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1. IDENTIFICATION

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Proposed Title: Design of the Reactor Coolant System and Associated Systems for Nuclear Power Plants

Proposed Action: Revision of IAEA Specific Safety Guide No. SSG-56 “Design of the Reactor Coolant System and Associated Systems for Nuclear Power Plants” (2020)

Review Committee: NUSSC, NSGC

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2. BACKGROUND

IAEA Safety Standards Series No. SSG-56, Design of the Reactor Coolant System and Associated Systems for Nuclear Power Plants, (hereinafter referred to as SSG-56) was published in 2020 to provide recommendations for meeting requirements for the systems established in 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 technologies, the recommendations provided in SSG-56 were intended to be primarily applicable to land-based stationary nuclear power plants (NPPs) with water cooled reactors.

Advancements in nuclear reactor technologies have led to the deployment and growing interest in non-water-cooled reactor (NWCR) designs, such as high temperature gas cooled reactors (HTGRs), liquid metal fast neutron reactors (LMFRs) and molten salt reactors (MSRs). 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.

The design of the reactor coolant system and associated systems in NWCRs differs significantly from those in water-cooled reactors. These differences arise from the use of different coolants and moderators, operation under different pressures (low-pressure or non-pressurised) and neutron spectra (including fast spectrum), operation under different temperature regime, with temperatures as high as 800°C to 1000°C, the adoption of different fuel types, and enrichment. Additionally, recent technological developments have led to the widespread use of passive safety systems, inherent safety features, and more integrated, compact reactor configurations, which are also being adopted in advanced water-cooled reactors, particularly small modular reactors (SMRs) and microreactors.

While these innovations claim to offer potential safety and operational benefits, they also introduce new challenges related to the performance, reliability, and functionality of the reactor coolant system and associated systems. For example, inherent safety features and passive safety systems require robust validation to demonstrate reliable performance under all operational and accident conditions. Similarly, compact and integral designs may affect effective implementation of design solutions for protection against common cause failures and pose challenges for ensuring effective operational activities such as

testing, inspection, maintenance, and decommissioning. HTGRs require maintaining an inert atmosphere and material properties at very high temperatures. In LMFRs, high temperature, high fast neutron flux, and corrosive environment impose significant constraints on both materials and the design of the reactor coolant system. Additionally, coolant specific considerations include the high density of lead and lead-bismuth and the chemical reactivity of sodium. In MSRs, the reactor coolant system materials are subjected to highly corrosive conditions, elevated temperatures, and high neutron flux.

The feedback analysis provided in Annex I includes a summary of relevant publications that highlight these challenges arising from 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 the specifics of advanced reactor technologies and designs¹, including both NPPs with NWCRs technologies and NPPs with water cooled reactor designs, such as those considered for some small modular reactors². 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-56 provides recommendations for meeting the requirements established in SSR-2/1 (Rev. 1). Specifically, the reactor coolant system and its associated systems are required to be designed in accordance with Requirements 47–53 of SSR-2/1 (Rev. 1), while also considering other relevant requirements. These systems should be capable of fulfilling their intended safety functions to support the achievement of the three fundamental safety functions.

In connection with the ongoing revision of SSR-2/1 (Rev. 1) under DS562, a preliminary analysis of the scope and content of SSG-56 has been conducted (see Annex I). It highlights the need to revise SSG-56 to address the changes in the relevant requirements envisaged in the revised version of SSR-2/1 (Rev. 1) under DS562.

Additionally, publications have been developed recently to compile the knowledge for the review of SSG-56. These include the Safety Report Series No. 123, 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-56 was identified as a Safety Standard with numerous applicability considerations, affecting more than one third of its content.

Based on the above context, it is proposed to revise SSG-56 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-56, hereinafter called SSG-56 (Rev. 1), is to provide recommendations for the design of the reactor coolant system and associated systems, as defined in the

¹ Advanced reactors technologies and designs refer to the terminology established in NT-T-1.19

² See the feedback analysis in Annex 1, on General Conferences Resolutions for advanced reactors and small modular reactors.

scope section of this DPP, to meet the relevant requirements for these systems established in the revised version of SSR-2/1 (Rev. 1) under DS562.

The recommendations in SSG-56 (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 the proposed Safety Guide are 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-56 (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 Standards³ (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 on-going revision of SSR-2/1 (Rev. 1) under DS562, SSG-56 (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 water-cooled (including advanced) and NWCRs technologies (e.g. HTGRs, LMFRs - including sodium fast reactors (SFRs) and lead and lead-bismuth fast reactors (LFRs), and MSR)⁴. In addition, modularization⁵ and specifics of NPPs with small and micro reactor designs, and corresponding deployment options (e.g. modularity⁶, remote locations, underground installation) will be considered.

SSG-56 (Rev.1) will provide recommendations for design considerations of the reactor coolant system and associated systems, including the ultimate heat sink for water-cooled and non-water-cooled reactors, designed for all power outputs.

SSG-56 (Rev.1) will primarily apply to land based stationary nuclear power plants. The proposed Safety Guide does not address the design specific aspects of transportable nuclear power plants (TNPPs⁷). 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.

Nuclear reactors for aviation or outer space applications, accelerator-driven system and fusion installations will be out of the scope of SSG-56 (Rev.1).

³ The current IAEA Safety Standards refer to the latest published versions of the documents.

⁴ The main design characteristics of HTGRs, LMFRs and MSRs are described in the IAEA TEDOCs of Safety Considerations of High Temperature Gas Cooled Reactors; Considerations on the Safety of Liquid Metal Fast Reactors; Considerations on the Safety of Molten Salt Reactors, respectively which are currently under development. The key characteristics to be considered and scope of the revision of SSG-56 are outlined Annex 1.

⁵ Modularization is recognized as the possibility to assemble several structures, systems and components (SSCs) of the NPP in the manufacturing factory, thereby facilitating subsequent transport / relocation of such assembled modules to the construction site. (IAEA-TECDOC-2010).

⁶ 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).

⁷ Transportable NPP (TNPP) is defined in a footnote of DPP of SSR-2/1 (Rev.1) revision and reproduced here. It is an NPP designed to be geographically relocated as complete, or nearly complete, system. Some of such NPPs may utilize modularization for ease of assembly and deployment but are not physically attached to a transport platform during operation. These NPPs are relocated and installed at the site, however they are not designed for energy utilization during the relocation phase. Other NPPs are integrated with and remain attached to a transport platform, such as truck, or integrated with a ship, or barge, allowing the entire plant to be relocated and operated from the transport platform (or ship or barge) itself, such as floating NPPs. In this category, some NPPs (including nuclear merchant ships) may use the produced energy for propulsion. The definition is not final and will be refined during the drafting process, in close collaboration with DS562.

Fuel elements and devices for controlling the core reactivity and shutting down the reactor will not be addressed in SSG-56 (Rev.1). These topics will be covered in the proposed revision of the Specific Safety Guide SSG-52, Design of the Reactor Core for Nuclear Power Plants.

Systems for core cooling and residual heat removal in design extension conditions with severe accident where the integrity of reactor coolant boundary is degraded or compromised, to the extent that the fuel cooling function cannot be ensured, are not addressed in SSG-56 (Rev. 1). These topics will be discussed in the proposed revision of the Specific Safety Guide SSG-53, Design of the Reactor Containment and Associated Systems for Nuclear Power Plants⁸.

The scope of SSG-56 (Rev.1) does not extend to the detailed design of specific components. Design limits and engineering criteria, together with the system parameters that should be used to verify these limits and criteria, are specific to individual designs for nuclear power plants and are therefore outside the scope of SSG-56 (Rev.1). However, qualitative recommendations on these topics will be provided.

The interactions between safety and security and between safety and safeguards related to the design of the reactor coolant system and associated systems, will be considered in SSG-56 (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 contents of all relevant Safety Standards will be maintained, in particular with those currently under revision and proposed to be revised, SSR-2/1 (Rev. 1, DS562), SSR-2/2 (Rev. 1, DS532), SSG-30 (proposed to be revised), SSG-48 (DS561), SSG-52 (proposed to be revised), SSG-53 (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.

This Safety 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-30 – Safety Classification of Structures, Systems and Components in Nuclear Power Plants (2014), proposed to be revised;
- 7) SSG-34 – Design of Electrical Power Systems for Nuclear Power Plants (2016);
- 8) SSG-39 – Design of Instrumentation and Control Systems for Nuclear Power Plants (2016);
- 9) 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-53 – Design of the Reactor Containment and Associated Systems for Nuclear Power Plants (2019), proposed to be revised;

⁸ It is acknowledged that additional technical clarification will be necessary during the drafting of SSG-52 and SSG-53, particularly for molten salt reactors with liquid fuel, where definitions such as the reactor coolant boundary differ significantly from those of solid-fuel reactors.

13. SSG-61– Format and Content of the Safety Analysis Report for Nuclear Power Plants (2024);
14. SSG-62 – Design of Auxiliary and Supporting Systems for Nuclear Power Plants;
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 DS563;
18. SSG-68 – Design of Nuclear Installations Against External Events Excluding Earthquakes (2021), under revision as DS564;
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-56 (Rev.1) will be coordinated, as relevant, together 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-56.

7. OVERVIEW

The recommendations made in SSG-56 (Rev.1) will retain the overall structure and table of contents of the current SSG-56, 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 Sections 1 to 4 as in the current version. The recommendations corresponding to Sections 2 to 4 are expected to remain mainly technology-neutral and inclusive.

Section 5 will provide specific recommendations for the design of the reactor coolant system to meet the relevant requirements of SSR-2/1 (Rev. 1) under DS562 covering all reactor technologies within the scope of this DPP.

Sections 6 to 12 will provide technology specific and design specific recommendations for the design of the associated systems to meet the relevant requirements of SSR-2/1 (Rev. 1) under DS562 with each section dedicated to a specific technology or design. Sections 6 to 8 will remain largely unchanged from the current SSG-56 but take the latest experience and advancements of water-cooled reactors into account. Considering the current development status of non-water-cooled reactors, new Sections 9 to 12

will provide recommendations for the design of associated systems for HTGR, SFR, LFR and MSR technologies by mirroring the approach in Sections 6 to 8.

The recommendations in SSG-56 (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. EXTENT OF REACTOR COOLANT SYSTEM AND ASSOCIATED SYSTEMS
3. DESIGN BASIS OF THE REACTOR COOLANT SYSTEM AND ASSOCIATED SYSTEMS
4. ULTIMATE HEAT SINK AND RESIDUAL HEAT TRANSFER
5. SPECIFIC CONSIDERATIONS IN DESIGN OF THE REACTOR COOLANT SYSTEM
6. SPECIFIC CONSIDERATIONS IN DESIGN OF THE ASSOCIATED SYSTEMS FOR PWR TECHNOLOGY
7. SPECIFIC CONSIDERATIONS IN DESIGN OF THE ASSOCIATED SYSTEMS FOR BWR TECHNOLOGY
8. SPECIFIC CONSIDERATIONS IN DESIGN OF THE ASSOCIATED SYSTEMS FOR PHWR TECHNOLOGY
9. SPECIFIC CONSIDERATIONS IN DESIGN OF THE ASSOCIATED SYSTEMS FOR HTGR TECHNOLOGY
10. SPECIFIC CONSIDERATIONS IN DESIGN OF THE ASSOCIATED SYSTEMS FOR SFR TECHNOLOGY
11. SPECIFIC CONSIDERATIONS IN DESIGN OF THE ASSOCIATED SYSTEMS FOR LFR TECHNOLOGY
12. SPECIFIC CONSIDERATIONS IN DESIGN OF THE ASSOCIATED SYSTEMS FOR MSR TECHNOLOGY

APPENDIXS (IF NEEDED)

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 full 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 RF⁹ 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, safety, security and safeguards in the design.

Similarly, the IAEA's Nuclear Harmonization and Standardization Initiative (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 Track¹⁰, aims to create a harmonized and technology inclusive approach for the review of advanced reactor designs building the IAEA Safety Standards.

The work performed under the SMR RF and NHSI provides technical insights and common positions on issues such as passive and inherent safety features, defence in depth, multi-unit and multi-module facilities, shared systems, design extension conditions, and the integration of safety, security and safeguards. These findings support the revision of SSG-56 by identifying areas where additional or technology-specific guidance may be needed for advanced reactors and SMRs.

Recent IAEA General Conference resolutions have highlighted several important gaps and priorities related to the design safety of advanced reactors. The 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/2¹¹).

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 technical information necessary for the future revision of IAEA Safety Standards. For the revision of SSG-56, the relevant feedback analysis has primarily considered inputs from the following two aspects:

- 1) Feedback from publications related to the latest developments of nuclear reactors for power generation including water-cooled and non-water-cooled reactor technologies;
- 2) Feedback from the gap analysis conducted by the Safety Assessment Section using SSG-56 for selected non-water-cooled reactor technologies.

1. Feedback analysis from relevant IAEA publications supporting the revision of SSG-56

Over the years IAEA has published several publications 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.

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

The report identifies areas of novelty in SMRs, and non-water-cooled reactors 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 lifecycle of these technologies - from siting and design to decommissioning.

⁹ <https://gnssn.iaea.org/regnet/SMR-Forum/Pages/default.aspx>

¹⁰ <https://nucleus.iaea.org/sites/smr/SitePages/NHSI-Regulatory-Track.aspx?web=1>

¹¹ <https://www.iaea.org/sites/default/files/gc/gc67-inf2.pdf>

With respect to SSG-56, the report outlines areas of non-applicability and identifies gaps and topics for additional consideration. In general, it indicates that SSG-56 can be applied to ‘evolutionary and innovative designs’ (EIDs) with caution, but technical interpretation is necessary because its guidance is primarily based on global operating experience for pressurized water reactors (PWRs), boiling water reactors (BWRs), and pressurized heavy water reactors (PHWRs). Some recommendations in Sections 3 and 4, which are not dependent on reactor technology or design, could be applicable. However, gaps remain, such as inadequacies in addressing accident conditions, limiting parameters, systems designed to mitigate accident conditions, and equipment failure modes for non-water-cooled reactors.

Section 6 of SSG-56 is specific to PWR technology, for example, discussing adjustments to the boric acid concentration in the primary coolant. Some advanced reactor designs, however, may have a boron-free operation with only an emergency boron injection subsystem. Consequently, much of the guidance in this section may not apply to these designs.

Overall, the report emphasizes the need to incorporate reactor technology-specific and design-specific characteristics into design guidelines for reactor coolant system and associated systems.

Other relevant publications

The following publications provide insights into advanced reactor technologies and identify technical areas that may require consideration in the revision of SSG-5.

Cross-cutting publications

- Publications addressing advanced reactor and SMR characteristics, including 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, and SMR RF phase 2 summary report (2021); IAEA-TECDOC-2110, Approaches to and Preparation for the Operation of Small Modular Reactors, highlight issues such as alternative coolants, passive safety features, natural circulation, integral and compact configurations, modularity, multi-module operation, shared safety systems and advanced automation. These topics may affect the design of reactor coolant systems and associated systems.
- 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 Demonstration of Defence-in-Depth (DiD), Implementation for Nuclear Power Plants using Deterministic and Probabilistic Analyses (in preparation), and TECDOC on Progress in the performance assessment and regulation of passive safety features on advanced nuclear power plant designs (in preparation), identify approaches for evaluating the performance and reliability of passive safety features. The findings support the consideration of passive system reliability within the revision of SSG-56.
- IAEA-TECDOC-2134, Technical Basis for the Emergency Planning Zone for Small Modular Reactors, provide insights into reactor coolant system boundaries, confinement functions and radionuclide transport behaviour for advanced reactor technologies, these considerations may influence recommendations related to safety functions performed by reactor coolant systems.
- 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), identify potential implications for the qualification, fabrication and long-term performance of safety-significant components. These findings may support revisions related to materials selection, manufacturing processes and equipment qualification.

Technology-specific publications

- High temperature gas cooled reactors (HTGRs): IAEA-TECDOC-1936 (2020), Applicability of Design Safety Requirements to Small Modular Reactor Technologies Intended for Near-Term Deployment; TECDOC on Safety Considerations of High Temperature Gas Cooled Reactors (in preparation), identify safety considerations related to functional containment, defence in depth and design extension conditions, including severe accidents. These topics may require technology-specific guidance in the revision of SSG-56.

- Liquid metal fast reactors (LMFRs): IAEA-TECDOC-1569 (2007), Liquid Metal Cooled Reactors: Experience in Design and Operation, provides an overview of the global experience in design, operation and decommissioning of LMFRs; IAEA-TECDOC-1912 (2020), Challenges for Coolants in Fast Neutron Spectrum Systems; 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), identify safety considerations associated with liquid metal coolants, coolant chemistry, severe accident behaviour and technology-specific mitigation features. These findings may support the development of recommendations tailored to the design of reactor coolant system and associated systems for LMFRs.
- Molten salt reactors (MSRs): Technical Report Series No. 489 (2023), Status of Molten Salt Reactor Technology, provides an overview of current MSR designs and their classification; TECDOC on Considerations on the Safety of Molten Salt Reactors (in preparation), identify challenges associated with the unique characteristics of fuel and coolant salts, fulfilment of safety functions, defence in depth, design extension conditions and the applicability of existing regulatory requirements. These findings may support the development of recommendations tailored to the design of reactor coolant system and associated systems for MSRs.

2. Preliminary gap analysis

In 2025, the IAEA performed a gap analysis of HTGR, LMFR and MSR technologies against the recommendations of SSG-56. The review was conducted on a paragraph-by-paragraph basis for Sections 2, 3, 4 and 5 of SSG-56, and the applicability of each recommendation to the design of the reactor coolant system and associated systems for HTGR, LMFR and MSR¹². The review follows the methodology outlined and applied in IAEA-TECDOC-2010 and in IAEA-TECDOC-1936, and the relevant results in SR-123. The results of the review will guide the necessary modifications to each recommendation in SSG-56, 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 Sections 2, 3, 4, and 5 of SSG-56 are categorized as follows:

- For HTGR: approximately 16% fall under Category C3, 11% under C2, and 73% under C1;
- For LMFR: approximately 15% fall under Category C3, 5% under C2, and 80% under C1;
- For MSR: approximately 10% fall under Category C3, 26% under C2, and 64% under C1.

In summary, Sections 2, 3, 4, and 5 of SSG-56 could be made more technically inclusive by refining the wording or broadening the scope. Furthermore, new sections could be introduced to provide recommendations for the design of associated systems for selected non-water-cooled reactor technologies, depending on their design maturity and deployment status.

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 reactor coolant system and associated systems for all nuclear power plants included within the scope of this DPP to ensure, or to contribute to, the

¹² A preliminary gap analysis has been conducted for several representative NWCR technologies, including HTR-PM, GTHR300, lead-cooled fast reactor designs (such as BREST-OD-300, LFR-AS-200, SEALER-55 and SVBR-100), and the IMSR design developed by Terrestrial Energy. The main design characteristics of these technologies are described in the IAEA publication Small Modular Reactors Technology Catalogue 2024 Edition. The results of the gap analysis were presented and discussed during the first Consultancy Meeting on the Development of the DPP for the Revision of Safety Guide SSG-56 (EVT2502287).

achievement of the three fundamental safety functions (i.e. Requirement 4 of SSR-2/1 (Rev.1)), particularly reactivity control, heat removal, and confinement through the integrity of the reactor coolant boundary. It will also consider relevant operating experience and the current status of technological development¹³, to provide recommendations on how to meet the revised or newly introduced requirements in the revision of SSR-2/1 (Rev. 1) under DS562, such as:

1. Integral or compact design¹⁴ of the reactor coolant system;
2. Natural circulation of the reactor coolant system during normal power operation as considered for some advanced reactor designs;
3. Low-pressure or non-pressurised reactor designs;
4. Impact of inherent reactivity control features (i.e. based on physical principles, such as negative reactivity feedback) on the design of reactor coolant system and associated systems;
5. Limiting parameters considered for the design of reactor coolant system and associated systems of non-water-cooled reactors, particularly those using molten salt fuel or TRISO particle fuel;
6. Inherent and passive features for residual heat removal in shutdown conditions;
7. Inherent and passive safety features, and passive safety systems for core cooling and/or decay heat removal in accident conditions;
8. Chemical properties, parameters, and design considerations specific to non-water-cooled reactors due to the use of different coolants;
9. Design of intermediate heat transport systems in some of advanced reactors to decouple reactor operation from electricity generation and industrial heat demand;
10. Novel aspects introduced by multi-unit and multi-module designs, including shared safety systems;
11. Use of new materials not currently included in the applicable codes and standards or use of existing materials outside their qualification domain;
12. Design of associated systems, specific for:
 - HTGR technology (e.g. systems for gas purification during normal operation and dehumidification after water-ingress accident);
 - SFR technology (e.g. primary heat transport system; intermediate coolant systems; cover gas system; oxygen control and monitoring system; sodium processing system);
 - LFR technology (e.g. cover gas management system; oxygen control and monitoring system; temperature regulation system);
 - MSR technology (e.g. intermediate coolant system; systems for off-gas removal and cooling, fuel salt make-up and transfer, molten salt draining and cooling, prevention of fuel salt freezing).

It is important to emphasize that SSG-56 (Rev.1) will not be limited to these changes. SSG-56 already provides recommendations for meeting all relevant requirements related to the design of reactor coolant system and 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-56 (Rev.1) will consider relevant interfaces to ensure

¹³ 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 that available for water-cooled reactor technologies, for which considerably more design, operational, and licensing experience exists.

¹⁴ As defined in IAEA-TECDOC-2010.

alignment and coherence across the IAEA Safety Standards.