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Design of nuclear power plants against seismic events —

Part 4: Components

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Conception parasismique des installations nucléaires —

Partie 4: Composants

FDIS stage

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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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO ~~had~~ had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at ~~www.iso.org/patents~~ www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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~~ www.iso.org/members.html.

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Introduction

In accordance with IAEA Safety Standards Series No. SSR-2/1, protective measures against seismic events are required, provided earthquakes ~~shall~~should be taken into consideration. Earthquakes comprise that group of design basis events that requires taking preventive plant engineering measures against damage and which are relevant with respect to radiological effects on the environment. The basic requirements of these precautionary measures are dealt with in ISO 4917-1:—.

ISO 4917-4 presents the basis for fulfilling the requirements regarding the verification of the site-specific earthquake safety of components.

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Design of nuclear power plants against seismic events —

Part 4: Components

1 Scope

This document applies to nuclear power plants with water cooled reactors. For other nuclear facilities check the applicability of the document might be possible but should be checked in advance, before it might be applied correspondingly.

This document specifies the requirements for the earthquake safety of components. The operation-specific safety-related requirements for each component, e.g. load-bearing capacity (stability), integrity and functionality (see 4.1)4.1) are not the subject of this document. With regard to analyzinganalysing the mechanical behaviour of the individual components and verifying the fulfillment of their safety related functions, additionally, the respective component-specific standards need to be consulted.

In this document, the term *mechanical components* refers to components such as vessels, heat exchangers, pumps, valves, lifting gear, distribution systems and pipe lines including their support structures in as far as these components are not considered to be civil structures in accordance with ISO 4917-3. Liners, crane runways, platforms and scaffoldings are not considered as being part of these mechanical components.

In this document, the term *electrical components* refers to the combination of electrical devices including all electrical connections and their support structures (e.g. cabinets, frames, consoles, brackets, suspensions or supports).

Supplementary to this standard the seismic qualification of electrical components is reported in IEC/IEEE 60980-344.

NOTE This document is independent of national standards. Recommendations, given in Annex A,Annex A, are mainly based on the Eurocodes-Design-Philosophy and European Standards. Alternatively other equivalent standards or regulations can be used in case the general requirements given in this document together with Annex AAnnex A can be met.

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.

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

<std>ISO 4917-3: , *Design of nuclear power plants against seismic events — Part 3: Design of structural components*</std>

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

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ISO 4917-3, *Design of nuclear power plants against seismic events — Part 3: Design of structural components*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4917-1 ~~:—~~ and the following apply.

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

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

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

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

3.1
behaviour coefficient
q
reduction coefficient applied to the force magnitude determined by linear analysis of earthquake events

Note 1 to entry: ~~—~~ The coefficient *q* takes the dissipative effects into account that arise from the materials used, from the support structure and from the structural design.

3.2
~~center~~centre of gravity
<dynamic> point of action of gravity, which can be considered as the point on the approximated single degree of freedom model of a structure, at which the acceleration is equal to the respective value of the response spectrum

3.3
~~Damping~~
damping
<modal> damping ratio of the respective eigenmode in mechanical systems

3.4
demand response spectrum
response spectrum that is specified for the design verification or qualification of structures, systems or components and that is usually obtained by multiplying the design response spectrum by safety factors and test-signal specific magnification factors

Note 1 to entry: ~~—~~ Demand response spectra may also be created as an enveloping curve of the response spectra at the various places of installation.

3.5
design spectrum
enveloping, widened and smoothed single-degree-of-freedom response spectrum that is used as the basis for the seismic design

Note 1 to entry: ~~—~~ In this context, it is differentiated between ground acceleration response spectrum (primary spectrum), building response spectrum (secondary spectrum) and component response spectrum (tertiary spectrum).

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3.6
non-linearity
<geometric or physical> nonlinear relationship between the quantities of action and reaction resulting from the equilibrium and kinematic analyses of a system

Note 1 to entry: A physical nonlinearity is the nonlinear relationship between stresses and distortions resulting from a nonlinear material behaviour.

Note 2 to entry: A geometric nonlinearity is defined by a change of dynamic behaviour due to a change of shape, closing or opening of gaps, uplifting or sliding of a component.

3.7
primary system
heavy structure that supports one or more lighter-weight *secondary systems* ~~(3.8)~~(3.8)

3.8
secondary system
lighter-weight partial system that is supported by a heavy *primary system* ~~(3.7)~~(3.7)

3.9
single-frequency excitation
frequency, which has a time history in which at every point in time only a single excitation frequency (e.g. sine sweep, fixed frequency) occurs

3.10
test response spectrum
response spectrum determined based on the actual motion of the shaking table

3.11
upper limit frequency
frequency above which no significant seismic response in mechanical components would occur

Note 1 to entry: The upper limit frequency may be specified as the cut-off frequency of the excitation spectrum.

4 General requirements

4.1 Basics

The general design requirements for components are specified in ISO 4917-1:—, 4.1. They include classification of the components, i.e. their assignment to seismic category 1, seismic category 2, and seismic category 3, as well as the general requirements regarding the verification of their earthquake safety.

The design of components and civil structures against seismic events should meet the objectives specified in ISO 4917-1.

It shall be verified for all seismic category 1 components that they are able to fulfill their safety related functions in the case of seismic events. The safety related functions shall be specified for each component. Typical safety related functions are:

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a) 1) Load-bearing capacity (stability):

— The load-bearing capacity is the capability of components to withstand the loads to be assumed on account of their strength, stability and secure positioning (e.g. their protection against falling over, against dropping down, against impermissible slipping).

— The load-bearing capacity shall be verified for the component and its support. The building structure interaction loads shall be specified.

b) 2) Integrity:

— Integrity is the ability of a plant component to fulfill its requirements with regard to leak tightness or deformation restrictions.

— The integrity of the components shall be verified based on requirements in accordance with the component-specific standards.

c) 3) Functionality:

— Functionality is the ability of a system or component to fulfill its designated safety functions during and after the seismic event

— In this context, it shall be differentiated between whether the functionality of the component shall be achieved

  — after the earthquake, or

  — during and after the earthquake.

— Furthermore, it shall be differentiated between active and passive functionalities.

— An active functionality of a component ensures that the specified movements (relative movements between individual parts) can be performed (closing of clearances, creating or changing of friction forces) and that the electrical functions are maintained.

— A passive functionality of a component means that permissible deformations and movements are not exceeded. Also, false signals should not appear in electrical equipment.

For all seismic category 2 components it is required to be verified that on account of earthquakes they will not adversly affect the seismic category 1 components and civil structures in a way that these would not anymore be able to fulfill their safety related functions. In this context, it is generally sufficient to verify the load-bearing capacity. In certain cases, it may be necessary to verify that limit deformations are not exceeded or that integrity (risk of flooding) is upheld.

Ageing effects that might influence the verification objective shall be taken into account.

NOTE Details regarding ageing effects are dealt with in IAEA Nuclear Energy Series No. NP-T-3.24.

In this document the verifications required for the mechanical and electrical components including their support structures are broken down into individual verification steps, i.e.

1) i) determining the excitation at the place of installation,

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