Document Preparation Profile (DPP)
Draft 3 (for submission to CSS)

1. IDENTIFICATION

Document Category Safety Guide

Working ID: DS 482

Proposed Title: Design of Reactor Containment Systems for Nuclear Power Plants

Proposed Action: Revision of the Safety Guide NS-G-1.10, IAEA, Vienna (2004)

Review Committee(s) or Group: NUSSC, NSGC

Technical Officer: Bernard Poulat

2. BACKGROUND

The IAEA Safety Guide NS-G-1.10,"Design of Reactor Containment Systems for Nuclear Power Plants" was published in 2004 to provide recommendations and guidance on how to comply with the requirements included in NS-R-1, "Safety Requirements on the Safety of Nuclear Power Plants: Design" of 2000. A decade later, in 2012, NS-R-1 was superseded by a new version, SSR-2/1, "Safety of Nuclear Power Plants: Design" whose objective was to better clarify to what extent severe accidents shall be considered for design, and to give a target for an upper limit for the associated radiological consequences. Consequently, the plant state categories were supplemented by incorporating in the design of the plant some former beyond design basis accidents as new design extension conditions. Avoiding unacceptable consequences for the public, the environment and the society by practically eliminating the sequences possibly leading to significant releases was also a new concept introduced in SSR 2/1 publication.

The IAEA Secretariat, following the request made by the Member States at the Ministerial conference held in June 2011, was requested by the General Conference, held in September 2011, to review and to revise as necessary the IAEA Safety Standards taking into account the analysis of the Fukushima Daiichi accident.

3. JUSTIFICATION FOR THE PRODUCTION OF THE DOCUMENT

On the basis of the outcomes of the review presented during the 35th NUSSC meeting, NUSSC approved the need to revise the Safety guide NS-G-1.10 "Design of Reactor Containment Systems for Nuclear Power Plants" to make it consistent with the requirements in SSR-2/1 amended by the addendum DS 462.

4. OBJECTIVE AND SCOPE

The revision of NS-G-1.10,"Design of Reactor Containment Systems for Nuclear Power Plants" aims at providing recommendations and guidance on how to comply with the requirements given by SSR2/1 supplemented with the amendments of DS 462. Particular attention will be paid to the role of the containment systems both for accidents without and with core melt taking into account the objectives in terms of protection of the public and the environment have been enhanced.
This revision is intended to apply primarily to new plants, and as the updated requirements might not be fully met at some existing plants designed to earlier standards, a specific section addressing recommendations and guidance on how to strengthen the capabilities of the existing containment systems will be kept.

In addition, the revision will consider the main outcomes of the reviews presented during the different NUSSC meetings (some examples are indicated in annex 1 of the DPP document).

Among modifications to be implemented, particular attention will be paid to provide:

- Recommendations to establish the design basis[1] of the containment systems with account taken of the relevant design basis accidents and design extension conditions,
- Recommendations to apply defence in depth to the containment systems,
- Recommendations to determine the relevant loads and combination of loads likely to occur in the different plant states and the associated acceptance criteria or stress limits,
- Recommendations to identify additional specific items to practically eliminate significant radiological releases,
- Recommendations regarding expected margins needed to avoid cliff edge effects and significant releases in case of internal events or external hazards,
- Recommendations to design connections for mobile equipment as well as use of mobile equipment to support the containment function.

Additional revisions to the document will include:

- The structure of the contents will be modified first to provide recommendations and guidance for the design of the containment systems of new plants, then a dedicated section on specific recommendations for existing plants, or guidance on how to strengthen the capabilities of the existing containment systems to some extend where it is reasonably practicable. Recommendations and guidance which apply to both types of plants will not be duplicated,
- ,Annex 1 will provide examples of solutions already back fitted to existing plants to illustrate the expectations in terms of feasibility
- Annex II will be updated if necessary according to the current practices for the containment isolation,
- Annex III " Severe accident phenomena" will be updated if necessary taking into account the current knowledge,
- Aspects that are covered in other safety guides, in particular related to safety classification and guidelines for severe accident management should be reduced to a minimum and linked to the appropriate safety guides,
- The terminology of the guide needs to be revised and be made consistent with the new definition of plant state categories introduced in SSR 2/1, i.e. the inclusion of design extension conditions (DECs) and the consideration of severe accidents in the design basis,
- The recommendations in the safety guide will be reformulated as necessary to align with the current design requirements in SSR-2/1,

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[1] The design basis of a SSC important to safety should be understood as the set of conditions, needs and requirements taken into account for its design as for examples, but not limited to: safety class, seismic category, quality grade, performances, loads and conditions for operation, lifetime.
Rules and methods to determine the design basis of SSCs of different safety significance may follow a graded approach. Equipment design basis is generally detailed and supplemented by Specification sheet.

- The safety guide will include the necessary changes to consider addendum to SSR-2/1 (DS 462).

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

The new version will be directly related to SSR-2/1, and will be consistent with the requirements, definitions and terminology given in:

- Radiation Protection and Safety of Radiation Sources, General Safety Requirement GSR part 3,
- Safety Assessment for Facilities and Activities, General Safety Requirement GSR part 4,
- Site Evaluation for Nuclear Installations, Safety Requirement NS-R-3.

Interface with other Safety Guides and Security guides will also be considered, including:

- External Events Excluding Earthquakes in the Design of Nuclear Power Plants, NS-G-1.5,
- Seismic Design and Qualification for Nuclear Power Plants, NS-G-1.6,
- Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants, NS-G-1.7,
- Design of the Reactor Coolant System and Associated Systems for Nuclear Power Plants, NS-G-1.9,
- Protection against Internal Hazards other than Fires and Explosions in the Design of Nuclear Power Plants, NS-G-1.11,
- Design of the Reactor Core for Nuclear Power Plants, NS-G-1.12,
- Design of Emergency Power Systems for Nuclear Power Plants, DS 430,
- Safety Classification of SSCs in Nuclear Power Plants, DS 367.
- Severe Accident management Programme for Nuclear Power Plants, DS 483
- Instrumentation and Control Systems Important to Safety in Nuclear Power Plants, DS 431,
- Deterministic Safety Analysis for Nuclear Power Plants, SSG-2,
- Security guides NSS-13 and NSS-14.

6. OVERVIEW

The revised document should have a structure in line with the current format and content of specific safety guides and a scope consistent with the relevant safety requirements of SSR 2/1. It is planned that the document will include the following paragraphs:

1. INTRODUCTION
Background
Objective
Scope
Structure

2. CONTAINMENT SYSTEMS AND THEIR SAFETY FUNCTIONS
General
Confinement of radioactive material
Protection against external events
Biological shielding

3. GENERAL DESIGN BASIS OF CONTAINMENT SYSTEMS

4. DESIGN OF CONTAINMENT SYSTEMS

5. TESTS AND INSPECTIONS

6. PLANTS DESIGNED WITH EARLIER STANDARDS

APPENDIX: INSTRUMENTATION FOR MONITORING AND TESTING OF THE CONTAINMENT

REFERENCES

ANNEX I: EXAMPLES OF CONTAINMENT DESIGNS

ANNEX II: ILLUSTRATION OF CATEGORIES OF ISOLATION FEATURES

ANNEX III: CHALLENGES TO CONTAINMENT POSED BY SEVERE ACCIDENTS

CONTRIBUTORS TO DRAFTING AND REVIEW BODIES FOR THE ENDORSEMENT OF SAFETY STANDARDS

7. PRODUCTION SCHEDULE:

Provisional schedule for preparation of the document:

STEP 1: Preparing a DPP	DONE
STEP 2: Approval of DPP by the Coordination Committee	July 2013
STEP 3: Approval of DPP by the relevant review Committees	October 2013
STEP 4: Approval of DPP by the CSS	November 2013
STEP 5: Preparing the draft	February 2015
STEP 6: Approval of draft by the Coordination Committee	April 2015
STEP 7: Approval by the relevant review Committees for submission to Member States for comments	Q2 2015
STEP 8: Soliciting comments by Member States	Q4 2015
STEP 9: Addressing comments by Member States	Q1 2016
STEP 10: Approval of the revised draft by the Coordination Committee Review in NS-SSCS	Q2 2016
STEP 11: Approval by the relevant review Committees	Q2 2016
STEP 12: Endorsement by the CSS	Q3 2016
STEP 13: Publication Committee	Q4 2016
STEP 14: Target publication date	Q1 2017

8. RESOURCES

It is envisaged that the development of the document would entail the organization of 3 consultancy meetings and 1 Technical Meeting for the production of the draft, and 2 further consultancy meetings for addressing comments from Member States, NUSSC and CSS.

ANNEX 1

Nuclear Safety Standards Committee

35th Meeting

24 – 28 June 2013

Agenda item 1.9

Pilot Review of Safety Guides

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Main conclusion:

As the latest revision of NS-G-1.10 was published in 2004 this Safety Guide didn't reflect the updates brought by the IAEA Requirement SSR2/1.
Main outcomes of the review of this Safety Guide :

- **Provide up to date guidance to meet the latest SSR2/1 design requirements relevant for containment systems of new plants,**
- **keep a specific section providing guidance for backfitting the containment systems of the existing plants with account taken of the various analyses performed by the Member States following the Fukushima Daichi accident.**

NS-G- 1.10 should be entirely re-formatted to better clarify the design basis of the containment systems for new plants and to include recommendations for the backfitting of the containment systems of the existing plants where it is feasible. Strengthening containment capabilities of the existing plants by backfitting modifications should be the priority prior to rely on mobile equipment.

This table does not provide a complete view of all the needed modifications but indicates the primarily modifications currently envisaged for which an agreement of the NUSSC is needed before going further.

DPP has to be prepared with account taken of this analysis as input.

Proposal following NUSSC WG meeting held from 5 to 8 March 2013	NSG-1-10
5.7.An analysis of the postulated initiating events for the plant shall be made to establish the preventive measures and protective measures that are necessary to ensure that the required safety functions will be performed.	See para 3.3: Design extension conditions that might necessitate confinement or might challenge the containment integrity should be considered for new and existing plants (Reactor pressure vessel failure at low pressure with the associated phenomena for design with an in vessel corium retention strategy or an ex vessel corium retention strategy).
Requirement 19: Design basis accidents **5.25 The design shall be such that for design basis accident conditions, key plant parameters do not exceed the specified design limits. A primary objective shall be to manage all design basis accidents so that they have no, or only minor, radiological impacts, on or off the site, and do not necessitate any off-site intervention measures**.	3.9 … **For new plants.** The design of the containment systems should be such that design basis accidents have no, or only minor radiological impacts, on or off the site, and do not necessitate off-site intervention measures. For design basis accident, key parameters for the containment systems do not exceed the specified design limits.
Requirement 20: Design extension conditions **5.29(d) Shall include sufficient design margins to remain operational in conditions moderately more severe than those considered in their design basis to avoid cliff edge effects to occur.**	Loads and combination of loads caused by design extension conditions should be addressed and the stress limits established. 3.17 Internal events and Margins

Proposal following NUSSC WG meeting held from 5 to 8 March 2013	NSG-1-10
5.31 The design shall be such that conditions that could lead to significant radioactive releases are practically eliminated (see footnote 1).	See para. 6.5: to be modified to apply for both new and existing plants, by design for the new plants, by backfitting the existing plants. See para 3.21: New plants: Design extension conditions should be considered for the design of the containment systems. Less conservative rules may be used.
5.31.a For design extension conditions only protective measures that are of limited scope in terms of area and time shall be necessary for protection of the public, and sufficient time shall be made available to implement these measures.	See para. 6.6 and 3.21: New plants: For DEC the design of the containment systems should be such only protective measures that are of limited scope in terms of area and time shall be necessary for protection of the public, and sufficient time shall be made available to implement these measures. Key parameters for the containment systems should not exceed the specified limits. Not strictly applicable to existing plants. Guidance given by para 6.4 is correct but should be slightly modified to strengthen the capabilities of the unit as much as feasible prior to rely on mobile equipment.

Proposal following NUSSC WG meeting held from 5 to 8 March 2013	NSG-1-10
2.13. (4) The purpose of the fourth level of defence is to mitigate the consequences of accidents that result from failure of the third level of defence in depth. This level is aimed at preventing the progression of fuel damage and mitigating consequences of severe accidents. **In case of a severe accident, the most important objective for this level is to ensure the confinement function, thus ensuring that significant radioactive releases (footnote) would be practically eliminated**.	Significant releases as defined in SSR 2/1 should be practically eliminated by design for the new plants, and by backfitting modifications for the existing plants if not already implemented in the original design.
6.28 a **The design shall include features to facilitate the use of alternative/mobile equipment for removing heat from the containment for preserving its integrity in case of loss of all containment cooling systems**	See para. 6.4 for existing plants and 6.6.a for new plants For existing plants, for the management of the conditions which were not considered in the original design, a full use should be made of all available equipment, including mobile equipment available at the site or from off site. Nevertheless, the installation of additional equipment (backfitting) to the extent practicable should be considered as a first priority in order to improve the capabilities of the containment systems for preventing or mitigating the consequences of severe accidents. For new plants, the consequences of the design extension conditions should be mitigated without the use of non-permanent equipment. For conditions exceeding those considered for the Design Extension Conditions, large releases should be avoided and mobile equipment might be used to restore the plant resources and hence to maintain the confinement function provided that the time delay for its installation is consistent with the plant autonomy and capacities.

Proposal following NUSSC WG meeting held from 5 to 8 March 2013	NSG-1-10
6.28.b **The loss of containment integrity shall be practically eliminated. This shall be achieved without significant radioactive releases**	. 6.20 to be modified: 1. The containment venting should not be the primarily mean to prevent containment over pressurization, 2. When necessary, the opening of the containment venting line should not lead to significant radioactive releases, 3. For DBAs, containment venting should not be necessary to maintain containment structural integrity.
5.21 The design of items important to safety shall provide for adequate provisions or margins to avoid cliff edge effects in the event of a external hazard of a severity or duration moderately exceeding that considered in their definition. **For systems and structures necessary to prevent significant radiological releases, this requirement shall be fulfilled with significant margins to accommodate with external hazards of a severity or duration exceeding that considered in their definition.**	New plants: 3.17 should be supplemented so that the design of the containment systems will provide significant margins to accommodate with external hazards of a severity or duration exceeding those considered in their definition Note: Margins requested by the current revision of NS-G-1.10 are appropriate to cover cliff edge effect. For existing plants, the original design should be periodically re assessed on the basis of up to date knowledge and methodologies to estimate the margins.

Proposal following NUSSC WG meeting held from 5 to 8 March 2013	NSG-1-10
2.13 a The independent effectiveness of each of the different levels of defence is an essential element of defence in depth at the plant and this is achieved by incorporating measures to avoid the failure of one level of defence causing the failure of other levels. The independence of levels three and four is of particular relevance because of the severity of potential consequences should simultaneous failures of these two levels occur.	For new plants para. 4.11 needs to be modified to reflect this requirement. E.g. Containment systems implemented to cope with core melt accident should be specific and independent from other systems.
5.17. The design shall include due consideration of those natural and human induced external events (i.e. events of origin external to the plant) that have been identified in the site evaluation process. Natural external events shall be addressed. ~~including meteorological, hydrological, geological and seismic events.~~ Human induced external events arising from nearby industries and transport routes shall be addressed. Causality and likelihood shall be considered in postulating potential concurrent hazards. In the short term, the safety of the plant shall not be permitted to be dependent on the availability of off-site services such as electricity supply and fire fighting services. The design shall take due account of site specific conditions to determine the maximum delay time by which off-site services need to be available.	. Para 3.7: For new plants the crash of a commercial airplane and potential concurrent hazards should be added.