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Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 2201.5 (06/96)

Design of Nuclear Power Plants against Seismic Events Part 5: Seismic Instrumentation

(Auslegung von Kernkraftwerken gegen seismische Einwirkungen;
Teil 5: Seismische Instrumentierung)

A previous version of this Safety Standard was issued 06/90

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

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KTA SAFETY STANDARD

June 1996	Design of Nuclear Power Plants against Seismic Events Part 5: Seismic Instrumentation	KTA 2201.5

CONTENTS

Comments by the editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, the exceptions used, shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of this safety standard.

Fundamentals

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying safety related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act), in order to attain the protection goals specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and which are further detailed in “Safety Criteria for Nuclear Power Plants” and in “Guidelines for the Assessment of the Design of PWR Nuclear Power Plants against Incidents pursuant to Sec. 28 para. 3 of the Radiological Protection Ordinance - Incident Guidelines”.

(2) In order to attain these protection goals, safety standard KTA 2201.5 - a part of KTA 2201 entitled “Design of Nuclear Power Plants against Seismic Events” - deals with the seismic instrumentation of nuclear power plants. KTA 2201 also comprises the following parts:

Part 1: Principles

Part 2: Subsurface Materials (Soil and Rock)

Part 3: Design of Structural Components

Part 4: Requirements for Procedures for Verifying the Safety of Mechanical and Electrical Components against Earthquakes

Part 6: Post-Seismic Measures

(3) In this Part 5, a seismic instrumentation is specified that is based on the measurement principle of measuring of accelerations and which corresponds to current design practice and instrument technology.

(4) This safety standard specifies the requirements for a seismic instrumentation that, on one hand, can be used to ascertain, whether the parameters on which the inspection level has been based have been exceeded, and, on the other hand, to obtain input parameters for an analytical verification by recording the earthquake time histories.

1 Scope

This safety standard applies to nuclear power plants with light water reactors.

2 Terminology

(1) Accelerograph

A device which measures and records the absolute acceleration as a function of time. Its essential components are the acceleration sensors, recorders and seismic triggers.

(2) Triaxial Acceleration Sensors

A triaxial acceleration sensor is one that senses the acceleration in three orthogonal directions, of which one is the vertical, and that converts the acceleration into transmissible signals.

(3) Recorder

A device which records data as a function of time.

(4) Seismic Trigger

A seismic switch induces the starting and ending of the acquisition and recording of data.

(5) Seismic Switch

A measuring device which sends off a signal when the measured [seismic] value exceeds a specified limit value.

3 Number and Location

3.1 General Considerations

The following requirements regarding number and location of seismic instrumentation apply to plant sites for which the maximum acceleration of the design basis earthquake has been specified as a_{max} greater than or equal to 1 m/s². No seismic instrumentation is required at sites for which the maximum acceleration of the design basis earthquake has been specified as a_{max} less than 1 m/s².

3.2 Single-unit Plants

(1) Three triaxial acceleration sensors shall be installed in the reactor building: two in the foundation and one above these at an elevation level high enough that it represents a sufficiently large portion of the building and, thus, the amplitude amplification of the horizontal accelerations can be measured (e.g. at the reactor service level). The horizontal distance between the vertical axes of the acceleration sensors shall be chosen as large as possible. One seismic trigger shall be locally assigned to each of two random acceleration sensors. One seismic switch shall be locally assigned to each acceleration sensor.

(2) For the entirety of the other Class 1 buildings, one triaxial acceleration sensor shall be located in the open field. This acceleration sensor shall have a distance from the reactor building that is larger than two times the length of the largest dimension of the foundation of the reactor building, and, from the other buildings, at a distance that is larger than the length of the largest dimension of the horizontal cross-section of the buildings at ground level. One seismic trigger and one seismic switch shall be locally assigned to this acceleration sensor.

(3) The accelerograph and the seismic switches shall be accessible for the necessary servicing and maintenance. The accelerograph shall be designed and installed such that the possibilities for evaluating the recordings are not detrimentally affected.

(4) The acceleration sensors, seismic switches and seismic triggers shall be oriented such that their axes are parallel to the axes of that same coordinate system of the reactor building that has been assumed in the seismic analysis.

(5) The acceleration sensors, seismic switches and seismic triggers shall be installed such that no movement relative to their support structures is possible.

3.3 Multi-unit Plants

In the case of multi-unit plants each reactor building shall, basically, be equipped with seismic instrumentation. It is, however, sufficient to equip only one reactor building with seismic instrumentation if the floor response spectra of the reactor buildings do not vary by more than ± 10 % for any one frequency in the frequency range between 0.1 Hz and 30 Hz.

4 Instrument Characteristics

4.1 General

(1) A seismic instrumentation different from the type described herein (e.g., one that is based on digital technology) may be used if it allows determining the parameters required in accordance with this safety standard.

(2) The seismic instrumentation shall be capable of rendering a reliable comparison, between the design basis spectrum and the response spectrum of the actual seismic ground movement.

(3) In the case of a loss of external power supply to the instruments, a possibility for recording shall be ensured for 24 hours and a continuous system operation for 10 minutes.

(4) The instrument maintenance and testing shall be carried out in accordance with the recommendations of the manufacturer. Unless the equipment suitability tests allow to specify otherwise, the tests shall be carried out in three month intervals.

4.2 Accelerograph

(1) The accelerograph shall be designed and installed such that under the conditions to be assumed during specified normal operation, the following can be measured, recorded and reproduced:

a) the maximum acceleration correlated to the inspection level with an associated relative error not greater than ± 20 %,

b) the maximum acceleration of the design basis earthquake with an associated relative error not greater than ± 20 %,

c) the end value of the range of measurement with an associated relative error not greater than ± 5 %

(2) The dynamic range of the accelerograph including playback shall be 55:1 (corresponding to 35 dB).

(3) Characteristics of the accelerograph:

a) Acceleration Sensor

aa) In the frequency range from 0.1 Hz to 30 Hz, the deviation of the measured amplitude with respect to the mean amplitude shall not exceed ± 10 %. If this cannot be ensured, then an analytical correction of the measured data shall be possible with at least the same accuracy. There shall be no resonance in the frequency range between 0.1 Hz and 30 Hz.

ab) The damping shall be 65 % ± 5 % of the critical damping (D = 0.65 ± 0.05).

ac) The dynamic range shall be at least 100:1 (corresponding to 40 dB). The cross-axis sensitivity to acceleration components orthogonal to the sensor axis shall not exceed 3 %.

b) Recorder

ba) The dynamic range shall be at least 100:1 (corresponding to 40 dB) for a combined recording and playback. The measured data in all channels shall be recorded together with a time trace with an accuracy of ± 0.2 % and at least one mark per second.

bb) It shall be possible to resolve frequencies in the range between 0.1 Hz and 30 Hz.

bc) The recording media shall meet the requirements with respect to archival documentation.

c) Seismic trigger

ca) In the frequency range from 1 Hz to 10 Hz, the divergence of the absolute amplitude from the measured amplitude shall not exceed ± 35 %.

cb) To suppress influences not caused by earthquakes. the seismic trigger shall have a decreasing amplitude attenuation above 10 Hz.

cc) The vertical and the horizontal seismic excitation shall both cause an actuation.

(4) The acceleration sensors and recorders shall be fully operational within 0.1 seconds after the seismic trigger has registered that the limit value has been exceeded; they shall not be switched off earlier than 30 seconds after the limit value has last been exceeded. Subsequent to its actuation by the trigger impulse, the recording media shall be sufficient for a recording time of at least 10 minutes.

(5) It shall normally be possible to perform in-situ testing on the accelerograph for transmission characteristics, eigenfrequency and damping.

4.3 Seismic Switch

The seismic switch shall be sensitive to frequencies in the range between 0.1 Hz and 30 Hz. Vertical as well as horizontal seismic excitations shall actuate the signal indicating that the limit value has been exceeded.

5 Actuation and Signal

(1) It shall be ensured through circuit design that the actuation of any one seismic trigger starts all acceleration sensors and recorders. The seismic triggers in the reactor building shall be set for limit values of accelerations less than or equal to 0.1 m/s². The seismic trigger in the open field shall be set for a limit value of acceleration less than or equal to 0.2 m/s². If the trigger is often actuated by signals not caused by earthquakes, then, for example, it shall normally be placed in a different location. The limit value of acceleration may only be increased as a last resort.

(2) The limit values of the seismic switches shall be set for accelerations which correspond to the maximum acceleration values as specified or calculated for the inspection level at the location.

(3) The following signals shall be registered by the stripchart recorder either in the control room or in a control room annex:

a) actuation of the acquisition and recording of data,

b) actuation of each seismic switch,

c) loss of the external power supply to those instruments required in accordance with Section 3.

These signals shall be combined into a group alarm which shall be signaled optically and acoustically in the control room.

(4) When such a group alarm is given, it shall be verified that it has been actuated by an earthquake.

(5) In the case of a multi-unit plant, if only one reactor building is equipped with seismic instrumentation, then the signals specified under paragraph (3) shall be similarly transmitted to all control rooms.

6 Documentation

The results of the measurements, maintenance and tests on seismic instrumentation shall be documented.