IEC 63186

Edition 1.0 2021-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear power plants – Instrumentation and control systems important to safety – Criteria for seismic trip system

Centrales nucléaires de puissance – Systèmes d'instrumentation et de contrôle-commande importants pour la sûreté – Critères pour système de protection sismique

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NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY – CRITERIA FOR SEISMIC TRIP SYSTEM

FOREWORD

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IEC 63186 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
45A/1391/FDIS	45A/1397/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

a) Technical background, main issues and organization of the standard

Earthquakes pose one of the major external threats to the safe operation of nuclear power plants. Structures, systems and components important to safety of a nuclear power plant are generally designed to tolerate a postulated design basis earthquake. To mitigate the adverse effects of a strong earthquake and further enhance reactor safety, the seismic trip system has been implemented in many reactor designs.

Nevertheless, a dedicated IEC standard for the design of such I&C system was missing. Lessons learned from the Fukushima accident emphasize the importance of installing an automatic seismic trip system as it provides a valuable lead time and enhances the safety margins in potential accident conditions. IEC 63186 is the first effort in this field and provides technical guidance and requirements for the design of this system. It discusses general considerations for a seismic trip system and explains the rationale for the system design. Specific requirements for the system design and equipment specification are presented. Requirements for tests used to demonstrate the functionality of the designed system are also included.

b) Situation of the current standard in the structure of the IEC SC 45A standard series

IEC 63186 is the third level SC 45A document tackling the issue of the seismic trip system design.

It is built upon a number of first and second level SC 45A documents. For example, IEC 63186 refers to IEC 61513 for general requirements, IEC 61226 for classification determination, and IEC/IEEE 60780-323 for testing requirements.

For more details on the structure of the SC 45A standard series see item d) of this introduction.

c) Recommendations and limitations regarding the application of this standard

The design of the seismic trip system should be harmonized with overall plant designs and the seismic design requirements in particular. Key issues to be coordinated include, but are not limited to, classification, system architecture, acceleration sensor mounting positions, interface to actuated device, and trip set-point.

This document focuses on the design requirements for the seismic trip system. Other parts of the system lifecycle, particularly the operation and maintenance requirements are not within the scope of IEC 63186.

d) Description of the structure of the IEC SC 45A standard series and relationships with other IEC documents and other bodies documents (IAEA, ISO)

The top-level documents of the IEC SC 45A standard series are IEC 61513 and IEC 63046. IEC 61513 provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 63046 provides general requirements for electrical power systems of NPPs; it covers power supply systems including the supply systems of the I&C systems. IEC 61513 and IEC 63046 are to be considered in conjunction and at the same level. IEC 61513 and IEC 63046 structure the IEC SC 45A standard series and shape a complete framework establishing general requirements for instrumentation, control and electrical systems for nuclear power plants.

IEC 61513 and IEC 63046 refer directly to other IEC SC 45A standards for general topics related to categorization of functions and classification of systems, qualification, separation, defence against common cause failure, control room design, electromagnetic compatibility, cyber security, software and hardware aspects for programmable digital systems, coordination of safety and security requirements and management of ageing. The standards referenced directly at this second level should be considered together with IEC 61513 and IEC 63046 as a consistent document set.

At a third level, IEC SC 45A standards not directly referenced by IEC 61513 or by IEC 63046 are standards related to specific equipment, technical methods, or specific activities. Usually these documents, which make reference to second-level documents for general topics, can be used on their own.

A fourth level extending the IEC SC 45 standard series, corresponds to the Technical Reports which are not normative.

The IEC SC 45A standards series consistently implements and details the safety and security principles and basic aspects provided in the relevant IAEA safety standards and in the relevant documents of the IAEA nuclear security series (NSS). In particular this includes the IAEA requirements SSR-2/1, establishing safety requirements related to the design of nuclear power plants (NPPs), the IAEA safety guide SSG-30 dealing with the safety classification of structures, systems and components in NPPs, the IAEA safety guide SSG-39 dealing with the design of instrumentation and control systems for NPPs, the IAEA safety guide SSG-34 dealing with the design of electrical power systems for NPPs and the implementing guide NSS17 for computer security at nuclear facilities. The safety and security terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

IEC 61513 and IEC 63046 have adopted a presentation format similar to the basic safety publication IEC 61508 with an overall life-cycle framework and a system life-cycle framework. Regarding nuclear safety, IEC 61513 and IEC 63046 provide the interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector. In this framework IEC 60880, IEC 62138 and IEC 62566-2 correspond to IEC 61508-3 for the nuclear application sector. IEC 61513 and IEC 63046 refer to ISO as well as to IAEA GS-R part 2 and IAEA GS-G-3.1, and IAEA GS-G-3.5 for topics related to quality assurance (QA). At level 2, regarding nuclear security, IEC 62645 is the entry document for the IEC/SC 45A security standards. It builds upon the valid high level principles and main concepts of the generic security standards, in particular ISO/IEC 27001 and ISO/IEC 27002; it adapts them and completes them to fit the nuclear context and coordinates with the IEC 62443 series. At level 2, IEC 60964 is the entry document for the IEC/SC 45A control rooms standards and IEC 62342 is the entry document for the ageing management standards.

NOTE It is assumed that for the design of I&C systems in NPPs that implement conventional safety functions(e.g. to address worker safety, asset protection, chemical hazards, process energy hazards) international or national standards would be applied.

NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY – CRITERIA FOR SEISMIC TRIP SYSTEM

1 Scope

This document specifies the minimum requirements for the design of the seismic trip system, and the components thereof, used in a nuclear power plant to mitigate seismic effects. This system is intended to shut down the reactor in operation automatically before it is significantly impacted by the vibratory ground motion incurred by strong earthquakes. This document is applicable to both the design of new built plants and the upgrading of plants in operation. It may be used for the design of other types of nuclear facilities where normal operation shall be stopped in case of strong seismic motions.

NOTE In addition to the seismic trip system, other names are possible for the system covered in this document, e.g. automatic seismic trip system or earthquake scram/trip system.

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.

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60671, *Nuclear power plants – Instrumentation and control systems important to safety - Surveillance testing*

IEC 60709, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Separation*

IEC/IEEE 60780-323, *Nuclear facilities – Electrical equipment important to safety – Qualification*

IEC 60880, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer–based systems performing category A functions*

IEC/IEEE 60980-344:2020, *Nuclear facilities – Equipment important to safety – Seismic qualification*

IEC 60987, *Nuclear power plants – Instrumentation and control important to safety – Hardware requirements*

IEC 61226, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Categorization of functions and classification of systems*

IEC 61513:2011, *Nuclear power plants – Instrumentation and control important to safety – General requirements for systems*

IEC 62003, *Nuclear power plants – Instrumentation, control and electrical power systems – Requirements for electromagnetic compatibility testing*

IEC 62138, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category B or C functions*

IEC 62566, *Nuclear power plants – Instrumentation and control important to safety – Development of HDL-programmed integrated circuits for systems performing category A functions*

IEC 62566-2, *Nuclear power plants – Instrumentation and control systems important to safety – Development of HDL-programmed integrated circuits – Part 2: HDL-programmed integrated circuits for systems performing category B or C functions*

IEC 62645, *Nuclear power plants – Instrumentation, control and electrical power systems – Cybersecurity requirements*

3 Terms and definitions

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

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
acceleration sensor
instrument capable of sensing absolute acceleration and producing an analog or digital signal

3.2
cumulative absolute velocity
time integral of absolute acceleration over the duration of the strong earthquake shaking

3.3
free field
location on the ground surface or in the site soil column that is sufficiently distant from the site structures to be essentially unaffected by the vibration of the site structures

3.4
operating basis earthquake
OBE/S1
earthquake that could reasonably be expected to occur at the plant site during the operating life of the plant considering the regional and local geology and seismology and specific characteristics of local subsurface material

Note 1 to entry: It is that earthquake that produces the vibratory ground motion for which those features of the nuclear power plant, necessary for continued operation without undue risk to the health and safety of the public, are designed to remain functional.

[SOURCE: IEC/IEEE 60980-344, 2020, 3.25]

3.5
peak ground acceleration
PGA
the maximum absolute value of ground acceleration displayed on an accelerogram; the greatest ground acceleration produced by an earthquake at a site

[SOURCE: IAEA Safety Glossary, 2018 Edition]

3.6
qualification
process of determining whether a system or component is suitable for operational use. The qualification is performed in the context of a specific class of the I&C system and a specific set of qualification requirements

[SOURCE: IEC 61513, 2011, 3.38]

3.7
safe shutdown earthquake
SSE/S2
earthquake that is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake that produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems, and components are those necessary to provide reasonable assurance of the following:

a) Integrity of the reactor coolant pressure boundary
b) Capability to shut down the reactor and maintain it in a safe shutdown condition
c) Capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to applicable regulatory requirements

[SOURCE: IEC/IEEE 60980-344, 2020, 3.39]

3.8
safety function
a specific purpose that must be accomplished for safety for a facility or activity to prevent or to mitigate radiological consequences of normal operation, anticipated operational occurrences and accident conditions

[SOURCE: IAEA Safety Glossary, 2018 Edition]

3.9
tri-axial
able to measure a variable in three mutually orthogonal components (directions), one of which is usually vertical

Note 1 to entry: Applies to description of the function of an instrument or group of instruments.

4 Abbreviated terms

ALARA	As Low As Reasonably Achievable
CAV	Cumulative Absolute Velocity
CRDM	Control Rod Drive Mechanism
EMC	Electromagnetic Compatibility
ESS	Earthquake Scram System
FRS	Floor Response Spectrum
FPGA	Field Programmable Gate Array
HMI	Human Machine Interface
IAPS	Industrial Anti-Seismic Protecting System
I&C	Instrumentation and Control
MEMS	Micro-Electromechanical Systems
NPP	Nuclear Power Plant

PGA	Peak Ground Acceleration
SOE	Sequence of Event
SSCs	Structures, Systems and Components
VVER	Water-Water Hull Nuclear Power Reactor with Pressurized Water

5 General considerations

5.1 Purpose

Earthquakes pose one of the major external threats to the safe operation of nuclear power plants. To withstand the potential effects of earthquakes, structures, systems and components important to safety of a nuclear power plant are generally designed to tolerate a postulated design basis earthquake. To mitigate the adverse effects of a strong earthquake and further enhance reactor safety, the seismic trip system has been implemented in some reactor designs.

The seismic trip system may be used for different purposes, e.g. as a precautionary measure against inadequate seismic designs identified during operation. In cases where geological studies or observed earthquakes near the site indicate that the risk of seismic hazard is higher than the design basis, then the seismic trip system may be applied as an additional measure to enhance the seismic robustness for an operating plant.

In other cases, where the expected seismic level is bounded by design basis earthquakes, safety systems are adequately engineered to implement the desired safety functions during and after seismic motions. In such cases the seismic trip system may be deployed to further improve reactor safety against earthquakes. Both experience and technical studies have indicated that an immediate seismic trip during a strong earthquake can provide a favourable lead time, e.g. between 5 s to 20 s, which helps to reduce the loads during the seismic event and there will be less burden incurred on the plant systems. Such lead-time also helps to reduce the likelihood of a loss-of-coolant accident or severe transient after a seismic event. For example, earlier trip can reduce transient pressure and loads, as well as the heat generation rate in the core. In the event of a loss-of-coolant accident, an earlier trip will reduce the fuel rod temperature transient and the containment vessel pressure.

A seismic trip system can contribute to the safety of an operating nuclear power plant by mitigating the risk from seismic activity. The timing of the seismic trip system tripping actuation may be of relevance to facilitate post-trip analysis, therefore the actuation status of the seismic trip system may be transmitted to an SOE system.

Some examples of implementation of the seismic trip system are given in Annex A.

5.2 Decision issues for the seismic trip system implementation

The decision to install a seismic trip system will depend upon national regulatory requirements, the conclusions from the plant safety analysis and the utility owner's considerations. In general, a well-informed decision should take into account the following factors:

a) The level, frequency and duration of earthquake activity at the plant site.
b) The robustness of nuclear power plant systems against seismic shocks.
c) Considerations relating to spurious trips.
d) Impact on national or local electricity grid stability.
e) Mandatory requirements manifested in national regulations.
f) Other factors as applicable and appropriate.

A decision may be made based on one or a combination of these factors, and the relative importance of each of the issues may vary from one country to another.

5.3 Categorization and classification

The safety class of a seismic trip system shall correspond to its assigned category of functions in accordance with IEC 61226 and IEC 61513 and in particular mandatory national regulation requirements. In international practices, seismic trip systems classified as Category B or C are both found.

The seismic trip function may either be implemented in a standalone system or integrated as a part into other I&C systems. In the case of integration into other systems, the seismic trip system shall be designed in such a way as to prevent the propagation of failures from or to the integrated system.

5.4 Multi-unit station consideration

If the seismic trip system is shared by multiple units located at the same site, then the transient affect on the grid due to simultaneous tripping by spurious actuation should be considered, especially for countries with small national grids, as this might lead to failure of the national grid.

Where it is determined appropriate to share the seismic trip system trip signals, annunciations shall be made in each plant. Caution should be taken when transmitting the trip actuation signals across the units, to ensure their functionality during and after S2 earthquakes. Adequate electrical isolation shall be provided for the trip actuation signal.

6 System design requirements

6.1 General

The seismic trip system continuously monitors the site seismic activities, and automatically generates a trigger signal when the monitored variable exceeds the set-point or prescribed criterion. The trip signal is sent to trip the reactor by selected means, e.g. opening circuit breakers controlling power feed to control rod drive mechanisms (CRDMs).

Design efforts shall be commensurate with the safety significance and classification assigned to the seismic trip system, which is the result of overall plant design considerations. Special considerations shall be taken into account to avoid spurious reactor trip as much as technologically possible.

6.2 Seismic design requirements

The seismic trip system is intended to implement automatic reactor trip on occurrence of a strong earthquake; subsequently it is an inherent requirement for the system and its components to remain functional during and after an earthquake. In order to guarantee such capabilities, the seismic trip system shall be designed, fabricated, and tested against the design basis earthquake known as S1/S2. The level shall be chosen according to the system design.This shall be ensured by qualification in conformance with IEC/IEEE 60980-344.

6.3 System architecture

The engineered system architecture for the seismic trip system shall comply with applicable requirements from IEC 61513. In particular, the seismic trip system architecture shall be designed to prevent spurious reactor trips.