IEC/TR 62096

Edition 2.0 2009-03

TECHNICAL REPORT

RAPPORT TECHNIQUE

Nuclear power plants – Instrumentation and control important to safety – Guidance for the decision on modernization

Centrales nucléaires de puissance – Instrumentation et contrôle-commande importants pour la sûreté – Guide pour décider d'une modernisation

IEC/TR 62096:2009

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX XA

ICS 27.120.20

ISBN 978-2-88910-618-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL IMPORTANT TO SAFETY – GUIDANCE FOR THE DECISION ON MODERNIZATION

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 62096, which is a technical report, 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 2002.

This edition includes the following significant technical changes with respect to the previous edition:

– update on the format to align with the current IEC/ISO directives on style of documents;
– update on references, taking into account Standards published since the first edition;
– update on the terminology;

– incorporation of a number of clarifications proposed by National Committees.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
45A/711/DTR	45A/726/RVC

Full information on the voting for the approval of this technical report 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.

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) Technical background, main issues and organisation of this Technical Report

Normal procedures for evaluation of plant safety, operations and maintenance provide information about potential needs for renewal or upgrades. After many years of operation, the Instrumentation & Control (I&C) systems may no longer fulfil actual or anticipated safety requirements, may be obsolete or unreliable, or may no longer be fit for required lifetime extensions. In such cases, modernization provides the way forward to adapt the I&C systems to meet the requirements or to deal with the problems and costs caused by the obsolescence or aging of the equipment. During modernization, the benefits offered by modern I&C equipment can be evaluated.

It is intended that this Technical Report be used by operators of NPPs (utilities), systems evaluators and by licensors.

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

IEC 62096, as a Technical Report, is the fourth level IEC SC 45A document tackling the issue of guidance for decision for modernisation.

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

c) Recommendations and limitations regarding the application of this Technical Report

There are no particular recommendations, neither limitations regarding the use of this Technical Report.

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, 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 standards, as well as to IAEA 50-C-QA (now replaced by IAEA GS-R-3) 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 IMPORTANT TO SAFETY – GUIDANCE FOR THE DECISION ON MODERNIZATION

1 Scope and object

This technical report is intended to support owners of an NPP in the decision-making process and in the preparation for partial or complete modernization of the I&C. For this, it provides:

– a summary of the motivating factors for I&C modernization,
– the principal options for the elaboration of different scenarios for I&C modernization,
– the technical and economic criteria for the selection of a long term I&C strategy,
– the principal aspects to be taken into account for a detailed technical feasibility study.

In addition, this report contains detailed recommendations and practical advice for:

– the technical evaluation of the actual status of the I&C systems,
– the content of the I&C system requirement specification and for the project management following the guidance given in IAEA TECDOC 1016 and 1066,
– considerations on modernization strategy.

Special attention is paid to the improvement of reactor safety and of the human machine interface. The report does not provide I&C design requirements. For these it is assumed that the IAEA Codes and Guides are used as top level documents while IEC publications are mainly used for system design, requirements on equipment and some work methods. IAEA Reports and other documents are referenced to give information that is more detailed on specific areas.

The structure of the report is given in Figure 1. The recommended sequence is, first, to summarize the more easily obtained motivations (Clause 5) and then establish a project that works in structured and more and more detailed steps: Long term I&C strategy – Feasibility studies – Tender specification and order (Clause 6). Clauses 7 and 8 may be used as checklists during each step.

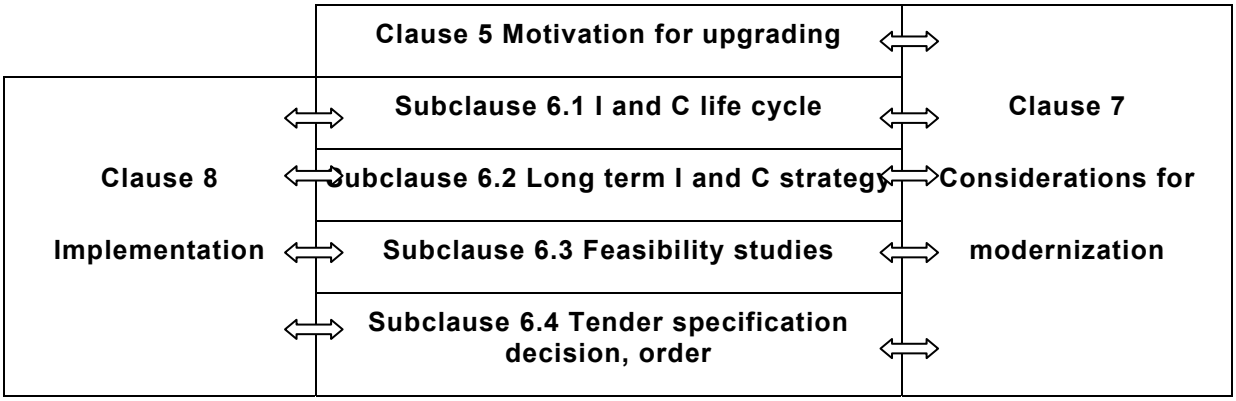

Figure 1 – IEC 62096 structure

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 60050-191:1990, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 60300-3-3:2004, *Dependability management – Part 3-3: Application guide – Life cycle costing*

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

IEC 60880:2006, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category A functions*

IEC 60964:2009, *Nuclear Power Plants – Control rooms – Design*

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

IEC 61839, *Nuclear power plants – Design of control rooms – Functional analysis and assignment*

IEC 61888, *Nuclear power plants – Instrumentation important to safety – Determination and maintenance of trip setpoints*

IEC 62241, *Nuclear power plants – Main control room – Alarm functions and presentation*

IEC 62342:2007, *Nuclear power plants – Instrumentation and control systems important to safety – Management of ageing*

IAEA-TECDOC-1066:1999, *Specification of requirements for upgrades using digital instrument and control systems* (only available in English)

IAEA-TECDOC 1147:2000, *Management of aging of I&C equipment in nuclear power plants* (only available in English)

IAEA:2007, *IAEA safety glossary terminology used in nuclear safety and radiation protection*

3 Terms and definitions

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

3.1
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]

NOTE This ability depends on the combined aspects of the reliability performance, the maintainability performance and the maintenance support performance.

3.2
configuration management
the process of identifying and documenting the characteristics of a facility's structures, systems and components (including computer systems and software), and of ensuring that changes to these characteristics are properly developed, assessed, approved, issued, implemented, verified, recorded and incorporated into the facility documentation

[IAEA Safety Glossary, 2007]

3.3
Human Machine Interface
the interface between operating staff and I&C system and computer systems linked with the plant. The interface includes displays, controls, and the Operator Support System interface

[IEC 60964, 3.13]

3.4
I&C system
system, based on electrical and/or electronic and/or programmable electronic technology, performing I&C functions as well as service and monitoring functions related to the operation of the system itself

The term is used as a general term which encompasses all elements of the system such as internal power supplies, sensors and other input devices, data highways and other communication paths, interfaces to actuators and other output devices. The different functions within a system may use dedicated or shared resources

[IEC 60964, 3.14]

3.5
life cycle
time interval between a product's conception and its disposal

[IEC 60300-3-3, 3.1]

3.6
life cycle cost
cumulative cost of product over its life cycle

[IEC 60300-3-3, 3.3]

3.7
maintainability
probability that a given active maintenance action, for an item under given conditions of use can be carried out within a stated time interval, when the maintenance is performed under stated conditions and using stated procedures and resources.

[IEV 191-02-07, modified]

3.8
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 term 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 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.

[IEC 62342, 3.10]

3.9
nuclear safety
achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards

NOTE Often abbreviated to safety in Agency publications on nuclear safety, particularly when other types of safety (e.g. fire safety, conventional industrial safety) are being discussed.

[IAEA Safety Glossary, 2007]

3.10
requirements
expression in the content of a document conveying criteria to be fufilled if compliance with the document is to be claimed and from which no deviation is permitted

[ISO/IEC Directives, part 2, 2004, 3.12.1]

NOTE 1 In IEC/SC 45A documents the following types of requirement are distinguished:

Safety requirements – Requirements imposed by authorities on the safety of the NPP in terms of impact on individuals, society and environment during the NPP lifecycle.

Functional and performance requirements – Functional requirements state what actions the system must take in response to specific signals or conditions, and performance requirements define features such as response times and accuracy.

Operational requirements – Requirements on the operational capacity and ability of the plant imposed by the owner.

Plant design requirements – Technical requirements on plant general design for the fulfillment of the safety requirements and operational requirements on the plant.

System design requirements – Design requirements on individual systems to give a design of the complete plant fulfilling the plant design requirements.

Equipment requirements – Requirements on individual equipment for its fulfillment of the demands of the system design.

NOTE 2 The IAEA Safety glossary (2007) contains the following definition:

Required, requirement – Required by (national or international) law or regulations, or by IAEA Safety Fundamentals or Safety requirements.

The requirements aimed at by this IAEA definition are the same designated by the IEC/SC 45A definition "Safety requirement".

3.11
specification
document that specifies, in a complete, precise, verifiable manner, the requirements, design, behaviour, or other characteristics of a system or component and, often the procedures for determining whether these provisions have been satisfied

[IEC 60880, 3.39]

4 Abbreviations

CAD	Computer Aided Design
CDF	Core Damage Frequency
CMF	Common Mode Failure
DBA	Design Basis Accident
DCS	Distributed Control System
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference

FAT	Factory Acceptance Tests
HMI	Human Machine Interface
I/O	Input/Output
I&C	Instrumentation & Control
LOCA	Loss Of Coolant Accident
O&M	Operation & Maintenance
PAM	Post Accident Monitoring
PLC	Programable Logic Controller
PSA	Probabilistic Safety Assessment
SAT	Site Acceptance Tests
SCC	Station Control Computer
SW V&V	Software Verification&Validation
VDU	Visual Display Unit
3D analysis	Defence-in-Depth and Diversity analysis

5 Motivation for modernization

5.1 General

The motivating factors for modernization can be considered under two headings according to the main benefits: economic and safety. The replacement of I&C equipment with a more modern equivalent usually leads to increased functionality and performance improvements, but it is likely that most upgrades are primarily motivated by problems with the old equipment rather than the perceived benefits of the new.

5.2 Economic motivating factors

5.2.1 General

The economic yield should be optimised using a life-cycle costing approach, taking into account not only lower costs but also increased production.

5.2.2 Cost reductions

Cost reductions can be achieved in the following areas:

– Operating costs can be reduced through efficiency improvements leading to savings in fuel, power consumption, consumables, or operational manpower requirements.

– Maintenance costs can be reduced by extending maintenance intervals and/or reducing the time and effort required for maintenance tasks. Improvements in the reliability of equipment reduce the cost of repair work and spares inventory. Also the reduction of the number of equipment families by the use of a single system platform may lead to a

reduced spare parts inventory. In some cases, high redundancy design can allow preventive maintenance during normal operation.

– Administration costs can be reduced through improvements in the way in which information is collected, processed, stored, and presented.

Cost reductions should be considered using a life-cycle costing approach focused on minimizing the total cost of the system over its intended life cycle. Note that a modernization with an expensive type of component with high reliability may increase the procurement cost but reduce the long-term support cost, and may give the lowest overall life cycle cost.

5.2.3 Revenue

Revenue can be increased in the following ways:

– Higher generation level

Improvements in monitoring and protection systems can give greater confidence in plant status, allowing reduction of safety margins at the same plant safety level and more power output.

– Increased availability

Shorter shutdowns for repairs, routine maintenance and fuelling, and a lower probability of spurious trips result in better plant utilisation. This can be achieved through improvements in reliability and stability, and through the use of 'smart' systems with capabilities for self-checking, diagnostics and auto-calibration, and improved operator support by HMI and I&C functions. The upgrading of obsolete equipment reduces the probability of a prolonged shutdown due to the unavailability of replacement parts.

– Increased plant lifetime

If the operation of the plant can be extended beyond its planned economic lifetime, there is a considerable benefit in accounting terms, because the revenue is no longer offset by capital charges. It is necessary to modernize any equipment or systems whose predicted residual life will be insufficient for the planned plant life extension.

5.2.4 Economically motivated modernization

Economically motivated modernization may be initiated by one or more of the following factors:

– Obsolescence

Equipment obsolescence occurs towards the end of a product's life cycle. When an item of equipment is no longer in production, the level of service available from the manufacturer decreases, and spare parts and consumables become unavailable or unacceptably expensive. Obsolescence also occurs at the electronic component level, where life cycles can be as short as a few years.

The initial effect of obsolescence is to increase timescales and costs for maintenance and repair work. Ultimately the equipment will be rendered unserviceable by the non-availability of spare parts.

– Competence of personnel

A related problem is the decreasing availability of suitably skilled maintenance personnel. Recently trained personnel do not have the required skills for analogue electronics. Technical education and training courses tend to concentrate on digital technology.

– Aging

The aging effects suffered by electronic components and assemblies can lead to problems with noise, drift, response time, EMI susceptibility, and general reduced reliability.

Examples of degradation due to aging include:

– chemical effects such as oxidation or corrosion, which lead to high resistance contacts in connectors, switches and solder joints,

– drying out of electrolytic capacitors,