BRITISH STANDARD

BS IEC 62342:2007

Nuclear power plants — Instrumentation and control systems important to safety — Management of ageing

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British Standards

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee NCE/8, Reactor instrumentation.

A list of organizations represented on this committee can be obtained on request to its secretary.

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INTERNATIONAL STANDARD

Nuclear power plants – Instrumentation and control systems important to safety – Management of ageing

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INTRODUCTION

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

With the majority of NPPs over 20 years old, the management of the ageing of instrumentation is currently a relevant topic, especially for those plants that have extended their operating licences or are considering this option. This standard is intended to be used by operators of NPPs (utilities), systems evaluators, and by licensors.

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

IEC 62342 is the second-level IEC SC 45A document tackling the generic issue of management of ageing of nuclear instrumentation.

IEC 62342 is the IEC SC 45A chapeau standard covering the domain of the management of ageing of nuclear instrumentation systems used in NPPs to perform functions important to safety. IEC 62342 is the introduction to a series of standards to be developed by IEC SC 45A covering the management of ageing of specific I&C systems or components such as sensors, transmitters, and cables.

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

c) Recommendations and limitations regarding the application of the standard

It is important to note that this standard establishes no additional functional requirements for safety systems. Ageing mechanism has to be prevented and thus detected by performance measurements. Aspects for which special recommendations have been provided in this Standard are:

- criteria for evaluation of ageing of I&C equipment in NPPs;
- steps to be followed to establish an ageing management program for NPP I&C equipment; and
- tracking of performance indices such as response time and calibration stability as the means to manage the ageing of sensors and transmitters.

It is recognized that testing and monitoring techniques used to evaluate the ageing condition of NPPs' I&C systems are continuing to develop at a rapid pace and that it is not possible for a standard such as this to include references to all modern technologies and techniques. However, a number of techniques have been mentioned within this standard and are described in Annexes B and C.

To ensure that this standard will continue to be relevant in future years, the emphasis has been placed on issues of principle, rather than specific technologies.

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 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

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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 SC45 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 Requirement 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 NPPs. The terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

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NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY – MANAGEMENT OF AGEING

1 Scope

1.1 Management of physical ageing

This International Standard provides strategies, technical requirements, and recommendations for the management of ageing of nuclear power plant (NPP) instrumentation and control (I&C) systems and associated equipment. The standard also includes informative annexes on test methods, procedures, and technologies that may be used to verify proper operation of I&C equipment and aim to prevent ageing degradation from having any adverse impact on the plant safety, efficiency, or reliability. The standard applies to all types of NPPs and relates primarily to safety.

1.2 Management of technology ageing (obsolescence)

The scope of this standard has been intentionally focused on the management of physical ageing of I&C systems where this may be considered as having a direct consequence on the safety of the NPP. It does not cover technology ageing aspects (i.e., obsolescence) in any detail.

It should be noted, however, that, in practice, the overall scheme for the management of ageing will have to cover obsolescence. Indeed, obsolescence has been recognized as the dominant issue in the life cycle of many I&C technologies (from design through to operational maintenance, replacement, and updating).

1.3 Safety goal of this standard

This standard identifies minimum requirements aimed at ensuring that any potential impacts on NPP safety due to I&C ageing can be identified and that suitable actions are undertaken to demonstrate that the safety of the plant will not be impaired.

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 61513:2001, *Nuclear power plants – Instrumentation and control for systems important to safety – General requirements for systems*

3 Terms and definitions

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

3.1
accuracy of measurement
closeness of the agreement between the result of a measurement and the conventionally true value of the measurand

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NOTE 1 “Accuracy” is a qualitative concept.

NOTE 2 The term “precision” should not be used for “accuracy”.

[IEV 394-40-35]

3.2
ageing
general process in which characteristics of a structure, system or component gradually change with time or use

NOTE This degradation is due to physical mechanisms inherent in component materials and linked to the I&C equipment design, assembly, and functional characteristics. It is influenced by the stresses from the equipment environment and from the equipment operation.

[IAEA Safety Glossary, 2006]

3.3
calibration
set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or a measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards

NOTE For more details, see [IVM 6.11].

[IEV 394-40-43]

3.4
channel
arrangement of interconnected components within a system that initiates a single output. A channel loses its identity where the single-output signals are combined with signals from another channel (for example, from a monitoring channel or a safety actuation channel)

[IAEA Safety Glossary, 2006]

3.5
cross-calibration
procedure of intercomparing the indications of redundant instruments (for example, temperature sensors) to identify outlier sensors as a means of verifying calibration or identifying calibration changes. A more appropriate term for this definition is "cross-validation," but, cross calibration is more commonly used

[IEC 62385, 3.6]

3.6
design life
period of time during which a facility or component is expected to perform according to the technical specifications to which it was produced

[IAEA Safety Glossary, 2006]

3.7

I&C life cycle
set of necessary activities involved in the implementation and operation of an I&C system occurring during a period of time that starts at a concept phase with the system requirements specification and finishes when the I&C system is no longer available for use

3.8
***in situ* test**
test of a sensor or a transmitter that is performed without removing the sensor or transmitter from its normal installed position in the system

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[IEC 62385, 3.9]

3.9
installed life
time interval from installation to removal, during which the equipment or components thereof may be subjected to design operational conditions

NOTE Equipment may have an installed life of 40 years with certain components changed periodically; thus the installed life of the component would be less than 40 years.

[IEC 60780, 3.10]

3.10
modernization
replacement or upgrading with newer systems and components. Replacement is the term to be used when there is no change in requirements; upgrading is the terms to be used when the level of requirements increases

NOTE 1 Backfit, refit, retrofit, refurbish and upgrade are similar terms which are often used interchangeably. They only differ in shades of meaning (IAEA-TECDOC-1066). Upgrading is the term to be used when there is an increase in requirements. Upgrading also includes the implementation of new functionality.

NOTE 2 Replace and renew are similar and often interchangeable. The terms are used from a single component up to the complete I&C.

3.11
monitoring
continuous or periodic measurement of radiation or other parameters for determination of the status of a system

[IEV 393-18-40]

3.12
operating conditions
environmental, power, and signal conditions expected as a result of normal operation and postulated initiating event conditions

3.13
performance limits
limits defining the quantitative static and dynamic characteristics of the input and output subsystems measured during the operation/surveillance of the instrument channel for a given environmental condition (for example, radiation, humidity, temperature, electromagnetic field, etc.)

NOTE Instrument channel accuracy, response time, and stability are some of the attributes of performance limits.

3.14
predictive maintenance
form of preventive maintenance performed continuously or at intervals governed by observed conditions to monitor, diagnose or trend a structure, system or component's condition indicators. Results indicate present and future functional ability or the nature of, and schedule for, planned maintenance

NOTE It is also termed condition-based maintenance.

[IAEA Safety Glossary, 2006]

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3.15
preventive maintenance
actions that detect, preclude or mitigate degradation of a functional structure, system or component to sustain or extend its useful life by controlling degradation and failures to an acceptable level

NOTE 1 Preventive maintenance may be periodic maintenance, planned maintenance or predictive maintenance.

NOTE 2 Contrasted with corrective maintenance.

[IAEA Safety Glossary, 2006]

3.16
qualified life
period for which a structure, system or component has been demonstrated, through testing, analysis or experience, to be capable of functioning within acceptance criteria during specific operating conditions while retaining the ability to perform its safety functions in a design basis accident or earthquake

[IAEA Safety Glossary, 2006]

3.17
response time
period of time necessary for a component to achieve a specified ouput state from the time that it receives a signal requiring it to assume that output state

[IAEA Safety Glossary, 2006]

3.18
time constant
in the case of a first-order system, time required for the output signal of a system to reach 63,2 % of its final variation after a step change of its input signal.

If the system is not first-order system, the term “time constant” is not appropriate. For a system of a higher order, the term “response time” should be used

[IEC 62397, 3.9]

3.19
trending analysis
process of obtaining instrument data over time to form a history of the instrument channel or its components (for example, calibration) or compared to redundant instruments (for example, cross-calibration/comparison) to determine if the performance has been affected

3.20
upgrading
refurbishment of equipment with design or functional enhancements based on operating experience and new technology/materials availability. These include changing to materials more resistant to ageing stressors, reconfiguring for improved reliability, even relocating equipment and implementation of new functionality

4 Background

Experience throughout the utility and process industries has shown that the increasing age of I&C systems in older plants could lead to deterioration of operability and maintainability. The problem is also shared by NPPs. Maintaining adequate performance and dependability of I&C is governed by two main issues:

a) physical ageing of the I&C equipment leading to defects;

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b) obsolescence of equipment (systems and components) in terms of both replacement parts and suppliers' support.

NPP I&C applications raise special lifetime dependability problems due to the relatively long-life expectancy of the plant compared to that of the I&C, exposure to ionizing radiation, and the demanding qualification requirements for safety systems.

As well as being necessary to ensure industrial asset management and economical plant operation, the control or management of ageing of I&C in NPPs may be a formal obligation to be demonstrated to the nuclear safety authority. One solution is to systematically renew I&C at or before the onset of any ageing problems. However, many plant I&C installations have not been designed with this option in mind and are not amenable to quick and simple replacement with equivalent systems. The use of nuclear specific I&C, installation in restricted (radioactive) working environments, safety licensing authority approval, and cost of long plant outages are only a few examples of why upgrading the I&C can be a long, complex, and expensive activity. Another approach is to prolong the use of the existing I&C by taking appropriate measures to maintain the equipment. The annexes to this document provide examples of measures that are implemented in NPPs to cope with the ageing of nuclear plant I&C equipment.

5 Requirements for ageing management

5.1 General

This clause provides requirements and recommendations to establish the methodological approaches and the practical processes necessary for I&C ageing management.

5.2 Methodology

A suitable methodology for the management of ageing of I&C which allows all relevant and interacting issues of long-term plant operating strategies to be evaluated with respect to safety shall be established.

Potential impacts on NPP safety due to I&C ageing shall be identified and suitable actions shall be undertaken to demonstrate that the safety of the plant will not be impaired. Furthermore, the qualification of the I&C shall be maintained. In addition, during the estimation of the effects of ageing mechanism on an equipment or component, it is necessary to consider both

a) those which could lead to failure during normal conditions; and
b) those which could lead to failure during accidental conditions (including seismic and design basis accident conditions).

The parameters relevant to I&C ageing affecting safety (for example, calibration drift, response time degradation) shall be identified and the means and methods used to acquire data for verification of performance of I&C equipment shall be established. The I&C performance data should be obtained periodically, analysed, and compared with acceptance criteria. Since it is difficult to identify ageing mechanisms completely, it is important to establish an efficient information feedback system taking advantage of experience from NPPs and other industries. Of course, the quality of information sources should be controlled by audits. The methodology used should take into consideration the foreseeable evolution of functional needs, material performances, component supply, and human resources that are needed to maintain the required targets for plant availability and preserve the plant safety.

The basic methodology of ageing management should involve the following three conceptual steps in an iterative way.

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a) Understanding the ageing phenomenon and identifying the (potential) effects on I&C. This understanding may be gained from research, operating experience, and other resources (see Clause 6).

b) Evaluating the specific impact of these effects on the plant taking into account operational profiles and analysing the risks, selecting I&C equipment and component items, analysing the NPP operating conditions, and evaluating ageing degradation (see Clause 7).

c) Carrying out necessary mitigating actions to counteract the effects of ageing, defining specific means for I&C ageing management such as improved testing and maintenance, establishing "ageing control" programs, and developing modification and replacement strategies (see Clause 8 and annexes).

Due to the importance of I&C to plant safety, ageing management in practice shall be prioritized. This may be achieved by selecting I&C equipment and components according to susceptibility to ageing, operating conditions, and impact of failure on the safety of the system to which they belong.

Condition monitoring of the plant and of the I&C equipment is necessary either as part of the preliminary ("one-off") evaluation to identify ageing equipment and/or as a continued long-term action before replacing the equipment.

The means for I&C ageing management will include existing arrangements, provisions by design, maintenance, surveillance testing, etc., the adequacy of which must be verified. It may be necessary to define additional means for I&C ageing management such as improved maintenance, specific "ageing control" programs, modification and replacement strategies.

5.3 Process

The methodology considerations given in 5.2 shall be implemented in an ageing management process. The process for management of physical ageing of I&C shall comprise actions to identify the parts of the equipment having characteristics changing with time and follow these up with necessary testing and surveillance as well as corrective or mitigating measures to ensure dependability, performance and, where applicable, qualified life. This may be organized as a programme of specific actions to address ageing, as a verification of existing (short- and long-term) maintenance activities, or a combination of both. Table 1 shows how the ageing management process is presented by the different clauses of this document. The requirements and recommendations concerning actual practical steps made in the ageing management process are detailed in the clauses which follow. The steps in an I&C ageing management process are illustrated in the flowchart of Figure 1.

Table 1 – Ageing management process as outlined in various clauses of this standard

Introduction
Clause 1. Scope *Describes the scope of the standard with respect to the management of physical ageing of NPP I&C, technology ageing, and impact on nuclear safety.*
Clause 2. Normative references *IEC standards that relate to this standard are listed in this clause.*
Clause 3. Terms and definitions *The terms used in this standard are all defined in this clause.*
Clause 4. Background *This clause contains a general background on why I&C ageing management is important.*

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Clause 5. Requirements for ageing management *This clause describes the methodological approach and the practical processes necessary for ageing management.*							
5.1 General	5.2 Methodology	5.3 Process					
Clause 6. Understanding I&C ageing phenomena *Characterizing the ageing phenomena and identifying the (potential) effects on I&C from knowledge gained from research, operating experience, and other resources.*							
6.1 General	6.2 Stresses causing ageing	6.3 Ageing mechanisms and ageing effects					
Clause 7. Requirements to address ageing effects *Evaluating the specific impact of ageing effects on the plant taking into account operational profiles and analysing the risks.*							
7.1 Ageing effect identifi-cation	7.2 Selection of I&C components for ageing evaluation	7.3 Evaluating ageing degradation of I&C	7.4 Ageing stresses	7.5 Intended function versus qualification	7.6 Surveillance tests and maintenance requirements	7.7 Support resources	7.8 Docu-mentation require-ments
Clause 8. Requirements for ageing control *Carrying out necessary mitigating actions to counteract the effects of ageing by defining specific means for I&C ageing management such as improved testing and maintenance or "ageing control" programmes.*							
8.1 General	8.2 Definition of ageing control programs	8.3 Means for I&C ageing management					
Clause 9. Organization *Organising the ageing management process including the definition of long-term strategies, I&C life cycle, quality control, and reporting.*							
9.1 General	9.2 Organization for ageing management	9.3 Identifying long-term operating strategies and I&C life cycle	9.4 Organization for the long-term maintenance of I&C equipment	9.5 Quality assurance	9.6 Reporting		
Annex A *Guidance on characterizing I&C ageing phenomena and acquiring data for ageing management of I&C components in nuclear power plants*							
A.1 Examples of stress factors, ageing mechanisms, and ageing effects on different I&C components	A.2 Data for ageing management	A.3 Testing and monitoring					
Annex B *Examples of ageing management practices for selected I&C components in nuclear power plants*							

RECOMMENDATIONS & REQUIREMENTS

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