

Comparison & Analysis of IEEE 344 and IEC 60980 standards for harmonization of seismic qualification of safety-related equipments

Youngok Lee^{a*}, Jong-Seog Kim^b, Jeong-Ho Seo^c, Myung-Jun Kim^c

^aKEPCO-ENGINEERING & CONSTRUCTION COMPANY, 2354 Yongudaero, Giheung-gu, Yongin-si, Gyeonggi-do, Korea

^bResearch Institute of Korea Electric Power Corporation, 103-16 Munji-dong, Yuseong-gu, Daejeon, Korea

^cKorea Electric Association, Supyo-dong 11-4, Jung-gu, Seoul, Korea

*yolee@kepc0-enc.com

1. Background

The seismic qualification of safety related equipments in nuclear power plants should demonstrate an equipment's ability to perform its safety function during/or after the time it is subjected to the forces resulting from one SSE. In addition, the equipment must withstand the effects of a number of OBEs, preceding the SSE. IEEE 344 and IEC 60980 present the criteria for establishing procedures demonstrating that the Class 1E equipment can meet its performance requirement during seismic events.

Currently, IEEE 344 is used for regulation of nuclear power plant in the United State whereas IEC 60980 is mainly used in Europe. In particular, NPPs of France and China apply with RCC-E and GB that are domestic standards, respectively.

Equipment supplier and Utility have difficulties because of different applicable standards. Equipment supplier to export S/R components/equipments to other standard area performs additional seismic qualification. For example, equipments are qualified according to IEC 60980, RCC-E, GB although they have been qualified in accordance with IEEE 344. Also, utility to attempt power up-rate, life extension of NPP constructed under rules of RCC-E such as Ulchin NPP 1&2 has similar difficulties.

RCC-E endorses IEC 60980 and GB is almost same as IEC 60980 except minor difference of earthquake environment definition. Therefore this paper surveys the similarities and differences between IEEE 344 and IEC 60980. In addition, this paper considers how the two sets of standards may be used in a complementary fashion to be possible using one or the other standard area.

2. International trends

Two of the primary standards organizations worldwide are the US IEEE's Nuclear Power Engineering Committee(NPEC), and IEC subcommittee on Reactor Instrumentation(SC45A). In recent years, IEEE committee has been under research of using same logo of IEEE and IEC, at the same time as making efforts for harmonization of IEEE 323 and IEC 60780 standard. However, research for harmonization of IEEE 344 and IEC 60980 is not started by now.

3. Results of comparison and analysis

The contents of IEEE 344 and IEC 60980 have some overlap, but in many cases significantly different topics. For example, IEEE 344 goes to great depth on seismic qualification of many specific types of components, while IEC 60980 covers the topic only electrical equipment and the instrumentation and control equipment of the safety system. Conversely, IEC 60980 deals with specific topic at seismic qualification process where IEEE 344 is not described.

3.1. Terminology

The IEEE 344 and IEC 60980 take different approaches to terminology. The IEC attempts provide one definition of each term with other international bodies such as ISO and IAEA. The IEEE does not make an attempt to unify terminology. The representative terminologies are shown in table 1.

Table 1. Difference of terminologies

IEC 60980	IEEE 344
<ul style="list-style-type: none">• S1 earthquake• S2 earthquake	<ul style="list-style-type: none">• Operating Basis earthquake(OBE)• Safety Shutdown earthquake(SSE)
<ul style="list-style-type: none">• Analysis	<ul style="list-style-type: none">• Computation

3.2. Similarities and Differences

3.2.1. Subjects of seismic qualification

The IEEE 344 and IEC 60980 have the similarities and differences. At first, IEEE 344 is applicable to electric equipment, I&C component, and mechanical equipments while IEC 60980 is applicable to only electrical equipment and I&C components. Accordingly, although the IEEE 344 and IEC 60980 have similar methods for seismic qualification in over viewpoint, two standards have quite different concepts for analysis, one of acceptable seismic qualification methods.

3.2.2. Qualification methods

Two standards present that the most commonly used methods for seismic qualification are analysis, test, and a combined method of test and analysis. However, IEEE 344 mentioned that analysis without testing can

be acceptable if structure integrity alone can ensure the design-intended function, while IEC 60980 mentioned that computation may complement tests, to extrapolate or interpolate experimental data and investigate established failure modes related to structural integrity, fatigue and stress-strain behavior. For example, Motor is an electrical component that structure integrity alone can ensure the design-intended function. Reliance motor which is one of representative Class 1E motor manufacturers in US qualified Class 1E motor using analysis for seismic qualification. It is acceptable for IEEE 344 whereas it is not acceptable for IEC 60980.

3.2.3. Seismic Testing

The most of testing methods can be used in other standard area if we pay attention to followings.

- Number of OBE(S1) testing

Seismic qualification tests on equipment must include OBE(S1) tests, preceding the SSE(S2). The IEEE 344 and IEC 60980 require that the number of OBEs shall produce the equivalent effect of five OBEs.

In IEC 60980, instead of five OBE(S1), two tests corresponding to level SSE(S2) is acceptable while IEEE 344 requires the justification that two tests corresponding to level SSE(S2) produce the equivalent effect of five OBEs.

- Test duration

For earthquake environment, IEEE 344 describes that the strong motion portion of the earthquake may last from 10s to 15s and the ground motion is typically broadband random over a frequency range of 1 Hz to 33 Hz while IEC 60980 describes that an earthquake of magnitude 6 or higher on the Richter scale may persist for 15s to 30s and the typical broadband random motion occurs over a frequency range from 1 Hz to 35 Hz. Therefore, the required test durations are slightly different. IEEE 344 requires that the duration of the strong motion portion of each test should at least be equal to a minimum of 15s while IEC 60980 requires the testing duration shall be not less than 30s and the number of significant cycles shall range between 5 and 10.

- Requirements of single frequency testing

Requirements of test inputs for single frequency testing have big differences between two standards as shown in Table 2. Fortunately, Single frequency testing is not frequently used except line-mounted equipments such as valve assembly, damper etc. In case of valve actuator, seismic testing methods required by IEEE 344 are same as IEC 60980.

- Acceptance Criteria

Acceptance Criteria of IEEE 344-1987/2004 currently used for seismic qualification has been mitigated in comparison with that of IEEE 344-1975 which had same acceptance criteria with IEC 60980.

Table 2. Difference of testing frequencies

IEEE 344	IEC 60980
<ul style="list-style-type: none"> • Testing at frequencies spaced 1/2 octave interval 	<ul style="list-style-type: none"> • Testing at frequencies spaced 1/3 octave interval
<ul style="list-style-type: none"> • Testing only at the equipment resonances 	<ul style="list-style-type: none"> • Testing at critical frequencies and two adjacent frequencies for which the TRS of test wave is reduced by a factor of $\sqrt{2}/2$

3.2.4. Seismic Analysis

We should be careful in choice of damping values. IEEE 344 presents that appropriate values of damping may be obtained from tests or other justifiable sources. At present, 2% & 3% damping values for OBE & SSE are chosen based on Reg. Guide 1.61 in US. However, IEC 60980 recommends damping values different from IEEE 344. For example, 7% for Control panel, 2 % for motor and 10% for cable tray are recommended.

8. Conclusions

Comparisons of the similarities and differences in subjects of seismic qualification, seismic testing and seismic analysis of IEEE 344 and IEC 60980 were implemented. The subjects to be considered for synergistic use are grouped into two categories:

- Seismic testing

In the viewpoint of IEEE 344, the equipments /components qualified in accordance with IEEE 344 meets the requirements of IEC 60980 except single frequency testing without additional actions. However, it is not met always in opposition. The most of testing methods can be used in other standard area if we pay attention to number of OBE testing, test duration, acceptance criteria.

- Seismic analysis

The analysis methods are on the whole same if damping values is chosen with attention. However, IEEE 344 allows analysis without testing if structure integrity alone can ensure the design-intended function, while IEC 60980 didn't allow seismic qualification of electrical items by analysis alone.

REFERENCES

- [1] IEEE Power Engineering Society, 'IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations', IEEE std 344-2004, 2004
- [2] International Electro-technical Commission, 'IEEE Recommended Practice for Seismic Qualification of Electrical Equipment of the Safety System for Nuclear Power Generating Stations', 1989