平成２８年９月
関西電力株式会社

IAEA安全基準「原子力発電所の安全：設計」について

国際原子力機関（IAEA）は、国際的原子力安全基準類の策定活動を通じて、数多くの原子力安全基準（Nuclear Safety Standards）を公表している。その1つである「原子力発電所の安全：設計」（原題：Safety of Nuclear Power Plants: Design）は、原子力発電所の構築物、系統及び機器に関する設計要件を定めるとともに、安全上重要な手順と組織上の措置に対する設計要件を定めたものであり、2016年2月に改訂1版が発行されている。

序文でまとめられているとおり、本改訂は、福島第一原子力発電所事故を契機として、IAEAがとりまとめている安全基準シリーズのうち安全要件に係る出版物のレビューを進める中で実施されたものである。改訂にあたっては、福島第一原子力発電所事故から得られた各種知見が取り込まれている。

別紙1及び別紙2は、本安全基準において原子力発電所の設計に際して考慮すべき事項としてまとめられたもののうち、安全重要度分類、外的危険要因及び非常用電力供給装置について、関係する要求事項を抽出したものである。このうち、改訂1版で内容の見直し又は追加があったものは、5.15A、要件68、6.43、6.44A、6.44B、6.44C、6.44D及び6.45Aである。

なお、本安全基準の全体構成は、目次を参照されたい。

別紙1　IAEA Safety Standards “Safety of Nuclear Power Plants: Design” No. SSR-2/1 (Rev.1)（抜粋）

別紙2　IAEA Safety Standards “Safety of Nuclear Power Plants: Design” No. SSR-2/1 (Rev.1)（抜粋部の和訳）（作成者：関西電力株式会社）

IAEA Safety Standards

for protecting people and the environment

Safety of Nuclear Power Plants: Design

Specific Safety Requirements

No. SSR-2/1 (Rev. 1)

IAEA
International Atomic Energy Agency

PREFACE

The accident at the Fukushima Daiichi nuclear power plant in Japan followed the Great East Japan Earthquake and Tsunami of 11 March 2011. The IAEA Action Plan on Nuclear Safety (GOV/2011/59-GC(55)/14) was developed in response to the Fukushima Daiichi accident[1] and was approved by the IAEA Board of Governors and endorsed by the IAEA General Conference in September 2011 (GC(55)/RES/9). It includes an action headed: Review and strengthen IAEA Safety Standards and improve their implementation.

This action called upon the Commission on Safety Standards (CSS) and the IAEA Secretariat to review, and revise as necessary, the relevant IAEA safety standards in a prioritized sequence, and called on Member States to utilize the IAEA safety standards as broadly and effectively as possible.

This review covered, among other topics, the regulatory structure, emergency preparedness and response, and nuclear safety and engineering aspects (site selection and evaluation, assessment of extreme natural hazards, including their combined effects, management of severe accidents, station blackout, loss of heat sink, accumulation of explosive gases, the behaviour of nuclear fuel and the safety of spent fuel storage).

In 2011, the Secretariat commenced such a review of Safety Requirements publications in the IAEA Safety Standards Series on the basis of information that was available on the Fukushima Daiichi accident, including two reports from the Government of Japan, issued in June 2011 and September 2011, the report of the IAEA International Fact Finding Expert Mission conducted in Japan from 24 May to 2 June 2011, and a letter from the Chair of the International Nuclear Safety Group (INSAG) to the Director General dated 26 July 2011. As a priority, the Secretariat reviewed the Safety Requirements publications applicable to nuclear power plants and to the storage of spent fuel.

The review consisted first of a comprehensive analysis of the findings of these reports. In the light of the results of this analysis, the Safety Requirements publications were then examined in a systematic manner in order to decide whether amendments were desirable to reflect any of these findings.

On that basis, the CSS approved, at its meeting in October 2012, a proposal for a revision process by amendment for the following five Safety Requirements publications: Governmental, Legal and Regulatory Framework for Safety (IAEA Safety Standards Series No. GSR Part 1, 2010); Safety Assessment for Facilities

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[1] For further information, see INTERNATIONAL ATOMIC ENERGY AGENCY, The Fukushima Daiichi Accident: Report by the Director General, IAEA, Vienna (2015).

and Activities (GSR Part 4, 2009); Safety of Nuclear Power Plants: Design (SSR-2/1, 2012); Safety of Nuclear Power Plants: Commissioning and Operation (SSR-2/2, 2011); and Site Evaluation for Nuclear Installations (NS-R-3, 2003).

Additional inputs were considered in preparing the draft text of the proposed amendments to these five safety standards in 2012 and 2013, including the findings of the IAEA International Experts Meetings and presentations made at the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety, in August 2012. Several national and regional reports were also considered.

On the review of the Safety Requirements, the Commission's conclusion, reflected in a letter from the CSS Chair to the Director General dated 6 January 2014, was that:

> "the review has confirmed so far the adequacy of the current Safety Requirements. The review revealed no significant areas of weakness, and just a small set of amendments were proposed to strengthen the requirements and facilitate their implementation. The CSS believes that the IAEA Safety Standards should be enhanced mainly through the well-established review and revision process that has been in use for some years. At the same time, CSS members highlighted that the basis for the review and revision of the IAEA Safety Standards should not be limited to the lessons of the Fukushima Daiichi accident. This basis should also include other operating experience from elsewhere as well as information gained from advances in research and development. The CSS also stressed that greater attention needs to be paid to the implementation of IAEA safety standards by and in Member States."

The draft amendments were reviewed by the Secretariat in consultants meetings, as well as by the Nuclear Safety Standards Committee, the Radiation Safety Standards Committee, the Transport Safety Standards Committee and the Waste Safety Standards Committee, in the first half of 2013. They were also presented for information to the Nuclear Security Guidance Committee in 2013. The draft amendments were then submitted to IAEA Member States for comment and revised in consultants meetings in the light of comments received. The proposed amendments were then approved by all four Safety Standards Committees at their meetings in June and July 2014, and were endorsed by the CSS at its meeting in November 2014.

The revisions to SSR-2/1 relate to the following main areas:

— Prevention of severe accidents by strengthening the design basis for the plant;

— Prevention of unacceptable radiological consequences of a severe accident for the public and the environment;
— Mitigation of the consequences of a severe accident to avoid or to minimize radioactive contamination off the site.

Amendments have been made to specific paragraphs, as outlined below. New paragraphs have been added; these are indicated by means of an uppercase letter (A, B, …). In addition, where a paragraph has been deleted, this is indicated in the text.

The following requirements and paragraphs have been amended or added in this revised edition: 2.13, 4.13A, 5.1, Requirement 17, 5.15A, 5.15B, 5.17, 5.18, 5.20, 5.21, 5.21A, 5.22, Requirement 19, 5.27, 5.28, 5.31, 5.31A, 5.55, Requirement 33, 5.63, 5.73, 5.75, 5.76, Requirement 53, 6.19A, 6.19B, 6.28A, 6.28B, 6.39, 6.40A, Requirement 67, 6.42, Requirement 68, 6.43, 6.44A, 6.44B, 6.44C, 6.44D, 6.45A, 6.68 and 6.68A. Some amendments of an editorial nature have also been made.

A table of changes made is available upon request to the IAEA (Safety.Standards@iaea.org).

The Board, at its meeting starting on 2 March 2015, established as an IAEA safety standard — in accordance with Article III.A.6 of the Statute of the IAEA — the draft of this revised Safety Requirements publication, and authorized the Director General to promulgate these revised safety requirements and to issue them as a Safety Requirements publication in the IAEA Safety Standards Series.

The 59th IAEA General Conference, in September 2015, encouraged Member States to implement measures nationally, regionally and internationally to ensure nuclear, radiation, transport and waste safety, as well as emergency preparedness, taking full account of IAEA safety standards; requested the IAEA to continuously review, strengthen and implement as broadly and effectively as possible the IAEA safety standards; and supported the CSS and the Safety Standards Committees in their review of the relevant safety standards in the light of the Fukushima Daiichi accident, as well as the lessons identified in the IAEA report on the Fukushima Daiichi accident[1].

The General Conference requested the Secretariat:

> "to continue its close cooperation with the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Commission on Radiological Protection (ICRP) and other relevant organizations in the development of safety standards, including, but not limited to, the protection of the environment".

The 59th IAEA General Conference also encouraged Member States to use the IAEA safety standards in their national regulatory programmes, as appropriate, and noted the need to consider the periodic review of national regulations and guidance against internationally established standards and guidance, and to report on progress in appropriate international fora such as review meetings under the terms of the relevant safety conventions.

The General Conference further encouraged Member States to ensure regular self-assessments of their domestic nuclear, radiation, transport and waste safety, as well as emergency preparedness, using the IAEA self-assessment tools and taking into account relevant IAEA safety standards.

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actions. An assessment shall be made of the potential for an operator to worsen an event sequence through erroneous operation of equipment or incorrect diagnosis of the necessary recovery process.

5.13. The operator actions that would be necessary to diagnose the state of the plant following a postulated initiating event and to put it into a stable long term shutdown condition in a timely manner shall be facilitated by the provision of adequate instrumentation to monitor the status of the plant, and adequate controls for the manual operation of equipment.

5.14. The design shall specify the necessary provision of equipment and the procedures necessary to provide the means for keeping control over the plant and for mitigating any harmful consequences of a loss of control.

5.15. Any equipment that is necessary for actions to be taken in manual response and recovery processes shall be placed at the most suitable location to ensure its availability at the time of need and to allow safe access to it under the environmental conditions anticipated.

Requirement 17: Internal and external hazards

All foreseeable internal hazards and external hazards, including the potential for human induced events directly or indirectly to affect the safety of the nuclear power plant, shall be identified and their effects shall be evaluated. Hazards shall be considered in designing the layout of the plant and in determining the postulated initiating events and generated loadings for use in the design of relevant items important to safety for the plant.

5.15A. Items important to safety shall be designed and located, with due consideration of other implications for safety, to withstand the effects of hazards or to be protected, in accordance with their importance to safety, against hazards and against common cause failure mechanisms generated by hazards.

5.15B. For multiple unit plant sites, the design shall take due account of the potential for specific hazards to give rise to impacts on several or even all units on the site simultaneously.

Combinations of events and failures

5.32. Where the results of engineering judgement, deterministic safety assessments and probabilistic safety assessments indicate that combinations of events could lead to anticipated operational occurrences or to accident conditions, such combinations of events shall be considered to be design basis accidents or shall be included as part of design extension conditions, depending mainly on their likelihood of occurrence. Certain events might be consequences of other events, such as a flood following an earthquake. Such consequential effects shall be considered to be part of the original postulated initiating event.

Requirement 21: Physical separation and independence of safety systems

Interference between safety systems or between redundant elements of a system shall be prevented by means such as physical separation, electrical isolation, functional independence and independence of communication (data transfer), as appropriate.

5.33. Safety system equipment (including cables and raceways) shall be readily identifiable in the plant for each redundant element of a safety system.

Requirement 22: Safety classification

All items important to safety shall be identified and shall be classified on the basis of their function and their safety significance.

5.34. The method for classifying the safety significance of items important to safety shall be based primarily on deterministic methods complemented, where appropriate, by probabilistic methods, with due account taken of factors such as:

(a) The safety function(s) to be performed by the item;
(b) The consequences of failure to perform a safety function;
(c) The frequency with which the item will be called upon to perform a safety function;
(d) The time following a postulated initiating event at which, or the period for which, the item will be called upon to perform a safety function.

5.35. The design shall be such as to ensure that any interference between items important to safety will be prevented, and in particular that any failure of items important to safety in a system in a lower safety class will not propagate to a system in a higher safety class.

Requirement 67: Emergency response facilities on the site

The nuclear power plant shall include the necessary emergency response facilities on the site. Their design shall be such that personnel will be able to perform expected tasks for managing an emergency under conditions generated by accidents and hazards.

6.42. Information about important plant parameters and radiological conditions at the nuclear power plant and in its immediate surroundings shall be provided to the relevant emergency response facilities[23]. Each facility shall be provided with means of communication with, as appropriate, the control room, the supplementary control room and other important locations at the plant, and with on-site and off-site emergency response organizations.

EMERGENCY POWER SUPPLY

Requirement 68: Design for withstanding the loss of off-site power

The design of the nuclear power plant shall include an emergency power supply capable of supplying the necessary power in anticipated operational occurrences and design basis accidents, in the event of a loss of off-site power. The design shall include an alternate power source to supply the necessary power in design extension conditions.

6.43. The design specifications for the emergency power supply and for the alternate power source at the nuclear power plant shall include the requirements for capability, availability, duration of the required power supply, capacity and continuity.

6.44. The combined means to provide emergency power (such as water, steam or gas turbines, diesel engines or batteries) shall have a reliability and type that are consistent with all the requirements of the safety systems to be supplied with power, and their functional capability shall be testable.

[23] Emergency response facilities are addressed in IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [11]. For nuclear power plants, emergency response facilities (which are separate from the control room and the supplementary control room) include the technical support centre, the operational support centre and the emergency centre.

6.44A. The alternate power source shall be capable of supplying the necessary power to preserve the integrity of the reactor coolant system and to prevent significant damage to the core and to spent fuel in the event of the loss of off-site power combined with failure of the emergency power supply.

6.44B. Equipment that is necessary to mitigate the consequences of melting of the reactor core shall be capable of being supplied by any of the available power sources.

6.44C. The alternate power source shall be independent of and physically separated from the emergency power supply. The connection time of the alternate power source shall be consistent with the depletion time of the battery.

6.44D. Continuity of power for the monitoring of the key plant parameters and for the completion of short term actions necessary for safety shall be maintained in the event of loss of the AC (alternating current) power sources.

6.45. The design basis for any diesel engine or other prime mover[24] that provides an emergency power supply to items important to safety shall include:

(a) The capability of the associated fuel oil storage and supply systems to satisfy the demand within the specified time period;
(b) The capability of the prime mover to start and to function successfully under all specified conditions and at the required time;
(c) Auxiliary systems of the prime mover, such as coolant systems.

6.45A. The design shall also include features to enable the safe use of non-permanent equipment to restore the necessary electrical power supply.[25]

[24] A prime mover is a component (such as a motor, solenoid operator or pneumatic operator) that converts energy into action when commanded by an actuation device.

[25] Non-permanent equipment need not necessarily be stored on the site.

【表紙】

IAEA（国際原子力機関）　安全基準
（公衆及び環境防護用）

原子力発電所の安全：設計

個別安全要件
整理番号SSR-2/1（改訂1）

【序文】

序文

2011年3月11日の東日本大震災及び津波により、日本の福島第一原子力発電所における事故は発生した。同事故に対応してIAEAの「原子力安全に係るアクションプラン」が起草され、IAEA理事会で承認された後に2011年9月のIAEA総会にてエンドースされた。同計画には「IAEA安全基準の見直し及び強化並びに履行の向上」と題する活動が含まれている。

（中略）

2011年において、6月及び9月に発行された日本政府による2つの報告書、5月24日から6月2日に日本で実施されたIAEA国際事実調査専門家ミッションの報告書、及び国際原子力安全諮問グループ（INSAG）議長からIAEA事務局長に宛てた7月26日付け書簡を含む福島第一事故についての利用可能な情報を基に、IAEA事務局はIAEA安全基準シリーズのうち安全要件に係る出版物のレビューを開始した。

（中略）

当該のレビューは、第一にこれら報告書の知見の包括的な分析から行われた。本分析の結果に照らして、これらの知見を反映するための修正が必要か否かを決定するため、安全要件に係る出版物は系統的な方法で調査された。

それを踏まえて、安全基準委員会は次の5つの安全要件出版物、即ち「安全のための政府、法律及び規制の枠組み」（IAEA安全基準シリーズNo. GSR Part1, 2010）、「施設と活動に対する安全評価」（GSR Part4, 2009）、「原子力発電所の安全：設計」（SSR-2/1, 2012）、「原子力発電所の安全：試運転及び運転」（SSR-2/2, 2011）及び「原子炉等施設の立地評価」（NS-R-3, 2003）について、修正による改訂プロセスの提案を2012年10月の会議で承認した。

（中略）

SSR-2/1の見直しは、次の主要分野に関連する。

－プラントの設計基準の強化による過酷事故の防止

－過酷事故による公衆及び環境に対する許容できない放射線影響の防止

－サイト外の放射性物質汚染の回避又は最小化のための過酷事故による影響の緩和
（以下略）

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【5章】

要件17：内的危険要因及び外的危険要因

5.15A. 安全上重要な機器等は、危険要因の影響に耐えるように、又はそれらの機器等の安全上の重要度に応じて危険要因及び危険要因により生ずる共通要因故障メカニズムに対して防護されるように、その他の安全に対する関連事項に配慮しつつ設計、配置されなければならない。

要件22：安全重要度分類

全ての安全上重要な機器等は特定されなければならず、またそれらの機能とそれらの安全上の重要度に基づいて分類されなければならない。

【6章】

要件68：外部電源喪失に耐えるための設計

原子力発電所の設計は、外部電源喪失時において、運転時の異常な過渡変化及び設計基準

事故の際に必要となる電力を供給可能な非常用電力供給装置を含まなければならない。また、(設計基準事故を超える) 設計拡張状態において、必要となる電力を供給する代替電源を含まなければならない。

6.43. 原子力発電所における非常用電力供給装置及び代替電源の設計仕様は、供給能力、利用可能性、電源が要求される期間、容量及び継続性に対する要件を含まなければならない。

6.44. 非常用電源を供給する組み合わせ方法 (例えば、水、蒸気タービン又はガスタービン、ディーゼル機関又は蓄電池) は、電源供給を受ける安全系の全ての要件と整合のとれた信頼性及び型式を有しなければならず、また、それらの機能上の能力は試験可能でなければならない。

6.44A. 代替電源は、非常用電力供給装置の故障を伴う外部電源喪失時に、原子炉冷却材系の健全性維持及び炉心と使用済燃料の著しい損傷を防止するために必要な電力を供給可能なものでなければならない。

6.44B. 炉心の溶融の影響を緩和するために必要な設備は、利用可能な電源のいずれかから電力供給が可能でなければならない。

6.44C. 代替電源は、非常用電力供給装置から独立し、かつ物理的に分離されていなければならない。代替電源の接続所要時間は、蓄電池の枯渇時間に整合していなければならない。

6.44D. 重要なプラントパラメータの監視及び安全のために必要となる短期的な活動の完遂に要する電力の継続性は、交流電源の喪失時に維持されなければならない。

6.45. 安全上重要な機器等に非常用電源を供給する、いかなるディーゼル機関又はその他の主駆動源に対する設計基準は、以下のものを含まなければならない。

(a) 定められた時間内における要求量を満足するため、関連する燃料油貯蔵及び供給系の能力

(b) 定められた全ての条件下で必要とされる時間に首尾良く起動し、機能するための主駆動源の能力

(c) 冷却系などの主駆動源の補助系統

6.45A. 設計は、必要となる電力供給装置を復旧するための恒設ではない設備を安全に使用可能とする機構も含まなければならない。