SPESS F
Document Preparation Profile (DPP)
Version 1, dated 03-Apr-2025

1. IDENTIFICATION

Document Category or batch of publications to be revised in a concomitant manner

Specific Safety Guide

Working ID: **DS560**

Proposed Title: **Development and Application of Level 3 Probabilistic Safety Assessment for Nuclear Power Plants**

Proposed Action: **new publication**

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

Technical Officer(s): Shahen POGHOSYAN (NSNI/SAS), Dmitry SIROTKIN (NSNI/SAS)

2. BACKGROUND

A Level 3 Probabilistic Safety Assessment (PSA) provides estimates related to the public health and other radiological consequences (e.g. contamination of land or food) from the accident sequences that lead to a release of radioactive material to the environment. In the conventional progressive three-level PSA framework for nuclear power plants (NPPs), a Level 3 PSA represents the final level of assessment, focusing on the radiological consequences attributable to individual and societal risk (e.g. radiation doses, health effects, contaminated areas, associated economic costs) due to accidents at NPPs and other nuclear installations. A Level 3 PSA is directly aimed at assessing the risk for people and the environment from nuclear installations, and therefore constitutes an important tool to be used in achieving compliance with the fundamental safety objective "to protect people and the environment from harmful effects of ionizing radiation" as the IAEA Fundamental Safety Principles, Safety Fundamentals No. SF-1 states.

While Level 1 and Level 2 PSAs have now been carried out for most NPPs worldwide, estimating core/fuel damage frequency and radiological release frequency correspondingly, Level 3 PSA studies are relatively infrequent, however, there have been recent advancements in research and some national regulations in the area of Level 3 PSA.

A Level 3 PSA is explicitly required by the national regulations in some Member States, while in most countries, the nuclear regulatory authorities do not mandate the performance and submission of a Level 3 PSA for NPPs. Nevertheless, an increasing number of organizations in a multitude of Member States are engaged in the advancement and implementation of Level 3 PSA highlighting its benefits for risk informed decision making process and other applications, e.g. supporting emergency planning, public and industry risk communication. The growing interest is also driven by the rapid developments in the area of non-water-cooled reactors, for which the traditional risk metrics connected with core damage might not be representative, and risk metrics related to the off-site radiological consequences could be applied in order to gain meaningful risk insights with regard to the factors influencing public health (see also IAEA SSG-3(Rev.1), 2.11(d)).

Also, following the Fukushima accident, additional interest was expressed by Member States in relation to Level 3 PSAs, particularly for assessment of multi-unit accidents involving multiple source term releases.

Compared to Level 1 and Level 2 PSA, for which the methodologies are sufficiently developed and documented in various guidance documents, including in two IAEA Specific Safety Guides SSG-3 (Rev.1) and SSG-4 (Rev.1), there is no IAEA Safety Guide which establishes the recommendations on Level 3 PSA. The IAEA Safety Series No. 50-P-12, published in 1996, is the sole publication on Level 3 PSA. It discusses the purpose of a Level 3 PSA, the generic methodology, and provides descriptions of the procedure, review, and management of a Level 3 PSA project. This publication represents neither a detailed procedural guide, nor an exhaustive set of recommendations for meeting the requirements of GSR Part 4 (Rev. 1) in relation to development and application of Level 3 PSA.

3. JUSTIFICATION FOR THE PRODUCTION OF THE PUBLICATION

Currently, there is no Safety Guide on development and application of Level 3 PSA for NPPs and this gap was highlighted when reviewing the applicability of current Safety Standards to non-water cooled reactors and small modular reactors (SMRs), which is summarised in IAEA Safety Reports Series No. 123. The existing IAEA Safety Series No. 50-P-12, representing a high-level, non-prescriptive introduction to the assessment, does not cover the variety of considerations and recent advancements in the area of Level 3 PSAs which form the state-of-the-art methodology for carrying out a Level 3 PSA. Therefore, the existing publication cannot be updated or amended to adequately reflect an increasing need for guidance on Level 3 PSAs.

The proposed Safety Guide will provide guidance to perform Level 3 PSAs aiming to evaluate the radiological consequences attributable to individual and societal risk, taking into account the latest developments in the area of Level 3 PSAs and considerations from accumulated practices and Member States' experience, as well as lessons learned from the Fukushima accident.

The proposed Safety Guide will complement the existing set of IAEA Safety Guides on PSA SSG-3 (Rev. 1) and SSG-4 (Rev. 1) and complete the overall PSA framework in the IAEA Safety Standards.

4. OBJECTIVE

The objective of the proposed publication is to provide recommendations for meeting the requirements of GSR Part 4 (Rev. 1), SSR-1, SSR-2/1 (Rev. 1), SSR-2/2 (Rev. 1) and GSR Part 7 regarding the evaluation of the radiological consequences in case of accidents with radioactive releases at NPPs.

It is expected that the Safety Guide, which will support harmonisation of Level 3 PSA methodology, will promote technical consistency among Level 3 PSA studies and their application to risk informed decision making.

In addition, this Safety Guide will provide a standard framework to facilitate a regulatory review or peer review of a Level 3 PSA and its various applications.

The Safety Guide is intended for use by designers, operating organizations, technical support organizations and regulatory bodies in the development, application and independent review of Level 3 PSAs.

5. SCOPE

This proposed Safety Guide will address the necessary methodological technical features of a Level 3 PSA and its applications for NPPs (both existing and new NPPs), on the basis of internationally

recognized good practices and Member States' experience. The Safety Guide will emphasize the procedural steps and essential elements of the PSA rather than the details of the modelling methods.

The Safety Guide will focus mostly on the off-site consequences, however, aspects related to the on-site consequences assessment will also be addressed in the Safety Guide.

The Safety Guide will focus on releases of radioactive material resulting from severe accidents in the reactor and in the spent fuel pool (SFP). The Safety Guide will also cover the development of a multi-unit Level 3 PSA for sites where several units are located (including sites with multi-module SMRs), suitable for use where national regulatory requirements require such an assessment.

Other sources of radioactivity from the plant (e.g. dry storage of irradiated fuel, stored radioactive waste) are out of the scope of the Safety Guide. However, it is expected that the recommendations in the Safety Guide may also be applied for sources of radioactivity other than reactors and SFPs, with judgement.

The consideration of hazards arising from malicious acts is out of the scope of this Safety Guide.

The recommendations of this Safety Guide are intended to be technology inclusive to the extent possible, and it is expected that the recommendations will be applicable to various types of nuclear power plants, including SMRs and non-water cooled reactors.

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

The proposed Safety Guide falls within the thematic area of safety assessment and will interface with the following IAEA Safety Standards and other publications (this is not, and cannot be, regarded as an exclusive or exhaustive list):

- GSR Part 4 (Rev. 1) – Safety Assessment for Facilities and Activities (2016)
- GSR Part 7 – Preparedness and Response for a Nuclear or Radiological Emergency (2015)
- SSR-1 – Site Evaluation for Nuclear Installations (2019)
- SSR-2/1 (Rev. 1) – Safety of Nuclear Power Plant: Design (2016)
- SSR-2/2 (Rev. 1) – Safety of Nuclear Power Plants: Commissioning and Operation (2016)
- SSG-2 (Rev. 1) – Deterministic Safety Analysis for Nuclear Power Plants (2019)
- SSG-3 (Rev. 1) – Level 1 Probabilistic Safety Analysis for Nuclear Power Plants (2024)
- SSG-4 (Rev. 1) – Level 2 Probabilistic Safety Analysis for Nuclear Power Plants (2025)
- DS529 Investigation of Site Characteristics and Evaluation of Radiation Risks to the Public and the Environment in Site Evaluation for Nuclear Installations (revision of NS-G-3.2). The proposed Safety Guide will make special reference with DS529 where detailed recommendations are provided on all radiation dispersion mechanisms in air, water and groundwater to be considered in case of accidental releases.
- GSG-10 Prospective Radiological Environmental Impact Assessment for Facilities and Activities (2018)
- Safety Report No. 123 – Applicability of IAEA Safety Standards to Non-Water Cooled Reactors and Small Modular Reactors (2023)
- Safety Report No. 110 – Multi-unit Probabilistic Safety Assessment (2023)

- Safety Report No. 96 – Technical Approach to Probabilistic Safety Assessment for Multiple Reactor Units (2019)
- Safety Series No. 50-P-12 – Procedures for Conducting Probabilistic Safety Assessment of Nuclear Power Plants (Level 3). Off-Site Consequences and Estimation of Risks to the Public (1996)

Given the interfaces with other IAEA Safety Standards listed above, the Safety Guide is planned to be developed in close co-operation with NSNI/EESS, NSRW and IEC.

7. OVERVIEW

The Safety Guide will include the following contents (the contents may be adjusted during the development of the publication):

1. INTRODUCTION
2. GENERAL CONSIDERATIONS RELATING TO THE PERFORMANCE AND USE OF LEVEL 3 PSA
3. PROJECT MANAGEMENT AND ORGANIZATION FOR LEVEL 3 PSA
4. DETERMINATION OF LEVEL 3 PSA CONSEQUENCES AND ASSOCIATED RISK METRICS
5. ENVIRONMENTAL TRANSPORT AND DISPERSION MECHANISMS
6. INPUT DATA AND PREREQUISITES
7. INTERFACES WITH LEVEL 1/2 PSA
8. EXPOSURE PATHWAYS AND RADIOLOGICAL CONSEQUENCE ASSESSMENT
9. CONSIDERATION OF COUNTERMEASURES
10. QUANTIFICATION AND ANALYSIS OF RESULTS
11. DOCUMENTATION OF ANALYSIS
12. LEVEL 3 PSA FOR SPENT FUEL POOL
13. LEVEL 3 PSA FOR MULTI-UNIT NUCLEAR POWER PLANTS
14. USE AND APPLICATIONS OF LEVEL 3 PSA

REFERENCES

ANNEXES (e.g., specific examples and Member States experience)

8. PRODUCTION SCHEDULE:

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

	A*
STEP 1: Preparing a DPP	DONE
STEP 2: Internal review of the DPP (Approval by the Coordination Committee)	Q1 2025
STEP 3: Review of the DPP by the review Committee(s) (Approval by review Committee(s))	Q2 2025
STEP 4: Review of the DPP by the CSS (approval by CSS) or information of the CSS on the DPP	Q4 2025
STEP 5: Preparing the draft publication	Q1 2027

STEP 6: First internal review of the draft publication (Approval by the Coordination Committee)	Q1-Q2 2027
STEP 7: First review of the draft publication by the review Committee(s) (Approval for submission to Member States for comments)	Q2 2027
STEP 8: Soliciting comments by Member States	Q4 2027
STEP 9: Addressing comments by Member States	Q3 2028
STEP 10: Second internal review of the draft publication (Approval by the Coordination Committee)	Q3 2028
STEP 11: Second review of the draft publication by the review Committee(s) (Approval of the draft)	Q4 2028
STEP 12: (For Safety Standards) Editing of the draft publication in MTCD and endorsement of the draft publication by the CSS (For nuclear security guidance) DDG's decision on whether additional consultation is needed, establishment by the Publications Committee and editing	Q3 2029
STEP 13: Approval by the Board of Governors (for SF and SR only)	N/A
STEP 14: Target publication date	Q4 2029

9. RESOURCES

Secretariat:

- 24 staff weeks

Member States:

- 15 consultant weeks (assuming 3 one-week consultancy meetings, each with 5 experts)
- 6 consultant weeks (assuming 6 one-week home based assignments)

ANNEX: Gap Analysis

Long term structure of the IAEA Safety Standards and current status, November 2024, envisages the addition of a Safety Guide for Level 3 PSA.

In 2023, the IAEA completed Safety Report No. 123 which comprises the outcomes of a high level review of applicability of the IAEA safety standards to various technologies, including SMRs and non-water cooled reactors. The report emphasizes that a specific Safety Guide on the PSA of off-site consequences might become important for the safety demonstration of those evolutionary and innovative designs, for which some of the risk metrics typically used in water-cooled reactors, may not be applicable.

At the 52nd NUSSC Meeting in November 2021, NUSSC requested the Secretariat to develop a DPP for new Safety Guide on development and application of Level 3 PSA (see item 4.1 under actions following the 52nd NUSSC Meeting).

In addition, in 2012, the IAEA published the Working Material (Rev. 0) Output of the IAEA Technical Meeting on Level 3 Probabilistic Safety Assessment held in July 2-6, 2012. The publication contains information on national practices relating to the status, methodology, requirements, and up-to-date developments in the area of Level 3 PSA in 16 countries. Based on technical discussion, observations and identified gaps, the following recommendation was provided by the participants of the Technical Meeting to the IAEA:

"Consider developing (or updating the existing Safety Series publication (i.e. the IAEA Safety Series No. 50-P-12, 1996) guidance on performance and application of Level 3 PSA to take account of

experience accumulated (both experience in the performance of Level 3 PSA and the experience from other industries), advances in treatment of important issues, and lessons learned from the Fukushima accident addressing emerging issues. The guidance should address the following (recognizing that the importance of some of these topics has only recently been recognized and developments are ongoing):

- *Longer-term accident scenarios;*
- *Evaluation of aquatic pathways and ocean contamination;*
- *Evaluation of land contamination and economic loss;*
- *Impact of filtered containment venting;*
- *Evaluation of multiple source term;*
- *Integral site-wide risk evaluation considering all hazards (internal, external, combined hazards) and all sources of radioactivity;*
- *Modelling countermeasures in conditions of infrastructure damage by extreme external events;*
- *Treatment of large uncertainties associated with Level 3 PSA in decision making."*