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Design of nuclear power plants against seismic events —

Part 6: Post-seismic measures

Conception parasismique des installations nucléaires —

Partie 6: Dispositions et actions post-sismiques

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 6, *Reactor technology*.

A list of all parts in the ISO 4917 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The requirements in this document are based on the verification concept 'Inspection earthquake level' given in ISO 4917-1.

Up to the point where the value of the inspection level is not decisively exceeded; no earthquake-related deviations that could put specified normal operation conditions into question need to be expected in any areas designed against seismic events. Nevertheless, certain measures is performed to verify specified normal operation conditions before the inspection level is decisively exceeded; those measures are specified in this document.

Whenever the value of the inspection level is decisively exceeded, earthquake-related deviations that could put the specified normal operation condition into question cannot anymore be ruled out in the areas designed against seismic events. Therefore, if the inspection level is decisively exceeded the nuclear power plant is shut down and the measures be performed as specified in this document.

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Design of nuclear power plants against seismic events —

Part 6: Post-seismic measures

1 Scope

The document applies to nuclear power plants with water cooled reactors.

The present document does not apply to earthquakes stronger than the design basis earthquake.

This document specifies guidance on the actions to be taken in preparation for and following an earthquake at a nuclear power plant. This document is intended to be used as a guideline for decision making regarding continued operation, shutdown and restart of the nuclear power plant after an earthquake. It can also be used to assist operating organizations in the preparation and implementation of an overall pre- and post-earthquake action programme for dealing with situations in accordance with the level of seismic ground motion experienced at the site, and the seismic design level of the plant.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4917-1, *Design of nuclear power plants against seismic events — Part 1: Principles*

ISO 4917-5, *Design of nuclear power plants against seismic events — Part 5: Seismic instrumentation*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

3.1

specified normal operation

operation for which the nuclear power plant is technically intended, designed and suited

Note 1 to entry: The specified normal operation comprises the operating conditions and operating procedures

- during functioning condition of the facilities (undisturbed operational state, normal operation, “Normal Operation” according to IAEA Safety Standards Series No. SSR-2/1),
- during abnormal operation (disturbed operation, malfunction, “Anticipated operational occurrences” according to IAEA Safety Standards Series No. SSR-2/1), and
- during maintenance procedures (inspection, maintenance, repair).

4 Procedure

4.1 General requirements

After occurrence of an earthquake and depending on the level of the recorded acceleration time history a concept of graded measures shall be applied. This concept is shown in [Figure 1](#). The corresponding acceleration levels can be defined as plant-specific. Recommend values are indicated in this figure. Other types of intensity measures (e.g., cumulative absolute velocity (CAV) values) can also be specified additionally.

The individual required measures can be found in [4.4](#), [4.5](#) and [4.6](#). These measures should also be addressed in the operator’s manual.

NOTE Individual cases can require long-term measures. These can be performed even after the restart of the plant, however, they are not the subjects of the present document.

Recommended Acceleration Level	Plant Condition	Required Measure
1,0 DBE	Plant Shutdown	Surveillance from control room and plant walk-down inspection Shutdown inspection Additional measures
f 0,4 DBE (or OBE)	↓ <i>Shutdown Level</i> Continued Operation	Surveillance from control room and plant walk-down inspection Inspection and evaluation
0,4 DBE	↓ <i>Inspection Level</i> Continued Operation	Surveillance from control room and plant walk-down inspection
Trigger Threshold ^a	↓ <i>Plant Walk-down Inspection Level</i> Operation	Surveillance from control room and plant walk-down inspection none

^a Trigger threshold for data registration in accordance with ISO 4917-5.

Figure 1 — Concept of graded measures

In case an earthquake leads to an operational malfunction or design-basis accident, then the required measures to mitigate these events shall be performed with the highest priority.

4.2 Verification of the earthquake

Whenever the seismic recorder is activated ([Figure 2](#), chart item 1) it shall be investigated to determine whether an earthquake has occurred. This requirement may be met, e.g., by contacting institutions outside of the nuclear power plant and evaluating the recorded time histories with respect to faulty signals.

If the trigger thresholds for data recording of at least two installation locations of seismic instrumentations were exceeded (plant walk-down inspection level), it shall precautionarily be assumed that an earthquake has occurred.

In case of a faulty signal, its cause shall be determined. All faulty signals shall be documented. The documentation should be maintained as a quality record.

4.3 Classification of the earthquake

When an earthquake has occurred, the response spectra generated from the recorded time histories shall be evaluated based on the following criteria.

The earthquake shall be classified as specified in [Figure 2](#), chart item 2. The corresponding acceleration levels can be defined plant-specific. Recommended values are indicated in [Figure 1](#). Other types of intensity measures (e.g. CAV values) can also be specified additionally.

The factor f (see [Annex A](#)) may be assumed as being equal to 1,5. Using a factor f larger than 1,5 requires an individual plant-specific verification.

If the measured response spectrum exceeds the shutdown level (e.g. design basis response spectrum times $f \cdot 0,4$, or if available, the operating basis earthquake, OBE, response spectrum) at any frequency, it should be assumed that the inspection level has been decisively exceeded.

A different reference level (deviating from “design basis spectrum times $f \cdot 0,4$ ” or “operating basis earthquake OBE response spectrum”) is permissible in accordance with ISO 4917-1, provided that, it was verified that specified normal operation of the plant is possible even after the occurrence of an earthquake of that size.

If the inspection level is decisively exceeded only for frequencies above a predetermined plant specific upper bound frequency (e.g. 16 Hz), the status of the plant shall be evaluated by engineering-based considerations. For the length of these activities, a continued operation of the plant is permissible.

NOTE 1 The engineering-based evaluation may be based on, e.g., ground motion, spectral values, magnitudes or cumulative absolute velocity (CAV) values.

NOTE 2 In the case of safety-related buildings and components, the essential frequencies for the evaluation are typically the ones up to 16 Hz.

4.4 Initial measures

To obtain a quick overview of the effects that the earthquake had on the plant, the plant condition shall be determined by performing quickly executable measures.

Independent of the earthquake classification, the plant condition shall be determined by a plant inspection. This requires performing plant check-ups from the control room and plant walk-down inspections.

If the classification of the earthquake indicates that the inspection level was decisively exceeded, then a plant shutdown inspection shall be performed and the plant should be shut down.

4.4.1 Plant check-up from the control room and plant walk-down inspection ([Figure 2](#), chart item 3)

The condition of the plant shall be checked from the control room (e.g. computer printouts, displays, failure alarms, hazard alarms, indications of leakages).

Within the framework of an immediately initiated plant walk-down inspection (see [Annex B](#)), a visual inspection shall be performed to identify possible deviations caused by the earthquake. In this context, areas designed against, as well as areas not designed against seismic events shall be inspected. The type and extent of the plant walk-down inspection depend on the specific features of the plant and shall be specified in the operating regulations.

The plant walk-down inspection shall be performed at least with the extent and quality of a regular inspection round.

The results of the plant check-up and plant walk-down inspection shall be documented. The documentation shall be maintained as a quality record to be made available for third party audits.

4.4.2 Deviations caused by the earthquake (Figure 2, chart item 4)

During the plant walk-down inspection, particular attention shall be paid to obviously recognizable, earthquake-related deviations.

Provided, the earthquake classification shows that the inspection level was not reached and no earthquake-related deviations were discovered, then no in-depth measures are required and continued operation of the plant is permissible. If, however, earthquake-related deviations were discovered, it shall be checked whether the specified normal operation condition is being maintained.

If the earthquake classification shows that the inspection level was reached but not decisively exceeded and that no earthquake-related deviations were discovered, then in-depth measures shall be initiated. However, if earthquake-related deviations were discovered it shall first be checked to determine whether the specified normal operation condition is upheld before the in-depth measures are initiated.

4.4.3 Specified normal operation condition in accordance with the operating manual (Figure 2, chart item 5)

The specified normal operation condition may be considered as being maintained if the respective prerequisites and conditions specified in the operating manual are met and no earthquake-related deviations were detected that would lead to restricting specified normal operation.

If earthquake-related deviations are detected, the specified normal operation condition shall be checked and confirmed.

Provided, the specified normal operation condition is maintained, a continuation of plant operation should be permissible for the time being and the inspections and analyses described in 4.5.2 shall be performed.

If, however, the specified normal operation condition has not been maintained, a shutdown inspection as specified in 4.5.4 shall be performed and the plant shall be shut down as specified in 4.6.2.

4.5 In-depth measures

4.5.1 General

In-depth measures shall be performed depending on the classification of the earthquake and on the results of the initial measures. In-depth measures shall normally either ascertain the specified normal operation condition of the plant or facilitate its safe shutdown. The measures should be included in the operator's manual.

Provided the earthquake classification indicates that the inspection level was not reached, then in-depth measures are only required to be performed if earthquake-related deviations were detected.

If the classification of the earthquake indicates that the inspection level is exceeded, then in-depth measures shall be performed.

4.5.2 Special/Seismic inspections and analyses (Figure 2, chart item 6)

The special/seismic inspection shall be performed by a special plant inspection team as a walk-down inspection of the entire plant.

NOTE Examples for possible indications of earthquake-related deviations are presented in Annex C.

The limited accessibility of exclusion areas shall be taken into account depending on the actual plant conditions.