Technical Background of Draft Notice 'Investigation, Analysis, Evaluation Standards on Geology and Earthquake at Reactor and Related Facility Sites'

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1. Introduction

The draft notice 'Investigation, analysis, evaluation standards on geology and earthquake at reactor and related facility sites' [1] is intended to replace the notice of Nuclear Safety and Security Commission No. 2017-15 'Technical Standards for Locations of Nuclear Reactor Facilities' [2]. Details of the notice should be applied in accordance with applicable foreign regulations. In particular, seismic and geologic siting criteria for nuclear facility sites follow 10 CFR 100 Appendix A (hereinafter Appendix A) [3].

Meanwhile, U.S. newly established 10 CFR 100.23 [4] to reflect its past regulatory experiences on commercial nuclear facility sites and the latest geoscience technical levels. Related technical details were reflected in RG 1.165 [5] (withdrawn in 2010) and following RG 1.208 [6] and applied to commercial nuclear facility sites after January 10, 1997 (Prior to this date, Appendix A continues to apply). Therefore, it was necessary to revise the notice considering changes in international technical standards in U.S. and related advanced technical levels. Accordingly, U.S. technical standards are reflected as much as possible, but some items are required to reflect changes in domestic geologic and seismic environment and IAEA's safety standards.

In this paper, we will summarize and introduce main changes compared to the current notice.

2. Main Contents

2.1 Capable Fault

The term 'active fault' is used in a similar term to the term 'capable fault' in academia. However, this is based on 'quaternary' as a period basis for movement. Therefore, the criteria are flexible over the period. In addition, considering the probability of hazard, which is normally set 10^{-7}/year, the criteria are too strict to be suitable for nuclear safety regulations. So the term 'capable fault' is defined separately in the nuclear field.

'Capable fault' was defined in Appendix A [3] and changed in part in RG 1.208 [6]. Therefore, considering the definition of original criteria of Appendix A [3] and the modified definition of RG 1.208 [6], followings are summarized.

'Capable fault' is a tectonic structure that can generate both vibratory ground motion and tectonic surface deformation at or near earth's surface. It is described by at least one of following characteristics.

① a presence of faulting at or near the earth's surface at least once within past 50,000 years or more than twice within past 500,000 years
② a reasonable association with one or more moderate to large earthquakes or sustained earthquake activity that are instrumentally determined
③ a structural association with a capable fault that has characteristics of either item ① or ②

2.2 Seismic Source

The definition of a seismic source was developed from perspective of a capable tectonic source and a seismogenic source using the definition of RG 1.208 [6]. On the side of a capable tectonic source, a seismic source is defined as 'capable fault' or 'geological structure that is associated with one or more moderate to large earthquakes or sustained earthquake activity', and on the other side of a seismogenic source, it is defined as 'a portion of the earth that is assumed to have a uniform earthquake potential'. If one or more of those conditions is satisfied, it can be defined as a seismic source.

2.3 Scope of Investigation and Analysis

RG 1.208 [6] divided the scope of investigation into four stages: a site with a radius of 320 km (site region), 40 km (site vicinity), 8 km (site area) and 1 km (site location) respectively and listed investigation items that should be carried out for each scope. In addition, exceptions of investigation items are outlined when the scope of investigation should be expanded.

2.4 Determination of Safe Shutdown Earthquake (SSE)

Appendix A [3] lists eight items of investigation that should be carried out for earthquake ground motions including geologic conditions of the site and the region surrounding the site, tectonic structures, physical characteristics of the behavior during prior earthquakes of surficial geologic materials, static and dynamic engineering properties of materials underlying the site, listing of all historically reported earthquakes, correlation of epicenters or locations of highest intensity of historically reported earthquakes, locations of faults

and capable faults. However, since Appendix A [3] describes 'All of the steps in paragraphs (a)(5) through (a)(8) of this section need not be carried out if the Safe Shutdown Earthquake can be clearly established by investigations and determinations of a lesser scope.', only items that are essential for the determination of SSE are included in the draft notice [1].

On the other hand, Appendix A [3] specifies the minimum length of the fault to be considered versus distance from the site (Table I), which is quoted in the draft notice [1].

Table I: Minimum length of the fault to be considered versus distance from site

Distance from the site (miles):	Minimum length*
0 to 20	1
Greater than 20 to 50	5
Greater than 50 to 100	10
Greater than 100 to 150	20
Greater than 150 to 200	40

* Minimum length of fault (miles) which shall be considered in establishing Safe Shutdown Earthquake.

2.5 Evaluation of Uncertainty in SSE

As Appendix A [3] specifies that SSE is determined in a deterministic way and 10 CFR 100.23 [4] specifies that uncertainties must be addressed through an appropriate analysis, such as probabilistic seismic hazard analysis (PSHA) or suitable sensitivity analysis. While the implementation of PSHA was weakly enforced for the determination of SSE, RG 1.208 [6] specifies that SSE should be determined based on PSHA and also specifies its specific methods and procedures. Meanwhile IAEA SSG-9 [7] proposes that deterministic and probabilistic methods should be combined. Therefore, the draft notice [1] required SSE to be determined in a deterministic way considering domestic seismic characteristics, but verified by carrying out PSHA.

2.6 Determination of Zone Requiring Detailed Faulting Investigation

Appendix A [3] has procedures and intuitive illustrations for determining zone requiring detailed faulting investigation, and the draft notice [1] has been prepared with this in mind. Quantitative criteria applied to determining the impact range of surface faulting and the control width of fault are also referred to (Table II). Since Appendix A [3] and IAEA NS-R-3 [8] address that the site should be unsuitable if the site includes the range that surface faulting has potential to affect the safety of nuclear facility, the draft notice [1] is intended to include those points.

Table II: Determination of zone requiring detailed faulting investigation

Magnitude of earthquake	Width of zone requiring detailed faulting investigation
Less than 5.5	1×control width.
5.5 – 6.4	2×control width.
6.5 – 7.5	3×control width.
Greater than 7.5	4×control width.

3. Conclusion

With the newly establishment of 10 CFR 100.23 [4] and RG 1.208 [6] meeting 10 CFR 100.23 [4] in U.S., the draft notice 'Investigation, analysis, evaluation standards on geology and earthquake at reactor and related facility sites' [1] was prepared primarily by reference to Appendix A [3], 10 CFR 100.23 [4] and RG 1.208 [6]. Main contents of the draft notice [1] are definition, data investigation scope, design earthquake ground motion evaluation, surface faulting evaluation, geotechnical stability evaluation, etc. Among those, three major changes compared to the current notice [2] are the definition of a capable fault, data investigation scope and design earthquake ground motion evaluation.

The establishment of the draft notice [1] will allow the latest geoscience technical levels to be reflected, and the investigation, analysis and evaluation of reactor and related facility sites considering domestic geologic and seismic characteristics to be implemented. As a result, we believe that more reasonable and clear nuclear safety regulation related to the site will be made.

REFERENCES

[1] Draft Notice of the Nuclear Safety and Security Commission, Investigation, analysis, evaluation standards on geology and earthquake at reactor and related facility sites, 2019.
[2] Notice of the Nuclear Safety and Security Commission, Technical standards for locations of nuclear reactor facilities, No. 2017-15 (reactor.04).
[3] U.S. Code of Federal Regulations, Seismic and geologic siting criteria for nuclear power plants, 10 CFR 100 Appendix A.
[4] U.S. Code of Federal Regulations, Geologic and seismic criteria, 10 CFR 100.23.
[5] U.S. Nuclear Regulatory Commission, Identification and characterization of seismic sources and determination of safe shutdown earthquake ground motion, Regulatory Guide 1.165, 1997.
[6] U.S. Nuclear Regulatory Commission, A performance-based approach to define the site-specific earthquake ground motion. Regulatory Guide 1.208, 2007.
[7] International Atomic Energy Agency, Seismic hazards in site evaluation for nuclear installations, Safety Standards Series No. SSG-9, 2010.
[8] International Atomic Energy Agency, Site evaluation for nuclear installations. Safety Standards Series No. NS-R-3 (Rev. 1), 2016.