On the Upgrading of Japanese
“Examination Guide for Aseismic Design of Nuclear Power Reactor Facilities”

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Abstract

Japanese “Examination Guide for Aseismic Design of Nuclear Power Reactor Facilities” [1] that has been established over 20 years ago is now under the process of upgrading by the Nuclear Safety Commission of Japan. The major points of the upgrading are related to the new developments of seismology, the safety concept for public understanding, and the reflection of the government policy to handle “Seismic margins of nuclear facilities” [2]. The works and discussions are currently still on going. In the present paper we introduce some key points on the upgrading works based on the open materials delivered by the Nuclear Safety Commission.

1. Introduction

Various technologies related to seismic design have been advanced, since “Examination Guideline for Aseismic Design of Nuclear Power Reactor Facilities” (hereafter we describe this as “Examination Guideline”) was established 20 years ago. [1] Through the experiences of big earthquakes including the 1995 Hyogo-ken Nanbu Earthquake (the Kobe Earthquake) in Japan, the latest knowledge related to earthquakes and earthquake ground motions has been accumulated. By taking into account these advanced technologies, experiences and knowledge, it is commonly recognized by Japanese experts on seismology and seismic engineering that some upgrading of the “Examination Guideline” is necessary to enhance the reliability of seismic safety of nuclear power plants (NPPs) based on the latest knowledge.

Standing on this background, a taskforce for performing works to upgrade the “Examination Guideline” has been being organized in Nuclear Safety Commission (hereafter we describe this as NSC) of Japan. Though the works and discussions are currently on going, we introduce some key points on the upgrading of the “Examination Guideline”.

In this paper we introduce some key points that are currently discussing.
1) The fundamental way of thinking about the safety evaluation of the seismic design.
2) Classification of safety importance in the seismic design.
3) Earthquake ground motion for use in the evaluation of the seismic safety.
4) Evaluation of the seismic safety of the facilities.
2. The fundamental Way of Thinking about the Safety Evaluation of the Seismic Design

For the fundamental way of thinking to confirm the safety of the seismic design of NPP facilities, the followings are recommended to describe in the "Examination Guideline".

The safety function of the important facilities including safety protection facilities should never be spoilt even if the plant is attacked by the earthquake ground motion presumed to occur in quite small probability from the viewpoint of the geology, the geological structure around the site, and the seismology within a certain period of service life of the NPP facilities.

The above facilities should be designed to have suitable safety margins based on the existence of the uncertainties in determining the above earthquake ground motion and the uncertainties (dispersion) in the seismic capacities of the NPP facilities.

3. Classification of Safety Importance in Seismic Design

At present, there are three classification of A, B, C in seismic design. Class A is especially divided into two classes A and As.

Through the works for upgrading, the classes A and As are proposed to be integrated (not to be distinguished).

The present "Examination Guideline" requires to classify the facilities into three classes depending on their seismic importance. Thus, they are designed to withstand the seismic load determined for each class. Furthermore, especially important facilities in the nuclear safety are picked up from class A facilities as the seismic class As. Then, they are required to withstand against the seismic ground motion of $S_2$, which exceeding the seismic ground motion of $S_1$ for which the facilities of the class A are required to maintain their safety functions.

On the other hand, as mentioned above, it is required to make the residual risk due to the existence of the uncertainty in the seismic capacities of the facilities and the uncertainties in determining a design earthquake ground motion as small as possible. For such a risk, it has been said that the risk is kept small enough by taking enough margins in the detailed design of the facilities against the seismic load by the design earthquake ground motion of $S_2$.

However, in the upgrading (revision) of the present "Examination Guideline", it is desirable to decrease the residual risk from the viewpoint of improving the safety much more. Based on this concept, it is proposed to revise the classification methodology in the "Examination Guideline" that the class A component, which has a function to redundant accident conditions when accident occurs, is changed over to the present class As so that the whole structures, systems, and components in the class A will be categorized into the present class As.

As for the name of every class, it is proposed to take "seismic class I, II, and III" in expression to avoid confusion.

The functional importance classification of the NPP facilities in seismic design based on the way of thinking described above is shown in the Table 1 below.
Table 1. The Functional Importance Classification of facilities in Seismic Design

<table>
<thead>
<tr>
<th>Seismic Class</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic Class I</td>
<td>A SSC* which has radioactive materials inside or a SSC directly related to other SSC having radioactive materials inside, then the function loss of the SSC might be a cause of radioactive material release in the atmosphere. Also a SSC needed to avoid radioactive materials release and a SSC needed to shutdown the reactor when accident occur or a SSC needed to reduce an influence by the radioactive material release in the atmosphere in addition those influence and the effect are large.</td>
</tr>
<tr>
<td>Seismic Class II</td>
<td>SSCs whose influence and effect is small as compare to the above mentioned phenomena in the seismic class I.</td>
</tr>
<tr>
<td>Seismic Class III</td>
<td>SSCs other than the seismic classes of I and II</td>
</tr>
</tbody>
</table>

* SSC: structures, systems and components

4. Earthquake Ground Motion for Use in the Evaluation of Seismic Safety

It is proposed to treat the earthquake ground motion for use in the evaluation of seismic safety. The earthquake ground motion of Ss is defined as an earthquake ground motion presumed to occur, or possibly occur, though its possibility is quite small, around the site from the viewpoint of seismology and earthquake engineering within a certain period of the plant life.

The earthquake ground motion of Ss is proposed to be designed based on the following:
1) It should be taken into account of past earthquake ground motion and ground motion caused by active faults. “Seismo-techtomic” knowledge is also considered for reference.
2) It should be taken into account as earthquake ground motion to be considered at least as “earthquake ground motion presumed without specifying the seismic sources”. It is presented that the common way of thinking to determine a response spectrum based on a probabilistic study and/or past earthquake records obtained in the neighborhood of epicenters without seismic fault in the inland cluster earthquakes.
3) Earthquake ground motion in the vertical direction at free field be also determined.
4) The probability of the ground motion level of Ss is checked after design.

Currently proposed methodology for determining the design ground motion of Ss is shown in Fig.1 for reference.

5. Evaluation of the seismic safety of the Facilities

It is proposed for evaluation of the facilities based on the fundamental way of thinking to secure the seismic safety described as follows:
1) The facilities of seismic class I should not be spoilt their safety functions by the seismic load of Ss. The way of thinking for the load combination of building, structure, piping, and equipment and the allowable state limit are followed after those for the standard earthquake ground motion of S_2 in the present “Examination Guideline”.

...
2) Furthermore, it is proposed to design the facilities to have suitable safety margins by taking into account the existence of the uncertainties relating to determining the design earthquake of Ss, and the uncertainties of their seismic capacity (dispersion).

To evaluate the “Safety Margins”, the followings are currently discussing.

How to evaluate the safety margins existing in buildings, structures, equipment and piping. The evaluation should be performed with suitable technique, which can take into account the uncertainties in determining the earthquake ground motion of Ss and the uncertainties in the quantitative seismic capacity of the facilities.

How to evaluate the seismic safety margins. There are two methodologies for evaluating the seismic safety margins, the conventional deterministic methodology and the newly introduced probabilistic methodology. Therefore before evaluating actual safety margins, it should be judged independently which methodology is taken at a stage of the detailed design, and then the evaluation should be performed properly.

How to situate the seismic Probabilistic Safety Assessment (Seismic PSA) techniques positively together with the concept of the safety goal in the examination guideline.

6. Concluding Remarks

As introduced in the present paper, the outline of revision of the “Examination Guideline for Aseismic Design of Nuclear Power Reactor Facilities” has come into sight little by little as a result of the works of the guideline revision. The major points in the revision are expected on the determination of the design earthquake ground motion, the seismic safety importance classification in the seismic design of nuclear facilities, and the evaluation methodologies of the margins related to seismic safety of the nuclear facilities. Currently these items are still on hot discussion among sub-committee members.

7. References

Figure 1. A Flow Chart for Generating Design Earthquake Ground Motion

Safety Function Confirmation Earthquake Ground Motion (Ss): The earthquake ground motion supposed to occur even though it is very rare from the seismological point of view, the results of the investigation made from the engineering point of view on the bases of the past earthquake situation, the properties of active faults in the vicinity of the site, and the geostructures of the site.

Site Specific Earthquake Ground motion

Past Earthquake Ground motions

Active Faults

Seismo-techthonic Map

Just for References

Earthquakes that should be taking into account for the evaluation of Ss Earthquake Ground Motion

The Ss Earthquake Ground Motion should be supposed by taking the occurrence situations of past earthquakes, characteristics of active faults around the site into account.

Evaluate the earthquake ground motion (response spectrum) for each Ss earthquake ground motions supposed

Eqs. of Evaluating Spectrum

Fault Models

Two directional components of horizontal and vertical.

Response spectra (Free-field surface)

Velocity

period

Two directional components of horizontal and vertical.

Response spectra (Free-field surface)

Envelope or individual definition

Velocity

period

Safety Function Confirmation Earthquake Ground Motion (Ss)