved, but they may be achieved through different structures, systems, and components (SSCs), depending on the reactor technology and design.

Such differences in design features arise primarily from the use of different coolants, moderators, neutron spectra, operating pressures, operating temperatures, and fuel types. Additionally, recent

[1] The reactor containment and its associated systems comprise the containment structure and the systems with the functions of isolation, control and management of mass and energy releases, control and limitation of radioactive releases, and control and management of combustible gases. This definition also applies to double wall containments.

[2] Advanced reactors technologies and designs refer to the terminology established in IAEA Nuclear Energy Series NT-T-1.19.

technological developments have led to a broad use of passive safety systems for ensuring reactor containment heat removal. Other advanced design features include underground deployment and compact reactor configurations[3].

For example, in HTGRs, the confinement of radioactive substances is provided primarily by the TRISO coated particle fuel, and the protection against external events is achieved by a concrete structure, such as the reactor building. Accident-condition pressures and temperatures in LMFRs differ significantly from those in WCRs and the role of the reactor coolant boundary, including the cover gas boundary, plays a central role in the confinement function, alongside the contribution of the coolant itself to the retention of radioactive materials. The same considerations on accident-condition pressures and temperatures also apply to MSRs, where design solutions to ensure the confinement function depend on the design. Moreover, the notion of severe accident, typically understood as a core melt in WCRs in many of the recommendations of SSG-53, applies differently to most of these technologies[4]. As a result, considering that the reactor building for these technologies may not have the same functional requirements as the reactor building of typical land-based stationary WCRs (requirements 54 to 58 in SSR-2/1 (Rev. 1)), related recommendations in the revision of SSG-53 will aim to reflect these differences.

In addition, specific features of some existing land-based stationary WCRs are not captured in the current version of SSG-53 (e.g. the unique containment design features of multi-unit CANDU stations). Furthermore, SSG-53 is limited to the reactor building and does not address other plant buildings containing significant radioactive inventories.

The feedback analysis provided in Annex I includes a summary of relevant publications that highlight these challenges, particularly those due to the specific characteristics of advanced reactor technologies.

3. JUSTIFICATION FOR THE PRODUCTION OF THE DOCUMENT

For several years, IAEA General Conference Resolutions on nuclear and radiation safety have requested the IAEA secretariat to update the IAEA Safety Standards to incorporate specifics of advanced reactors technologies and designs, included in both NPPs with NWCR technologies and NPPs with WCR designs, such as those considered for some SMRs[5]. In addition, recognizing the emergence of non-water-cooled reactor technologies, several Member States have undertaken or are considering new or updated guidance to address the specific characteristics and safety considerations associated with these designs.

Given this context, the IAEA has been collecting feedback for several years on the applicability of safety requirements and recommendations on design safety to identify possible gaps in the application of related IAEA Safety Standards to existing NPPs and to NPPs with advanced reactor technologies and designs. This feedback has been gathered from various IAEA activities, such as technical meetings, workshops, and technical safety reviews.

SSG-53 provides recommendations for meeting the requirements established in SSR-2/1 (Rev. 1). Specifically, the reactor containment and its associated systems are required to be designed in accordance with Requirements 54-58 of SSR-2/1 (Rev. 1), while also considering other relevant requirements.

In connection with the ongoing revision of SSR-2/1 (Rev. 1) under DS562, a preliminary analysis has been carried out to assess the applicability of SSG-53 to different reactor technologies (see Annex I). The results of this analysis highlight the need to revise SSG-53 to address the changes in the relevant requirements envisaged in the revised version of SSR-2/1 (Rev. 1) under DS562.

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[3] As defined in IAEA-TECDOC-2010. Compact configurations are not expected to significantly affect the safety functions of confinement of radioactive substances and protection against external hazards provided by the containment. However, they may have important implications for the fulfilment of the radiation shielding function.

[4] The definition of severe accident is currently being addressed in the revision of SSR-2/1 (Rev. 1) (DS562). SSG-53 (Rev. 1) will ensure consistency with the approach adopted in DS562.

[5] See the feedback analysis in Annex I, on General Conferences resolutions for advanced reactors and small modular reactors.

Additionally, recent publications have been developed to compile the knowledge for the review of SSG-53. These include the Safety Report Series No. 123 on Applicability of IAEA Safety Standards to Non-Water-Cooled Reactors and Small Modular Reactors, along with other publications (listed in Annex I). According to SRS-123, SSG-53 was identified as one of the safety standards with numerous applicability considerations, affecting more than a third of its content.

Based on the above context, it is proposed to revise SSG-53 to retain consistency with the revised version of SSR-2/1 (Rev. 1) under DS562 and enhance its applicability to a broader range of reactor technologies.

4. OBJECTIVE

The objective of the revision of SSG-53, hereinafter referred to as SSG-53 (Rev. 1), is to provide recommendations for the design of containment systems for NPPs as defined in the scope section of this DPP, to meet the relevant requirements established in the revised version of SSR-2/1 (Rev. 1) under DS562.

The recommendations in SSG-53 (Rev. 1) will be primarily aimed at regulatory bodies, designers and operating organizations of nuclear power plants. The recommendations will also be useful for technical support organizations and other organizations involved in manufacture, construction, modification, maintenance, commissioning, and decommissioning of nuclear power plants.

The recommendations in this proposed Safety Guide will be targeted mainly at new nuclear power plants. For existing stationary land-based nuclear power plants in operation or under construction, it may not be practicable to apply all the new or revised recommendations of SSG-53 (Rev. 1). Furthermore, it may not be feasible to modify designs that have already been approved by regulatory bodies. In such cases, it is expected that comparisons will be made with the current IAEA Safety Standards[6] (e.g. during periodic safety reviews) to assess whether reasonably practicable safety improvements could be implemented to further enhance the safety of the plant.

5. SCOPE

In line with the ongoing revision of SSR-2/1 (Rev. 1) under DS562, SSG-53 (Rev. 1) will expand its current scope to consider all power producing nuclear reactors used for civil purposes (e.g. electrical generation, process heat supply, and desalination), and to integrate updated considerations for WCR (including advanced) and NWCR technologies (i.e. HTGRs, LMFRs - including sodium fast reactors (SFRs) and lead and lead-bismuth fast reactors (LFRs), and MSRs)[7]. In addition, modularization[8] and specifics of NPPs with small and micro reactor designs, and corresponding deployment options (e.g. modularity[9], remote locations, underground installation) will be considered.

SSG-53 (Rev. 1) will primarily apply to land based stationary nuclear power plants. The recommendations from this publication may also be applied, with engineering judgement, to certain research reactors that require a containment structure. The proposed Safety Guide does not address the design specific aspects of transportable nuclear power plants (TNPPs). It is also recognized that, for reactor types other than those mentioned above, including innovative developments in future systems, certain parts of this Safety Guide may not be applicable or may require engineering judgment in their interpretation.

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[6] The current IAEA Safety Standards refer to the latest published versions of the documents.

[7] The main design-specific characteristics of HTGRs, LMFRs and MSRs are described respectively in the IAEA TECDOCs on Considerations on the Safety of High Temperature Gas Cooled Reactors, Considerations on the Safety of Liquid Metal Fast Reactors, Considerations on the Safety of Molten Salt Reactors, currently under development. These characteristics will be explicitly discussed in the revised safety guide.

[8] Modularization is understood as the possibility to assemble several SSCs of the NPP in the manufacturing factory, thereby facilitating subsequent transport / relocation of such assembled modules to the construction site (IAEA-TECDOC-2010).

[9] Modularity is understood as the possibility for the subsequent placing of SMR modules (i.e. reactor modules) close to each other in one NPP (IAEA-TECDOC-2010).

Some of the technologies mentioned above raise concerns about the potential release of toxic substances into the environment (e.g., sodium and derived compounds in SFRs). SSG-53 (Rev. 1) will not address specifically this aspect.

SSG-53 (Rev. 1) will address the functional aspects of the reactor containment and its associated systems. Consideration will be given to the definition of the design basis, including internal and external hazards, and structural design, including integrity and leak-tightness, as applicable. The Safety Guide will also address the capability, reliability, functionality and independence of the reactor containment and its associated systems contributing to different levels of defence in depth. In particular, it will include recommendations relevant to the design of equipment and systems necessary to mitigate severe accidents.

Recommendations will be provided on the tests and inspections that are necessary to ensure that the containment and its associated systems for nuclear power plants can accomplish their intended safety functions throughout the operating lifetime of the nuclear power plant.

SSG-53 (Rev. 1) will address the specific characteristic of shared containment for multiple reactor units (e.g. vacuum building for CANDU multi-unit stations) or modules[10].

SSG-53 (Rev. 1) will also address, where appropriate, SSCs other than the reactor containment and associated systems that contain significant radioactive inventories and that are implemented in some designs to ensure, or contribute to, the fulfilment of the functions of confinement of radioactive substances, protection against natural external events and human induced events, and radiation shielding (e.g. the radioactive effluent treatment or storage building, auxiliary buildings[11]). An exception is spent fuel stored outside the reactor containment[12]. The inclusion of SSCs beyond the reactor containment itself in the scope is the reason for changing the title of the Safety Guide from “Design of the Reactor Containment and Associated Systems for Nuclear Power Plants” to “Design of the Containment and Associated Systems for Nuclear Power Plants”.

The interactions between safety and security and between safety and safeguards related to the design of the containment and associated systems, will be considered in SSG-53 (Rev.1).

Design limits and engineering criteria, together with the system parameters that should be used to verify them, are specific to individual designs for nuclear power plants and to individual States and will be outside the scope of this Safety Guide. However, general recommendations on these topics will be provided.

Nuclear reactors for aviation or outer space applications, accelerator-driven system and fusion installations will be out of the scope of SSG-53 (Rev.1).

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

During the revision process, appropriate consistency with the content of all relevant Safety Standards will be maintained, in particular with those currently under revision or proposed to be revised, SSR-2/1 (Rev.1) (DS562), SSR-2/2 (Rev. 2, DS532), SSG-30 (proposed to be revised), SSG-52 (proposed to be revised), SSG-56 (proposed to be revised), SSG-67 (DS563) and SSG-68 (DS564). Representatives involved in the development and maintenance of these Safety Guides will be consulted as appropriate, and cross-references, scope boundaries and common technical topics will be reviewed during drafting meetings and technical reviews to ensure consistency of recommendations and coherent treatment of areas where the guidance overlaps or interacts.

[10] Such as NuScale.

[11] Particular attention will be given to ensuring consistency and addressing interfaces with SSG-62, Design of Auxiliary Systems and Supporting Systems for Nuclear Power Plants.

[12] Recommendations on spent fuel are provided in IAEA SSG-63, Design of Fuel Handling and Storage Systems for Nuclear Power Plants, and SSG-15, Storage of Spent Nuclear Fuel.

This Guide will interface with at least the following IAEA Safety Standards Series and other publications (the list is not intended to be final or exhaustive):

1. GSR Part 2 – Leadership and Management for Safety (2016);
2. GSR Part 5 – Predisposal Management of Radioactive Waste (2009), under revision as DS548;
3. SSR-2/1 (Rev. 1) – Safety of Nuclear Power Plants: Design (2016), under revision as DS562;
4. SSR-2/2 (Rev. 1) – Safety of Nuclear Power Plants: Commissioning and Operation (2016), under revision as DS532;
5. SSG-13 (Rev. 1) – Chemistry Programme for Water Cooled Nuclear Power Plants (2024);
6. SSG-15 (Rev. 1) – Storage of Spent Nuclear Fuel (2020);
7. SSG-30 – Safety Classification of Structures, Systems and Components in Nuclear Power Plants (2014), proposed to be revised;
8. SSG-34 – Design of Electrical Power Systems for Nuclear Power Plants (2016);
9. SSG-39 – Design of Instrumentation and Control Systems for Nuclear Power Plants (2016);
10. SSG-48 - Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants (2018), under revision as DS561;
11. SSG-52 – Design of the Reactor Core for Nuclear Power Plants (2019), proposed to be revised;
12. SSG-56 – Design of the Reactor Coolant System and Associated Systems for Nuclear Power Plants (2020), proposed to be revised;
13. SSG-61 – Format and Content of the Safety Analysis Report for Nuclear Power Plants (2021);
14. SSG-62 – Design of Auxiliary and Supporting Systems for Nuclear Power Plants (2020);
15. SSG-63 – Design of Fuel Handling and Storage Systems for Nuclear Power Plants (2020);
16. SSG-64 – Protection against Internal Hazards in the Design of Nuclear Power Plants (2021);
17. SSG-67 – Seismic Design for Nuclear Installations (2021), under revision as DPP563;
18. SSG-68 – Design of Nuclear Installations Against External Events Excluding Earthquakes (2021), under revision as DPP564;
19. SSG-69 – Equipment Qualification for Nuclear Installations (2021);
20. SSG-70 – Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants (2022);
21. SSG-74 – Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants (2022);
22. SSG-88 – Design Extension Conditions and the Concept of Practical Elimination in the Design of Nuclear Power Plants (2024);
23. SSG-90 – Radiation Protection in the Design of Nuclear Power Plants (2024);
24. Safety demonstration of innovative technology in power reactor designs (DS537);
25. IAEA Nuclear Safety and Security Glossary (2022);
26. NSS 13 – Nuclear Security recommendations on physical protection of nuclear material and nuclear facilities (2011);
27. NSS 48-T – Identification and Categorization of Sabotage Targets and identification of Vital Areas at Nuclear Facilities (2024);
28. NSS 33-T – Computer Security of Instrumentation and Control Systems at Nuclear Facilities (2018);
29. Legal Framework for IAEA Safeguards (2013).

Given the interfaces with these IAEA Safety Standards, the authoring of SSG-53 (Rev. 1) will be coordinated, as relevant, with NSNI/EESS, NSNI/OSS, NSNS and the safeguards team dealing with 'safeguards by design' (SGCP POC). In addition, staff from NE will be consulted on the revision of SSG-53.

7. OVERVIEW

The recommendations in SSG-53 (Rev. 1) will retain the overall structure and table of contents of the current SSG-53, while incorporating new sections, appendices as appropriate, to provide specific recommendations to cover various reactor technologies and their applications. Additional annexes may be included to support the interpretation and application of these recommendations through practical examples.

The proposed structure will preserve Section 1 as in the current version.

Section 2 will provide recommendations on the safety functions fulfilled by the containment and its associated systems and on the design approach. This section will include a technology inclusive part, as well as parts specific to the different reactor technologies within the scope of SSG-53 (Rev. 1).

Section 3 will provide recommendations on the generic design basis of the containment and its associated systems applicable to all reactor technologies, including specific aspects related to SMRs and micro reactors. This section will follow the same approach of Section 3 of SSG-53.

Section 4 will provide recommendations on the generic design of the containment and its associated systems applicable to all reactor technologies, including specific aspects related to SMRs and microreactors. This section will follow the same approach of Section 4 of SSG-53.

Section 5 will provide generic recommendations for tests and inspections applicable to all reactor technologies, including specific aspects related to SMRs and micro reactors. This section will follow the same approach of Section 5 of SSG-53.

Sections 6 to Section 10 will provide recommendations on specific design basis and specific design aspects of the containment and its associated systems, as well as on related testing and inspections, for different reactor technologies. These sections will consider the latest experience and advancements in WCRs (Section 6), as well as the current development status of NWCRs. The latter include HTGRs (Section 7), SFRs (Section 8), LFRs (Section 9) and MSRs (Section 10).

Section 11 will provide recommendations related to SSCs other than the reactor containment and its associated systems which contain significant radioactive inventories.

Accordingly, SSG-53 (Rev. 1) will have the overall structure at the section level as follows, considering that during the process of drafting, changes to the structure may be required.

1. INTRODUCTION
2. CONTAINMENT SAFETY FUNCTIONS AND THE DESIGN APPROACH
3. GENERIC DESIGN BASIS OF THE REACTOR CONTAINMENT AND ITS ASSOCIATED SYSTEMS
4. GENERIC DESIGN OF THE REACTOR CONTAINMENT AND ITS ASSOCIATED SYSTEMS
5. GENERIC RECOMMENDATIONS FOR TEST AND INSPECTION
6. REACTOR CONTAINMENT AND ITS ASSOCIATED SYSTEMS FOR PWRs, BWRs AND PHWRs
7. REACTOR CONTAINMENT AND ITS ASSOCIATED SYSTEMS FOR HTGRs
8. REACTOR CONTAINMENT AND ITS ASSOCIATED SYSTEMS FOR SFRs
9. REACTOR CONTAINMENT AND ITS ASSOCIATED SYSTEMS FOR LFRs
10. REACTOR CONTAINMENT AND ITS ASSOCIATED SYSTEMS FOR MSRs

11. SYSTEMS, STRUCTURES AND COMPONENTS OTHER THAN THE REACTOR CONTAINMENT

APPENDICES

REFERENCES

ANNEXES (IF NEEDED)

DEFINITIONS (IF NEEDED)

CONTRIBUTORS TO DRAFTING AND REVIEW

8. PRODUCTION SCHEDULE

The provisional schedule for preparation of the document, outlining realistic expected dates for each step, is as follows:

STEP 1: Preparing a DPP	DONE
STEP 2: Approval of DPP by the Coordination Committee	Q3 2026
STEP 3: Approval of DPP by the relevant review Committees	Q4 2026
STEP 4: Approval of DPP by the CSS	Q2 2027
STEP 5: Preparing the draft	Q2 2027 – Q1 2029
STEP 6: Approval of draft by the Coordination Committee	Q2 2029
STEP 7: Approval by the relevant review Committees for submission to Member States for comments	Q4 2029
STEP 8: Soliciting comments by Member States	Q2 2030
STEP 9: Addressing comments by Member States	Q3 2030
STEP 10: Approval of the revised draft by the Coordination Committee Review in NSOC-SGDS (Technical Editorial review)	Q3 2030
STEP 11: Approval by the relevant review Committees	Q4 2030
STEP 12: - Submission to the CSS - Submission in parallel and approval by the Publications Committee - MTCD Editing - Endorsement of the edited version by the CSS	Q2 2031
STEP 13: Establishment by the Publications Committee and/or Board of Governors (for SF and SR only))	NA
STEP 14: Target publication date	Q3 2031

9. RESOURCES

It is estimated that the revision of the Safety Guide will involve approximately 400 weeks of effort by experts. This is based upon assuming 10 one-week consultation meetings involving no more than 20 experts and an average of one week of work per expert between meetings. One Technical Meeting (one week) is also scheduled in October 2026 (EVT2503544).

Agency resources involved are estimated at 60 weeks of effort by the Technical Officer and 40 additional weeks of other IAEA staff.

Annex I - Feedback Analysis Report

In recent years, the IAEA Secretariat and Member States have launched several initiatives to support the deployment of nuclear reactors for power generation, including both water cooled and non-water-cooled technologies. Key initiatives include the SMR Regulators' Forum (SMR RF) and the Nuclear Harmonization and Standardization Initiative (NHSI).

The SMR RF[13] has conducted its work in phases, focusing on the safety and regulatory issues most affected by innovative SMR technologies. The SMR RF has developed common regulatory positions on topics such as the use of passive and inherent safety features, defence-in-depth, multi-units/modules and shared systems, design extension conditions, containment systems, mechanistic source term, safety, security and safeguards in the design.

Similarly, NHSI provides a platform for cooperation among regulatory bodies, technology developers, and industry stakeholders to facilitate the safe and efficient global deployment of advanced reactors. In particular, the NHSI Regulatory Track[14], aims to create a harmonized and technology inclusive approach for the review of advanced reactor designs building on IAEA Safety Standards.

The work carried out under the SMR RF and NHSI has highlights the need for the IAEA to consider revising its Safety Standards to better reflect the unique characteristics of advanced reactor and SMR designs, particularly non-water-cooled technologies. The technical outputs of these initiatives could provide valuable input to such a revision.

Furthermore, recent IAEA General Conference resolutions have highlighted several important gaps and priorities related to the design safety of advanced reactors. The 67th IAEA General Conference has acknowledged that current Safety Standards provide a strong foundation, however given the differences in reactor technologies there are gaps and additional considerations are needed to address the novel design features of advanced reactors and SMRs (Nuclear Safety Review 2023, GC(67)/INF/2[15]).

The 67th and 68th IAEA General Conferences reaffirmed the importance of updating safety standards to reflect these emerging technologies

Therefore, the IAEA has been working to compile the technical information necessary for the future revision of IAEA Safety Standards. For the revision of SSG-53, the feedback analysis has primarily considered inputs from:

1) Publications related to the latest developments of nuclear reactors for power generation including water cooled and non-water-cooled reactor technologies;
2) A preliminary gap analysis conducted by the Safety Assessment Section to assess the applicability of SSG-53 to water cooled and non-water cooled reactor technologies.

1. Feedback analysis from relevant IAEA publications supporting the revision of SSG-53

Over the years, the IAEA has published several documents that highlight the unique characteristics and key design features of advanced reactors. Many of them describe design aspects that may have a direct or indirect impact on the recommendations provided in the guide. While some of these publications do not directly assess gaps in the guide or its limitations, they offer valuable insights. A brief overview of relevant publications is provided in the following.

<u>IAEA Safety Report Series No. 123, "Applicability of IAEA Safety Standards to Non-Water-Cooled Reactors and Small Modular Reactors" (2023)</u>

The report identifies areas of novelty in SMRs and NWCRs compared to conventional designs and assesses their impact on the applicability and completeness of current IAEA safety standards. It highlights gaps and areas requiring further consideration in the safety standards across the entire

[13] https://gnssn.iaea.org/regnet/SMR-Forum/Pages/default.aspx

[14] https://nucleus.iaea.org/sites/smr/SitePages/NHSI-Regulatory-Track.aspx?web=1

[15] https://www.iaea.org/sites/default/files/gc/gc67-inf2.pdf

lifecycle of these technologies, from siting and design to decommissioning.

In general, SSG-53 is identified as presenting numerous gaps and applicability concerns. In particular, the two main sections of the safety guide ‘Design basis of the containment structure and its components and associated systems’ (Section 3) and ‘Design of the containment and its associated systems’ (Section 4) are identified as requiring significant interpretation to apply to EIDs.

The main gaps and areas of non-applicability are primarily related to the consideration of a robust single or double wall structure that provides three safety functions: (i) confinement of radioactive substances in operational states and in accident conditions; (ii) protection of the reactor against natural external events and human induced events; and (iii) radiation shielding in operational states and in accident conditions. In NWCR designs, the three safety functions are preserved, but they may be supplied by different design features. In addition, SSG-53 provides many recommendations referring to a core melt scenario as the most severe accident in WCRs. In this regard, the notion of severe accident applies differently to most EIDs. Moreover, several specific WCR design characteristics addressed by multiple recommendations – such as ventilation systems, pressure built up and venting, the need of emergency, diverse or alternate power sources, the use of large water reservoirs, containment spray systems, sumps and suppression pools, hydrogen treatment systems – may not be relevant for most EIDs.

As a conclusion, the report emphasizes the need to incorporate reactor technology-specific and design-specific characteristics into design guidelines for the reactor containment and associated systems.

<u>Other relevant publications</u>

The following publications provide insights into advanced reactor technologies and identify technical areas that may require consideration in the revision of SSG-53.

Cross-cutting publications

- Small Modular Reactors Catalogue 2024 (and the expected 2026 update).
- IAEA-TECDOC-2010 (2022), Approach and Methodology for the Development of Regulatory Safety Requirements for the Advanced Nuclear Power Reactors.
- SMR RF phase 2 summary report (2021). This publication identifies several key areas that require special attention during the safety assessment of both water cooled and non-water-cooled SMR designs.
- SMR RF phase 3 report on Containment Systems (2023).
- Publications addressing passive safety systems and defence in depth, including IAEA-TECDOC-1752 (2014), Progress in Methodologies for the Assessment of Passive Safety System Reliability in Advanced Reactors; TECDOC on Progress in the Performance Assessment and Regulation of Passive Safety Features on Advanced Nuclear Power Plant Designs (in preparation); TECDOC on Demonstration of Defence-in-Depth (DiD) Implementation for Nuclear Power Plants using Deterministic and Probabilistic Analyses (in preparation).
- TECDOC on Considerations for Qualification of Advanced Manufacturing and Materials for Component Important to Safety in Small Modular Reactors and Non-Water-Cooled Reactors (in preparation).

Technology-specific publications:

- HTGRs: IAEA-TECDOC-1936 (2020), Applicability of Design Safety Requirements to Small Modular Reactor Technologies Intended for Near-Term Deployment; TECDOC on Considerations on the Safety of High Temperature Gas Cooled Reactors (in preparation).
- LMFRs: IAEA-TECDOC-1569 (2007), Liquid Metal Cooled Reactors: Experience in Design and Operation; IAEA-TECDOC-1912 (2020), Challenges for Coolants in Fast Neutron Spectrum Systems, discusses alternate coolant options for reactor technologies operating in the fast neutron spectrum; IAEA-TECDOC-2079 (2025), Analysis and Modelling of Severe Accidents for Liquid Metal Fast Reactors; TECDOC on Considerations on the Safety of Liquid Metal Fast Reactors (in preparation); Generation IV International Forum (GIF), Safety Design Guidelines on Safety Approach and Design Conditions for Generation IV Sodium-cooled Fast Reactor Systems (2016);

Generation IV International Forum (GIF), Safety Design Guidelines on Structures, Systems and Components for Generation IV Sodium-cooled Fast Reactor Systems (2024).

- MSRs: Technical Report Series No. 489 (2023), Status of Molten Salt Reactor Technology; TECDOC on Considerations on the Safety of Molten Salt Reactors (in preparation).

2. Preliminary gap analysis

In 2026, the IAEA carried out a preliminary gap analysis to assess the applicability of SSG-53 to a range of reactors technologies, including pressurized water reactors (PWRs), pressurized heavy water reactors (PHWRs), boiling water reactors (BWRs), HTGRs, SFRs, LFRs, and MSRs. Water cooled SMRs were also included in the scope. The analysis was performed on a paragraph-by-paragraph basis for the entire document. The review follows the methodology outlined and applied in IAEA-TECDOC-2010 and in IAEA-TECDOC-1936, as well as the relevant results presented in SRS-123. The result of the review will guide the necessary modifications to each recommendation in SSG-53, based on the following rationale:

C1: The recommendation in this paragraph is technology neutral or technology inclusive and fully applicable to all reactor technologies and applications. No changes are necessary.

C2: The recommendation in this paragraph is not fully technology-inclusive, but only wording adjustments are needed to ensure broad applicability.

C3: The recommendation in this paragraph is technology specific to land-based, water cooled reactor technologies. It will be retained as is. Equivalent or additional recommendations should be developed for specific characteristics.

The gap analysis results indicate that the recommendations in SSG-53 are categorized as follows:

- For PWRs (including SMRs): approximately 90% fall under Category C1, 10% under C2, and 0% under C3;
- For BWRs: approximately 93% fall under Category C1, 6% under C2, and 1% under C3;
- For PHWRs: approximately 95% fall under Category C1, 5% under C2, and 0% under C3;
- For SFRs: approximately 56% fall under Category C1, 26% under C2, and 18% under C3;
- For LFRs: approximately 55% fall under Category C1, 27% under C2, and 18% under C3;
- For HTGRs: approximately 31% fall under Category C1, 24% under C2, and 45% under C3;
- For MSRs: approximately 56% fall under Category C1, 23% under C2, and 21% under C3.

Overall, SSG-53 was deemed to contain a significant number of gaps, where the existing text does not apply to advanced reactor technologies. In some cases, the existing text can be revised to become technology inclusive. In others, specific consideration for particular reactor technologies will be required.

3. Specific design characteristics to be considered for the revision of SSG-56

According to the above feedback analysis and preliminary gap analysis, the scope of the revision will focus on the specific design characteristics of the containment and its associated systems for all nuclear power plants included within the scope of this DPP. It will consider relevant operating experience and the current status of technology development[16], to provide recommendations on how to meet the revised

[16] It is acknowledged that operating and regulatory experience is currently limited for some NWCR technologies. Consequently, the recommendations for these technologies will largely depend on their design maturity and deployment status. As a result, the recommendations provided for certain NWCR technologies may not be as detailed as those for water cooled reactor technologies, which benefit from considerably more extensive design, operational, and licensing experience.

or newly introduced requirements in the revision of SSR-2/1 (Rev. 1) under DS562, including:

1. Low-pressure or non-pressurised reactor designs;
2. Passive features/systems for decay heat removal from the reactor containment in accident conditions;
3. Novel aspects introduced by multi-unit and multi-module designs, including shared safety systems;
4. Underground installation;
5. Physical-chemical properties, operating parameters, and design considerations specific to NWCRs due to different coolants and fuel forms (e.g. liquid fuel in some MSRs);
6. Specific reactor designs precluding large radioactive releases into the reactor containment (e.g. TRISO coated particle fuel in HTGRs);
7. Compact designs;
8. New technologies for containment design (e.g. steel-concrete composite structure).

It is important to emphasize that SSG-53 (Rev. 1) will not be limited to these changes. SSG-53 already provides recommendations for meeting all relevant requirements related to the design of the reactor containment and its associated systems, as established in SSR-2/1 (Rev. 1). The upcoming revision will build upon this foundation, ensuring continued alignment with the full set of applicable safety requirements. In addition, recognizing that the implementation of a single safety requirement may be supported by recommendations in multiple Safety Guides, SSG-53 (Rev. 1) will consider relevant interfaces to ensure alignment and coherence across the IAEA Safety Standards.