

# Development of IAEA TECDOC for Safety Evaluation of Nuclear Installations against Combinations of External Hazards

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## 1. Introduction

In 2011, the Great East Japan Earthquake caused a major accident at the Fukushima Daiichi Nuclear Power Plant due to an earthquake and tsunami, causing major damage, which is still not resolved. The Fukushima nuclear power plant accident not only showed that external hazards such as earthquakes greatly threatened the safety of nuclear power plants, but also showed that accidents caused by the combined occurrence of earthquakes and tsunamis are possible. The design of nuclear power plants is conservatively designed by considering the combination of various loads, but in the case of simultaneous accidents, the combination of loads is not considered when the frequency of occurrence is very low. However, after the accident at the Fukushima Daiichi nuclear power plant, there is a need to evaluate the combination of external hazards in the safety assessment of nuclear power plants. In response, the International Atomic Energy Agency (IAEA) began preparing a technical report (TECDOC) on combined hazards applicable to the safety assessment of nuclear power plants in 2020, which is now nearing completion. This paper will introduce the main contents of the TECDOC being prepared by the IAEA.

## 2. Key Concept and Terminology

When considering the external event, terminologies of event and hazards were mixed used even in IAEA documents. But according to recent glossary[1], external event and external hazard are clearly defined as below.

**External event:** Events (natural or human-induced) unconnected with the operation of the installation or that originate outside the plant buildings that could generate one or more hazards that could have an effect on the safety of the installation

Examples include: Earthquakes, Tropical cyclones, Thunderstorms, Transportation accidents

**External hazard:** Conditions or phenomena generated by an external event that could have an effect on the safety of the installation

Examples include:

Ground shaking hazards generated by an earthquake external event

Wind, precipitation, and lightning hazards generated by a thunderstorm external event

Pressure wave and projectile hazards generated by an offsite facility explosion

Chemical/toxic material release generated by an transportation accident external event

## 3. Overview of TECDOC

When performing a safety assessment considering the external hazard, combination of external event induced external hazards should be considered. The Procedure of external event induced external hazards combined safety assessment are as below;

- Hazard identification
- Hazard screening
- Hazard assessment
- Fragility and other component performance evaluations
- Plant response modeling, including human reliability analysis and quantification

Hazard identification determines the types of external hazards that should be considered and considers the impact of the hazard on the nuclear power plant. Hazard screening provides criteria and procedures for screening when assessing the effects of combined external hazards, so that reasonable results can be derived when assessing safety from many external hazards. Hazard assessment evaluates the return period of external hazards that may actually occur at a nuclear power plant site and considers the combination of hazards when each external hazard is considered in combination. Fragility and other component performance evaluations consider the failure probability of the safety related structures and components of a nuclear power plant in the event of a single hazard and the combination of methods. Plant response modelling, including human reliability analysis and quantification, describes the quantification of external hazard safety assessments considering combined hazards.

#### **4. Categories of Hazards Combination**

Based on the IAEA SSG-64[2], Appendix I on “Hazard Combination”, these are the following categories:

Combinations of consequential (subsequent) hazards,  
Combinations of correlated hazards,  
Combinations of unrelated(independent) hazards

In order to assess the combined impact of an external hazard, we must first be able to assess the impact of individual external hazards. However, few procedures for assessing the safety of nuclear power plants against external hazards other than earthquakes have been developed worldwide and few have been applied to nuclear power plants in practice. However, when considering the combined effects of external hazards, it is easy to apply the distinction made in SSG-64, as the methods and procedures for safety assessment will vary according to the distinction made above.

Consequential hazards are those where a single external event causes a series of external or internal hazards, e.g. an earthquake followed by a tsunami, or an earthquake followed by an internal fire or flooding. Correlated hazards occur when two or more internal and external hazards are caused by the same common cause initiator. Examples include a landslide, an external fire, an internal fire, an internal explosion, and a station blackout caused by an earthquake. Independent hazards are those that occur independently of each other without any connection to the cause of the hazard. In practice, the probability of occurrence is very low, so it is usually not reflected in the design. However, in the case of the Kumamoto earthquake in 2018, independent hazards occurred simultaneously, such as damage caused by a typhoon a week before and an earthquake afterwards, raising the need for safety assessment of nuclear power plants. Independent hazards are more likely to occur when one hazard occurs over a long period of time and another hazard occurs.

#### **5. Summary**

In response to the growing need to assess the safety of nuclear power plants against combined hazards, the IAEA began producing technical reports (TECDOC) in this regard in 2020. This technical report summarizes the state of the art for the safety assessment of nuclear power plants against combined hazards, identifies future directions for technology development, and summarizes the experiences of Member States for the benefit of all countries. The report is currently under development and is expected to be published by the end of 2023.

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#### **REFERENCES**

- [1] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Nuclear Safety and Security Glossary, Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response, IAEA, Vienna
- [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Protection against Internal Hazards in the Design of Nuclear Power Plants, IAEA Safety Standards Series No. SSG-64, IAEA, Vienna