

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 2201.3 (2013-11)

**Design of Nuclear Power Plants Against Seismic Events;
Part 3: Civil Structures**

(Auslegung von Kernkraftwerken gegen seismische Einwirkungen;
Teil 3: Bauliche Anlagen)

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

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KTA SAFETY STANDARD

2013-11

Design of Nuclear Power Plants Against Seismic Events; Part 3: Civil Structures

KTA 2201.3

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 35-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in the Federal Gazette (Bundesanzeiger) on May 06, 2015. Copies of the German versions of the KTA safety standards may be mail-ordered through the Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website (<http://www.kta-gs.de>).

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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 any 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 Criteria", the "Design-Basis Accident Guidelines" and the "Safety Requirements for Nuclear Power Plants (SiAnf)".

(2) In accordance with Criterion 2.6 of the Safety Criteria, protective measures against seismic events are required, provided, earthquakes must be taken into consideration. Table I of the Design-Basis Accident Guidelines classifies earthquakes as belonging to that group of design basis accidents that requires taking precautionary plant engineering measures against damage and which, within this group, are relevant with respect to radiological effects on the environment. The basic requirements of these precautionary measures are dealt with in the safety standard series KTA 2201.

(3) To achieve these goals, safety standard KTA 2201.3 deals with the requirements specific to the seismic design of civil structures above and beyond their conventional design. The safety standard series KTA 2201 comprises the following six parts:

KTA 2201.1: Principles

KTA 2201.2: Subsoil (soil and rock)

KTA 2201.3: Civil structures
(the present safety standard)

KTA 2201.4: Components

KTA 2201.5: Seismic instrumentation

KTA 2201.6: Post-seismic measures

1 Scope

(1) This safety standard applies to civil structures of nuclear power plants with light water reactors in order to achieve the protective goals specified in safety standard KTA 2201.1. It specifies the requirements for civil structures that must be met for the verification of their load-bearing capacity (stability) in case of a seismic event. Additionally, requirements are specified pertaining to the verification of the serviceability of civil structures as far as necessary for maintaining their safety-related function in case of a seismic event (e.g., deformation and crack-width limitations).

(2) This safety standard does not apply to cranes, to detachment devices for lifting equipment nor to the supporting and mounting constructions of components.

Note:

The term civil structures as used in this safety standard shall comprise buildings and structural members made of reinforced concrete, pre-stressed concrete, steel, as well as steel composite structures and brickwork. Among others, these include the containment, crane runways, platforms, anchor constructions and canals.

2 Definitions

(1) Radiation damping

Radiation damping is the damping due to energy being radiated into an adjacent medium, e.g. the subsoil.

(2) Ground, homogenous

The ground will be considered as being homogenous within the framework of calculations if a ground stratum with a near constant shear-wave velocity throughout its thickness is shown to have a ratio of thickness-to-foundation-radius larger than 4.

(3) Ground-building interaction

Ground-building interaction is the interaction relationship between local ground conditions and the vibration behavior of the building. This interaction comprises the kinematic interaction and the interaction due to the inertial forces of the building.

(4) Damping

Damping shall be distinguished according to:

a) Material damping

This is caused by internal micro-plastic procedures; it is measured in the laboratory excluding bordering influences and the like; it is dependent on the load level.

b) Component damping

This is the damping of a component (e.g., plate, beam) including bordering influences and effects from secondary components (concrete flooring, surfacing, etc.). For equal load levels, component damping is larger than material damping.

c) Structure damping

This is the damping of the total structure comprised of many components and it includes the influence from, e.g., non-supporting components, internals, connections and effects from radiation damping. For equal load levels, structure damping is significantly higher than component damping.

(5) Dimensionless frequency, a_0 , of a foundation

The dimensionless frequency, a_0 , is defined as follows:

$$a_0 = \frac{\omega \cdot r_0}{v_s} \quad (2-1)$$

Nomenclature:

ω : angular frequency,

r_0 : substitute radius determined from the condition of equality of areas for translatory degrees of freedom or from the moments of inertia for rotatory degrees of freedom

v_s : shear-wave velocity in the subsoil.

(6) Impedance functions

The impedance functions are the complex, frequency dependent foundation stiffness values in the subsoil; their real and imaginary parts characterize stiffness and damping.

(7) Non-linearity, geometric, physical

a) Geometric non-linearity

A geometric non-linearity is the non-linear relationship between force and path values caused by equilibrium and kinematic considerations for the deformed system.

b) Physical non-linearity

A physical non-linearity is the non-linear relationship between stresses and expansions caused by a non-linear material behavior.

(8) Rayleigh damping

Rayleigh damping exists whenever the damping matrix, **C**, can be assumed to be a linear combination of the mass matrix, **M**, and the stiffness matrix, **K**, using the Rayleigh parameters α and β as follows:

$$\mathbf{C} = \alpha \cdot \mathbf{M} + \beta \cdot \mathbf{K} \quad (2-2)$$