

Risk and Safety Working Group

The RSWG was formed in 2005 to promote a consistent approach to safety, risk and regulatory issues between the six Gen-IV systems, and to establish broad safety principles and attributes as input to R&D plans for specific design tracks based on high-level GIF safety and reliability goals. In 2021, RSWG membership included representatives from Canada, China, the European Union, France, Japan, Korea, South Africa, Russia, the United Kingdom and the United States. The IAEA Safety Department also participates as an observer.

The RSWG has developed the integrated safety assessment methodology (ISAM) as a technology-neutral toolkit to support design and evaluate risk and safety. After completion of the ISAM, the RSWG also supported its implementation by GIF System Steering Committees (SSCs) for specific Gen-IV design tracks as documented in a series of system-specific white papers. More recent emphasis has been placed on the preparation of system safety assessments as a summary of high-level safety design attributes and remaining R&D needs, also in close coordination with the respective GIF SSCs. Two ISAM documents, as well as the white papers and system safety assessment reports completed to date, are available on the GIF RSWG web page.¹

The first RSWG accomplishment in 2021 was the publication of the GIF report, *Basis for the Safety Approach for Design & Assessment of Generation IV Nuclear Systems* (GIF, 2021). As an update to the original 2008 version, the report aims to:

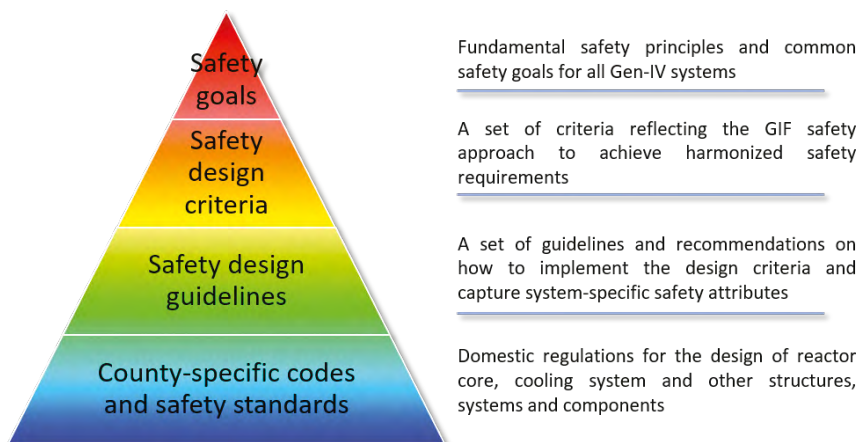
- capture the post-Fukushima recommendations and requirements to ensure a level of safety consistent with the regulatory expectations;

- provide common definitions for the plant states considered in a design and their alignment with the levels of defense in depth;
- clarify the concepts of design extension conditions and practically eliminated situations;
- achieve a balance between the prevention and mitigation of accidents, emphasizing the importance of reliance on inherent and passive safety;
- reinforce the independence of safety systems and features in different defense-in-depth levels.

The development of safety design criteria (SDC) and guidelines for specific systems is also an ongoing collaborative effort between the RSWG and SSCs to establish the basic requirements for design, fabrication, construction, inspection, testing and operation of Gen-IV prototypes. As shown in Figure RSWG-1, the SDC and guidelines are intended to fill the gap between the high-level GIF safety goals and country-specific codes and standards.

In 2021, the *Safety Design Criteria for Generation IV Lead-Cooled Fast Reactor System* report (GIF, 2021) was completed in collaboration with the LFR provisional SSC. Based on SFR SDC as the starting point, the LFR SDC introduces specific revisions that capture the impact of differences between sodium and lead as a very low Prandtl number liquid metal coolant with large thermal inertia and very high density, freezing and boiling points, induced coolant activity, and corrosion/erosion challenges posing elevated material compatibility concerns and requiring an elevated level of coolant purity control. Unique LFR thermo-fluid system designs with integrated primary coolant and power conversion systems (without an intermediate loop) are also addressed.

Figure RSWG-1: Hierarchy of safety standards



1. See: www.gen-4.org/gif/jcms/c_9366/risk-safety.

The LFR SDC mandates the robust assessment of accidents that may lead to core melt so as to demonstrate their practical elimination with a high degree of confidence.

The RSWG is currently collaborating with the VHTR SSC for SDC development. In 2021, an informal subgroup was created, gathering RSWG and VHTR SSC experts, who completed the first draft of SDC largely based on two previous IAEA efforts to revise the IAEA SSR 2/1 requirements for HTGRs. The draft VHTR SDC addresses consistency with the GIF basic safety approach and IAEA safety standards for design extension conditions, clarifies the requirements for confinement function versus the conventional containment structure, and introduces revisions and new requirements for the VHTR fuel forms based on coated fuel particles, as well as for unique coolant and decay heat removal system designs. The SDC development effort is expected to continue throughout 2022, before the report can be finalized.

The RSWG maintains technical interfaces with the OECD/NEA Working Group on the Safety of Advanced Reactors (WGSAR), which operates under the Committee on Nuclear Regulatory Activities (CNRA). In the past, the working group performed independent reviews of the SFR SDC and produced two SFR safety design guideline reports, providing extensive comments that led to significant revisions. Following its completion, the WGSAR is currently performing an independent review of the LFR SDC, and feedback is anticipated in 2022. In 2021, the RSWG also coordinated GIF contributions to the WGSAR report on "Fuel Qualification for Generation-IV Nuclear Energy Systems." GIF contributions provide high-level descriptions of SFR, VHTR, GFR, MSR, LFR and SCWR fuel types and forms, their role in the safety case and anticipated challenges for their qualifications.

Ongoing RSWG-WGSAR collaboration also includes the new joint initiative for the development of a risk-informed approach to the selection of licensing basis events and safety classification of systems, structures and components. In 2021, a position paper that introduces the foundational concepts and main elements of the approach was finalized by the RSWG and was distributed to WGSAR members. The paper establishes the event sequence categories considered in design to integrate the deterministic input and risk insights, defines a generic frequency-consequence target structure to categorize the event sequences against the regulatory requirements, outlines a process to classify the plant equipment based on their risk-significance and role in plant safety, and supports the selection of design-basis accidents and design extension conditions consist-

ent with the safety classification of the responding plant equipment. Based on WGSAR comments and input, the position paper is expected to be finalized in 2023.

The RSWG also maintains technical interfaces with the IAEA and participates in the new IAEA initiative on the development of safety standards for SMRs and novel advanced reactors. Since these reactors have many technical similarities to GIF systems, selected RSWG experts have been sharing GIF experience while identifying system-specific safety features and supporting completion of the IAEA report on the applicability of IAEA safety standards to novel advanced reactors. The RSWG also contributes to the organization of joint IAEA-GIF technical meetings on the safety of liquid metal-cooled fast reactors that focus on the development of safety design guidelines (SDGs) for SFRs and SDC for LFRs.

Having completed most of its 2019 missions, the SFR Safety Design Criteria Task Force (SDC-TF) members have now joined the RSWG, and the remaining work on updating the SDGs for SFR systems, structures and components based on IAEA and WGSAR comments is being subsumed by the RSWG. IAEA and WGSAR comments are currently being addressed, and they are expected to be incorporated into the next version of the report in 2022. These new RSWG members (former SDC-TF members) will also support the pilot implementation of the proposed risk-informed approach for GIF SFR design tracks to demonstrate its applicability and ensure its consistency with the SFR SDC and SDG reports completed in earlier years.

References

GIF (2021), *Safety Design Criteria for Generation IV Lead-Cooled Fast Reactor System*, GIF, Paris, available at: www.gen-4.org/gif/upload/docs/application/pdf/2021-04/lfr-sdc_report_rev_1_march_2021.pdf.

GIF (2021), *Basis for the Safety Approach for Design & Assessment of Generation IV Nuclear Systems*, Revision 2, GIF, Paris, available at: www.gen-4.org/gif/jcms/c_178828/bsa-update-v4-clean.



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Chair of the RSWG, with contributions from RSWG members