Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 2201.5 (2015-11)

Design of Nuclear Power Plants Against Seismic Events; Part 5: Seismic Instrumentation

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

The previous version of this safety standard was issued in 1996-06

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

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KTA SAFETY STANDARD

2015-11	**Design of Nuclear Power Plants Against Seismic Events; Part 5: Seismic Instrumentation**	KTA 2201.5

Previous versions of the present safety standard: 1977-06 (BAnz No. 144 of August 5,1977)
1990-06 (BAnz No. 20a of January 30, 1991)
1996-06 (BAnz No. 216a of November 19, 1996)

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, 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 the present safety standard.

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in AtG and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the SiAnf-Interpretations.

(2) To achieve these goals, the present safety standard KTA 2201.5 deals with the seismic instrumentation for nuclear power plants. The safety standards series KTA 2201 “Design of Nuclear Power Plants against Seismic Events” comprises the following six parts:

KTA 2201.1: Principles

KTA 2201.2: Subsoil (soil and rock)

KTA 2201.3: Civil structures

KTA 2201.4: Components

KTA 2201.5: Seismic instrumentation
(the present safety standard)

KTA 2201.6: Post-seismic measures

(3) Objective of the seismic instrumentation is to ascertain whether a seismic event has occurred at the site of the nuclear power plant and to determine the size of this seismic event in relation to the one on which the design of the plant was based.

(4) This safety standard specifies the requirements to be fulfilled by the seismic instrumentation such that, firstly, it can be ascertained whether any of the design quantities on which the plant walk-down level and the inspection levels are based have been exceeded and that, secondly, the recording of the time history of the earthquake provides the necessary input values for a post-seismic analysis. The requirements are specified such that, independent of the detection and recording system, comparable results within tolerances are achieved in the time range as well as the frequency range.

1 Scope

This safety standard shall apply to nuclear power plants with light-water reactors located at sites where the peak ground acceleration of the design basis earthquake does not exceed 0.25 g.

2 Definitions

(1) Acceleration sensor

Acceleration sensors detect the accelerations in three orthogonal directions and convert the accelerations into transferable signals.

(2) Accelerograph

An accelerograph is an instrument that measures and records the absolute acceleration as a function of time. It essentially consists of several acceleration sensors, recording devices and seismic triggers.

(3) Recording device

A recording device is one that records measurement values as a function of time.

(4) Trigger

A trigger is a device that initiates an action whenever a threshold value is exceeded.

3 Requirements for the Seismic Instrumentation

3.1 General requirements

(1) The seismic instrumentation shall be provided with the objective of

a) detecting and quantifying the seismic effects at the plant site and at the power plant itself,

b) measuring the accelerations, recording the acceleration time histories and storing these data, and

c) enabling the comparison (of these data) with the design quantities basic to the design of the power plant.

(2) It shall be ensured that, whenever trigger levels are exceeded, these are detected and displayed by the seismic instrumentation (for the plant inspections specified in safety standard KTA 2201.1).

Note:

Plant inspections in buildings containing safety-related plant components are dealt with in safety standard KTA 2201.6.

(3) It shall be ensured that, immediately after a seismic event, it is determined and displayed whether the criteria for the inspection level specified in safety standard KTA 2201.1 have been exceeded or have been significantly exceeded (shutdown level as specified in safety standard KTA 2201.6). This requires that, immediately after the recording has ended, the recorded acceleration time histories, the resulting response spectra as well as a comparison of the resulting response spectra with the ground response spectrum (free-field response spectrum) or with the analytic building response spectra are made available.

(4) The recorded acceleration time histories shall be properly suited for analytical verifications.

Note:

Analytical verifications may be, e.g., dynamic calculations or the comparison of spectra of safety-related plant components and safety-related building structures.

3.2 Placement location

Notes:

(1) The seismic design is based on the free-field response spectrum. A comparison of the response spectrum measured in the free-field with the corresponding site-specific free-field response spectrum allows evaluating the overall power plant because, in the course of the design procedure, the loading of the overall power plant was analytically determined based on the site-specific free-field response spectrum.

(2) Due to the analytical methods employed, the building response spectra contain certain degrees of conservativeness. Therefore, a comparison of the response spectra measured inside a building with the corresponding building response spectra allows evaluating only the placement location. However, the data measured inside the building can be used for assessment purposes and for the verification of the analytical models.

(1) Accelerographs shall be provided for in the free-field and inside the reactor building.

Note:

In case of an earthquake, acceleration values can be calculated for the inside of buildings from the free-field measurement data. This corresponds to the plant design procedure specified in safety standards KTA 2201.1 through KTA 2201.4.

(2) The placement locations in the free-field and in the reactor building shall be chosen such that it is ensured that the free-field response spectra and the building response spectra derived (in each of three orthogonal directions) from the measured acceleration time histories are sufficient to be used for the evaluation in accordance with safety standard KTA 2201.6.

Note:

The terms ‘free-field response spectrum’ and ‘building response spectrum’ are defined in safety standard KTA 2201.1.

(3) The mounting structure, the local topography of the terrain and the subsoil inhomogeneity shall not have more than a negligible influence on the measurement of free-field accelerations. Furthermore, the placement location of the accelerograph in the free-field shall be chosen such that any influence of buildings on the data to be measured can be ruled out. The accelerograph shall be placed at a distance away from the reactor building that it is equal to at least twice the largest length of the reactor building foundation and, also, away from other buildings by at least the largest ground-plan dimension of the respective building.

(4) If the reference horizons of the site spectrum and of the placement location of the free-field instrumentation do not coincide, a corresponding transformation of the site spectrum relative to the reference horizon of the placement location shall be performed.

(5) At least three accelerographs shall be installed in the reactor building. Two of these shall be installed in the lowest building level and one in an upper level of the reactor building (e.g., pool floor level); the horizontal distance between the lower acceleration sensors should be as large as possible. The placement locations of the accelerographs should be chosen such that a direct comparison of the measured data with the corresponding design quantities is possible. At their placement location, there should be only negligible operation-related effects on the measurements.

(6) The acceleration sensors of the accelerographs should normally be oriented such that their axes are parallel to the axes of the coordinate system used for the seismic analysis of the reactor building.

(7) The accelerographs shall be accessible for the necessary operating and maintenance procedures. The accelerographs shall be designed and installed such that an evaluation of the recorded data is not adversely affected, e.g., by damages to components or civil structures that fail during an earthquake nor by a superposition of the measured seismic signal with seismically induced oscillations of neighboring components.

(8) The acceleration sensors of the accelerographs shall be mounted such that no movements relative to the mounting support can occur.

(9) In the case of multi-unit power plants, a single mutual free-field accelerograph is sufficient, provided, similar subsoil conditions exist for all plant units and for the placement location of the accelerograph.

(10) In the case of multi-unit power plants, basically, each reactor building shall be equipped with seismic instrumentation. In well-justified cases, e.g., similar building structure and similar subsoil conditions, this requirement may be waived.

4 Characteristics of the Instrumentation

4.1 General requirements

(1) The seismic instrumentation shall, at all placement locations, enable a reliable comparison between the response spectra of the inspection level and design basis earthquake and the response spectra of the actual seismic event.

(2) In the case of a loss of the external power supply, system operation shall be ensured for 24 hours.

(3) Maintenance and testing of the instruments shall be carried out in accordance with the manufacturer recommendations.

(4) The test interval shall not exceed one year.

4.2 Accelerographs

(1) The accelerograph shall be designed and installed such that accelerations within the measurement range are measured with an error of no larger than 1 % of the full-scale value of the measurement range.

(2) Characteristics of the accelerograph:

a) Acceleration sensor

aa) In the frequency range of 0.1 Hz to 30 Hz, the amplitude frequency response shall not deviate by more than ± 1 % from the amplitude setpoint. No resonances are permissible in the frequency range between 0.1 Hz and 30 Hz. It is permissible to arithmetically correct the amplitude frequency response.

ab) In the frequency range from 1 Hz to 30 Hz, the phase frequency response may not deviate from the set point by more than ± 2 %. It is permissible to arithmetically correct the phase frequency response.

ac) The dynamic of the sensor shall basically be 84 dB. Provided, a lower required dynamic is verified, then a system with this lower dynamic may be deployed. The cross-axis sensitivity for acceleration components orthogonal to the sensor axis shall not exceed 3 %.

ad) The specifications shall be met within a temperature range from -20 °C to 60 °C.

ae) The distance between the background noise level and the lower limit of the measurement range shall be at least 20 dB.

b) Recording device

ba) The dynamic of the recording device shall be at least 72 dB. The measurement values of all channels shall be recorded. The time offset between the channels shall not be larger than 5 ms.

bb) The recordable frequency range shall reach from less than or equal 0.1 Hz up to at least 30 Hz.

bc) It shall be ensured that the recorded data is such that a frequency resolution of 0.1 Hz can be achieved by digital post-processing.

bd) Aliasing effects shall be prevented.

be) The recording device shall record the acceleration time history from at least 10 s before activation of the trigger.

c) Data recording trigger

ca) For triggering the data recording, a corresponding threshold value shall be set in the recording device for all three measurement directions.

cb) To suppress non-earthquake related interferences, a low-pass filter with a cutoff frequency of 10 Hz shall be employed for the triggering signal.

cc) Both the vertical as well as the horizontal seismic excitation shall trigger the data recording.

d) Alarm trigger

da) For triggering an alarm, a corresponding threshold value shall be set in the recording device for all three measurement directions.

db) The frequency range to be covered shall range from 0.1 Hz up to at least 30 Hz.

dc) Both the vertical as well as the horizontal seismic excitation shall cause triggering the alarm.

(3) The acceleration sensor and the recording device shall be permanently in operation. Data recording shall start as soon as the data recording trigger threshold is exceeded and shall not be shut down earlier than 30 seconds after the last exceeding of this threshold. The lead time specified under para. (2) item be) with respect to recording the time history before exceeding the data recording trigger threshold shall be accounted for. Data storage shall be sufficient for recording at least a 30-minute duration onward from the moment of exceeding the data recording trigger threshold and beginning of the recording.

Note:

By this design requirement for the seismic instrumentation it is ensures that, in addition to data from the main earthquake, any possible fore- and aftershocks can also be recorded and stored.

(4) It shall be possible to remove the sensors to enable regular inspections. At least their transfer behavior shall be tested mechanically, e.g., by subjecting them to a tilting table test.

(5) It shall be possible to activate an automatic and periodic self-testing program for testing the system by which the following points are tested and documented:

a) Trigger test for each channel

b) Data storage test (reading and writing)

c) Battery voltage test of all built-in batteries

(6) If it is technically impossible to perform an active measurement during the self-test, then it shall be ensured that the self-test is performed only at one measurement location at a time.

(7) It should be possible to check the functional capability of the sensor in its installed condition (e.g., by an external excitation).

5 Actuation and Alarms

(1) The threshold values for data recording triggers in the reactor building shall be adjusted to acceleration limit values of not more than 0.1 m/s². The threshold value for the data recording trigger in the free-field shall be adjusted to an acceleration limit value of not more than 0.2 m/s². It shall be ensured by means of appropriate circuitry that the data recording will be actuated at all placement locations even if only a single data recording trigger threshold is exceeded by accelerations at only a single measurement location.

(2) If a trigger threshold is regularly exceeded by non-seismic related events, this measuring device should, e.g., be relocated to another placement location. Increasing the acceleration trigger threshold is permissible only if no other measures are successful.

(3) The threshold values for alarms shall be adjusted to the acceleration limit values that correspond to the maximum accelerations specified or calculated for the inspection levels at the respective placement locations.

(4) The following alarms shall be documented in the main control room or in a control room annex:

a) Actuation of data measurement and recording,

b) Actuation of any one of the alarm triggers,

c) Loss of the external power supply to the instrumentation specified in Section 3.

These alarms shall be interconnected to initiate a group alarm that shall be optically and acoustically annunciated in the main control room.

(5) A comparison of the response spectra of the seismic event with the design basis response spectra as well as an assessment whether the inspection level was exceeded or significantly exceeded shall be made available in the main control room or an annex to the control room immediately after the seismic event.

6 Documentation

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

Appendix A

Regulations Referred to in the Present Safety Standard

(Regulations referred to in the present safety standard are valid only in the versions cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were established or issued.)

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 307 of the Act of August 31, 2015 (BGBl. I 2015, No. 35, p. 1474)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I, p. 1714; 2002 I, p. 1459), most recently changed by Article 5 of the Act of December 11, 2014 (BGBl. I, p. 2010)
SiAnf	(2015-03)	Safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B2)
SiAnf-Interpretations	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B3)
KTA 2201.1	(2011-11)	Design of nuclear power plants against seismic events; Part 1: Principles
KTA 2201.2	(2012-11)	Design of nuclear power plants against seismic events; Part 2: Subsoil
KTA 2201.3	(2013-11)	Design of nuclear power plants against seismic events; Part 3: Civil structures
KTA 2201.4	(2012-11)	Design of nuclear power plants against seismic events; Part 4: Components
KTA 2201.6	(2015-11)	Design of nuclear power plants against seismic events; Part 6: Post-seismic measures