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**Nuclear power plants – Instrumentation  
and control systems important to safety –  
Surveillance testing**

**Centrales nucléaires de puissance –  
Systèmes d'instrumentation et de contrôle-  
commande importants pour la sûreté –  
Essais de surveillance**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**NUCLEAR POWER PLANTS –  
INSTRUMENTATION AND CONTROL  
SYSTEMS IMPORTANT TO SAFETY –  
SURVEILLANCE TESTING**

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International Standard IEC 60671 has been prepared by subcommittee 45A: Instrumentation and control of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition published in 1980 and constitutes a technical revision.

The main technical changes with respect to the previous edition are as follows:

- Expand scope to cover all systems important to safety, and clarify requirement gradation for systems and equipment performing category A, B and C functions.
- Align with the new revisions of IAEA documents NS-R-1 and NS-G-1.3 (replacing D3 and D8).

- Provide references to relevant normative standards.
- Harmonize terminology with the existing standard hierarchy.
- Strengthen the role of computer self-supervision as an alternative to periodic surveillance testing.
- Introduce features of digital I&C that present special opportunities or problems to on-line testing.
- Present design requirements on testing features themselves (categorization, verification, etc.) that derive from the standards adopted since the first issue of IEC 60671, which will thus be updated to become consistent with the newer standards.

The text of this standard is based on the following documents:

FDIS	Report on voting
45A/648/FDIS	45A/655/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

In the United Kingdom some differences exist:

Introduction, Clauses 1, 2 and 4.2: The classification scheme captured in standard IEC 61226 edition 2 (2005-02) is contrary to the custom, practice, and regulatory expectations as set down by the United Kingdom Health and Safety Executive's Nuclear Installations Inspectorate and the understanding in the United Kingdom of IAEA safety guides. Users of this standard are advised that, in the United Kingdom, this standard should be read in conjunction with the edition of IEC 61226 published by the BSI, and the Health and Safety Executive's Nuclear Installations Inspectorate's Safety Assessment Principles to determine the classification of a function or system.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

## INTRODUCTION

### a) Background, main issues and organization of the standard

A fundamental requirement for I&C (instrumentation and control) systems important to safety in nuclear power plants is that they be capable of being demonstrated to be ready to perform their safety functions if needed. Surveillance testing may be performed by the execution of functional tests or by self-supervision within the I&C systems important to safety, and is augmented by diagnostic functions and by visual inspections of the I&C systems and their status indicators by the plant operation staff. Depending on the reliability targets and the testing conditions the demonstration of functional readiness may be performed either while the plant is on-line or during plant shutdown. This Standard provides technical requirements and recommendations for the implementation of surveillance testing for I&C systems important to safety.

The object of this standard is:

- in Clause 4:
  - to establish the principles for surveillance testing of I&C equipment important to safety.
- in Clauses 5 through 9:
  - to give requirements to be fulfilled in the design and operation of I&C equipment important to safety in regards to the surveillance testing.

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

IEC 61513 establishes the top level requirements for I&C systems and equipment important to safety. Among these requirements is the need to demonstrate, on a continuing basis, the operability of the equipment and its readiness to perform its safety or safety related functions.

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IEC 61226 establishes the principles of categorization of I&C functions according to their level of importance to safety. The reliability required from any function in categories A, B or C should be determined by either a quantitative probabilistic assessment of the NPP, or by qualitative engineering judgment, and included in the specification.

IEC 60671 provides the bases and requirements for surveillance testing to demonstrate the operability, under normal conditions, of these systems and equipment during their operative life.

IEC 60671 supports the achievement of the target reliability by detecting faults within the equipment allowing appropriate measures to be initiated (timely repair or any alternative solutions).

IEC 60671 is the third level SC 45A document tackling the issue of surveillance testing for I&C systems important to safety

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 the Standard

IEC 60671 applies to I&C systems and equipment important to safety. It establishes requirements for surveillance testing as a means of demonstrating on a continuing basis the readiness of the systems and equipment to perform their functions important to safety.



Additional requirements relating to reliability and detailed requirements for redundancy and diversity are not given in this standard but can be found in other documents of SC 45A.

The attention of the reader is drawn to the fact that in some countries the scope and the content of periodic testing are defined by regulatory requirements and that these definitions could differ from the ones used in this standard.

In the case of existing plants it may not be possible to apply all of the requirements of this standard. Therefore, at the beginning of a modernization project of an I&C system important to safety the subset of requirements to be applied shall be identified in regards to the overall scope and consequences of modification of the I&C systems.

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

The top-level document of the IEC SC 45A standard series is IEC 61513. It provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 61513 structures the IEC SC 45A standard series.

IEC 61513 refers directly to other IEC SC 45A standards for general topics related to categorization of functions and classification of systems, qualification, separation of systems, defence against common cause failure, software aspects of computer-based systems, hardware aspects of computer-based systems, and control room design. The standards referenced directly at this second level should be considered together with IEC 61513 as a consistent document set.

At a third level, IEC SC 45A standards not directly referenced by IEC 61513 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 45A standard series, corresponds to the Technical Reports which are not normative.

IEC 61513 has adopted a presentation format similar to the basic safety publication IEC 61508 with an overall safety life-cycle framework and a system life-cycle framework and provides an interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector. Compliance with IEC 61513 will facilitate consistency with the requirements of IEC 61508 as they have been interpreted for the nuclear industry. In this framework IEC 60880 and IEC 62138 correspond to IEC 61508-3 for the nuclear application sector.

IEC 61513 refers to ISO as well as to IAEA 50-C-QA (now replaced by IAEA 50-C/SG-Q) for topics related to quality assurance (QA).

The IEC SC 45A standards series consistently implements and details the principles and basic safety aspects provided in the IAEA code on the safety of NPPs and in the IAEA safety series, in particular the Requirements NS-R-1, establishing safety requirements related to the design of Nuclear Power Plants, and the Safety Guide NS-G-1.3 dealing with instrumentation and control systems important to safety in Nuclear Power Plants. The terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

## NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY – SURVEILLANCE TESTING

### 1 Scope

Where functional reliability is required by general safety standards, one aspect of demonstrating this reliability is testing performed on-line during plant operation or during plant shutdown in preparation for return to power operation.

This standard lays down principles for testing I&C systems performing category A, B and C functions, per IEC 61226, during normal power operation and shutdown, so as to check the functional availability especially with regard to the detection of faults that could prevent the proper operation of the functions important to safety. It covers the possibility of testing at short intervals or continuous surveillance, as well as periodic testing at longer intervals. It also establishes basic rules for the design and application of the test equipment and its interface with the systems important to safety. Further, the effect of any test equipment failure on the reliability of the I&C systems is considered.

Types of surveillance tests may include:

- self-tests for I&C equipment;
- test of a group of equipment or components to confirm properties that support the safety function (continuity, power availability, etc.);
- test based on information redundancy or comparison of control signatures (consistency checking for redundant sensors, CRC-checking, Checksum, etc.);
- periodic testing which is related to the correctness of functional behaviour of an I&C system.

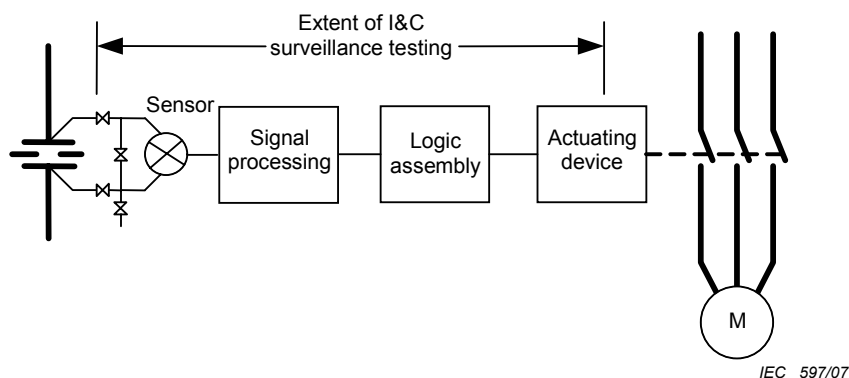
The dependability targets of any I&C system is reached using an appropriate combination of tests of the form indicated above.

The extent of the I&C system to be tested is from the interface of the sensors with the process through to the actuation devices (see Figure 1). It is applicable to the installed I&C systems as well as to temporary installations which are part of those I&C systems important to safety (for example, auxiliary equipment for commissioning tests and experiments). This standard also applies to individual electromechanical equipment, such as relays and solenoid actuators.

Additional testing and inspections may be performed on I&C equipment for purposes other than the demonstration of functional capability, such as to optimise preventive maintenance, etc. Such tests are beyond the scope of this standard; however, they may be combined with the surveillance testing discussed herein.

For any on-line tests the potential interaction and fault dependencies between the part of the system under test and the testing part, have to be carefully studied and their influences have to be fully integrated into the reliability assessment of the functions important to safety (in accordance with IEC 61513).

This standard applies to the I&C of new nuclear power plants as well as to I&C upgrading or back-fitting of existing plants. For I&C upgrades, only a subset of the requirements may be applicable; this subset is to be identified at the beginning of any project.



**Figure 1 – Extent of I&C surveillance testing**

## 2 Normative references

The following referenced documents are indispensable for the application 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 60880, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category A functions*

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IEC 60987, *Nuclear power plants – Instrumentation and control important to safety – Hardware design requirements for computer-based systems*

IEC 61226, *Nuclear power plants – Instrumentation and control systems important for safety – Classification of instrumentation and control functions*

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

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

IAEA Safety Guide NS-G-1.3, *Instrumentation and Control Systems Important to Safety in Nuclear Power Plants*

## 3 Terms and definitions

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

### 3.1 automatic test

a test in which the operation of all or part of the instrumentation and control system is checked in a completely automatic sequence. The automatic test sequence can be started either manually by the operator, cyclically by a clock or automatically by the verification of a well-defined condition

**3.2  
availability**

the ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided

[IEV 191-02-05]

**3.3  
bypass**

a device to inhibit, deliberately but temporarily, the functioning of a circuit or system by, for example, short circuiting the contacts of a relay.

- **maintenance bypass:** a bypass of safety system equipment during maintenance, testing or repair;
- **operational bypass:** a bypass of certain protective actions when they are not necessary in a particular mode of plant operation

[IAEA Safety Glossary, Ed. 2.0 2006]

NOTE 1 A maintenance bypass that is applied to a channel may still leave the safety function operable through redundancy and majority voting (e.g. two out of four coincidence logic becomes two out of three).

NOTE 2 A maintenance bypass is not the same as an operational bypass. A maintenance bypass may reduce the degree of redundancy of equipment, but it does not result in the loss of a safety function.

**3.4  
full functional test**

test that includes perturbation of the process variable, detection by the sensor, processing of the signal(s), actuation of the appropriate sub-assemblies, logic assemblies and actuation devices

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**3.5  
functional reliability**

ability to comply with requirements on complete and correct functionality and performance in:

- a) all defined plant operational modes and conditions,
- b) in all defined plant I&C system operational modes, and
- c) with all stipulated failures/failure modes of the plant I&C system under which correct function and performance is required

**3.6  
monitoring**

means provided to indicate continuously the state or condition of a system, sub-system, equipment or assembly

[IEV 393-08-48]

**3.7  
periodic testing**

performance of tests at predetermined time points to demonstrate that the functional capabilities of I&C systems and equipment important to safety are retained and that the characteristics relevant to the claims of the safety analysis are satisfied

**3.8  
self-supervision**

automatic testing of system hardware performance and software consistency of a computer-based I&C system

### 3.9

#### **surveillance testing**

complete scope of activities to demonstrate that the functional capabilities of I&C systems and equipment important to safety are retained and confirmation that the design basis requirements are met

### 3.10

#### **test duration**

the elapsed time between the test initiation and the test termination

### 3.11

#### **test initiation**

the application of a test input

### 3.12

#### **test input**

a real or simulated, but deliberate, perturbation of a measured variable or signal which is imposed upon all or part of a signal processing device, a logic assembly, or a final actuation device for the purpose of testing

### 3.13

#### **test interval**

the elapsed time between the initiation of identical tests on the same sensor and signal processing device, logic assembly or final actuation device

### 3.14

#### **test termination**

the removal of a test input with the results of the test being known

## 4 Basic principles for surveillance testing

### 4.1 General

The goals of surveillance testing are to ensure the functional capability of I&C systems and the related control path to actuate the process components important to safety and to give periodic confirmation that design basis requirements such as those for reliability, accuracy, response time and set points are met (Clause 4.82 of IAEA NS-G-1.3).

**4.1.1** Surveillance testing of I&C systems and equipment important to safety shall demonstrate and contribute to the achievement of the desired system reliability and availability, by means of the detection of faults, and shall call attention to performance that is not within prescribed limits. Prescribed limits are minimum performance requirements, such as response time and set-point accuracy and any other characteristics of the system which are essential to its satisfactory functioning. The surveillance testing has to confirm that the essential safety features are retained in comparison to a reference status which may originate from commissioning tests that verify the design basis requirements. While surveillance testing could permit the detection of some specific wear and ageing mechanisms, the detection scope is not sufficient to detect *a priori* all ageing mechanisms. The operability of equipment or a system under normal conditions is generally not sufficient to lead to judgements on the conservation of this property under design accident conditions. It is noted that many types of unrevealed faults that could be a cause of unsafe failures can only be detected by testing.

**4.1.2** Surveillance testing shall verify the relevant systems and equipment characteristics given directly by the safety assessment report, or other relevant safety documents, for the functions performed by the I&C systems important to safety. It could also be combined with maintenance tests for performance measures that do not have a direct contribution to safety. Such tests are not defined as surveillance tests (see 3.1) and are outside the scope of this standard.

## 4.2 Gradation of requirements based on category

**4.2.1** I&C functions important to safety are assigned a safety category according to the principles of IEC 61226. The surveillance requirements of the systems and equipment shall be commensurate with the category of the functions they perform.

**4.2.2** I&C systems and equipment performing category A functions shall be periodically tested to demonstrate proper function.

**4.2.3** I&C systems and equipment performing category B functions shall be periodically tested to the extent determined by an analysis taking into account the reliability goals of the functions.

**4.2.4** I&C systems and equipment performing category C functions may rely on general periodic observation of acceptable performance for continuously operating functions and on checks during shutdown periods, for functions which are not continuously operating.

**4.2.5** For I&C systems and equipment performing category B or C functions where redundancy is provided to meet established reliability goals, periodic individual testing of the functional capacity of all systems or sub-systems shall be included to the extent that faults of the redundant equipment are not revealed through other means, for example self-supervision.

**4.2.6** In the general case, test equipment may be assigned to a lower category than the systems or equipment that is being tested. However, to the extent that the test features could interfere in an inappropriate manner with the proper operation of the system or equipment performing the function important to safety, it shall be assigned to the same category.

## 4.3 Extent of surveillance testing

**4.3.1** The verification of correct operation during reactor operation shall include as much of the sensor and signal processing devices, of the logic assembly and the final actuation device under test as possible, without interfering unacceptably with normal plant operation.

**4.3.2** Where overall functional testing is not practicable, a series of partially overlapping tests shall be used in such a way that the combination of partial tests will satisfy all testing requirements.

**4.3.3** Functional tests may be supplemented with continuous monitoring to check for specific failure modes.

## 4.4 Self-supervision in lieu of periodic testing

I&C systems that have the capability to reveal faults, within a short time interval of their occurrence, by self-supervision performed by the equipment itself or by supervision of adjunct equipment, may be excluded from the requirement for periodic testing provided the following requirements are met.

**4.4.1** An analysis shall be performed on such equipment to identify those postulated failure modes that are revealed by the self-supervision.

**4.4.2** Any residual failure modes that are not revealed by self-supervision shall be shown not to affect the function important to safety of the equipment, or shall be covered by periodic testing designed to the requirements of this standard.

**4.4.3** Equipment faults revealed by self-supervision shall be made known to the plant operating staff through appropriate alarms and indicating displays.

#### 4.5 Continuous operation in lieu of periodic testing

Equipment that performs its function important to safety on a continuous basis, such as regulating controls, or that performs its function frequently during normal operation, as opposed to equipment that performs its function only in response to a plant upset condition or event, may be excluded from the requirement for periodic testing provided that the following requirements are met.

**4.5.1** Equipment actions and behaviours that are required for a function important to safety and that are demonstrated on a continuing basis may be excluded from periodic testing. Deviations of such actions and behaviours from acceptable states shall be made known to the operating staff by appropriate indicators and alarms.

**4.5.2** Equipment actions and behaviours that are required for a function important to safety and that are not demonstrated on a continuing basis shall be covered by periodic testing.

**4.5.3** If the adequate performance of equipment excluded from periodic testing under 4.5.1 (for instance time response or accuracy) cannot be confirmed through observation then other means shall be provided to confirm its adequate performance.

### 5 General requirements for surveillance testing

#### 5.1 Design requirements

**5.1.1** The I&C system and equipment important to safety, including the final actuation devices, shall be designed for testing during operation of the nuclear power generating station, as well as during station shut-down (attention is drawn to 7.2). This design shall permit independent testing of redundant assemblies while maintaining the system capability to respond to bona-fide signals during operation.

**5.1.2** The design shall provide for periodic testing to simulate accident signal trajectories, as closely as practicable, to verify the performance of the system required. The test shall be such as to demonstrate the full functional capability of the items under test.

**5.1.3** Testing equipment shall not cause a loss of independence between redundant assemblies.

**5.1.4** I&C systems and equipment shall be designed with due consideration of the impact of testing on plant availability and operation. Redundant equipment with coincidence logic should be provided, where necessary, to fulfil this provision.

NOTE This is not always possible for all parts of a system, for example for final actuation devices.

**5.1.5** The I&C system and equipment important to safety and the testing equipment shall be designed so as to avoid functional degradation while under test. In all cases where the I&C system important to safety includes redundancy, it shall be designed so that while a signal processing channel and the associated logic assembly are under test, the function can be provided by the remaining part of the system not under test even if the system is degraded by a single random failure. An artificial actuation signal may be induced as part of the testing procedure to fulfil this requirement.

NOTE "One out of two" systems can be justified for exemption of the single-failure criterion during surveillance testing, provided that the reliability goals for the function are met.

**5.1.6** Testability shall be considered in the selection of all components of I&C systems important to safety. Sensors should be accessible and, where practicable, installed so that their performance capability can be verified *in situ*. Selection of actuation devices shall consider their state indication capability.