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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Nuclear powers plants – Instrumentation and control important to safety – Management of ageing of sensors and transmitters – Part 1: Pressure transmitters

Centrales nucléaires de puissance – Instrumentation et contrôle-commande importants pour la sûreté – Gestion du vieillissement des capteurs et des transmetteurs – Partie 1: Transmetteurs de pression

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INSTRUMENTATION AND CONTROL
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Part 1: Pressure transmitters

FOREWORD

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International Standard IEC 62765-1 has been prepared by subcommittee 45A: Instrumentation, control and electrical systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

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

FDIS	Report on voting
45A/1001/FDIS	45A/1015/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.

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

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INTRODUCTION

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

With the majority of NPPs over 20 years old, the management of ageing of transmitters (pressure, level, flow) is currently a relevant topic, especially for those plants that have extended their operating licenses 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 62765 is the third level IEC SC 45A document comprising several parts to tackle the specific issue of management of ageing of sensors and transmitters in nuclear power plants (NPPs) for I&C systems important to safety. Part 1 of IEC 62675 is dedicated to pressure transmitters.

IEC 62342 is the second level standard of SC 45A 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 electrical cabling systems (IEC 62465), and sensors and transmitters (IEC 62765).

IEC 62765 is to be read in association with IEC 62342 and IEC/TR 62096, which is the appropriate IEC SC 45A Technical Report that provides guidance on the decision for modernisation when management of ageing techniques are no longer successful.

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 this standard

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

– criteria for evaluation of ageing of pressure transmitters in NPPs;

– steps to be followed to establish pressure transmitter testing requirements for an ageing management program for NPP instrumentation systems; and

– relationship between on-going qualification analysis and ageing management program with regards to pressure transmitters.

It is recognised that testing and monitoring techniques used to evaluate the ageing condition of NPPs transmitters 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.

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

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, 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. Regarding nuclear safety, it provides 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 and IEC 62138 correspond to IEC 61508-3 for the nuclear application sector. IEC 61513 refers to ISO as well as to IAEA GS-R-3 and IAEA GS-G-3.1 and IAEA GS-G-3.5 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 SSR-2/1, 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 IEC SC 45A standards are consistent with those used by the IAEA.

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, that are based on the requirements of a standard such as IEC 61508.

NUCLEAR POWERS PLANTS – INSTRUMENTATION AND CONTROL IMPORTANT TO SAFETY – MANAGEMENT OF AGEING OF SENSORS AND TRANSMITTERS –

Part 1: Pressure transmitters

1 Scope

This part of IEC 62765 provides strategies, technical requirements, and recommended practices for the management of ageing to ensure that ageing of pressure transmitters important to safety in nuclear power plants (NPPs) can be identified and that suitable remedial actions are undertaken as necessary to demonstrate that the safety of the plant will not be impaired. This standard is aligned with the IEC 62342 standards, which provides guidance on ageing management for I&C systems important to safety in NPPs. This standard, IEC 62765-1, is the first part for pressure transmitters in the IEC 62765 sensor and transmitter series for pressure, temperature, neutron and other sensors.

This standard deals with analogue electronic pressure transmitters, which have an electrical signal output that is a function of pressure applied on the sensing part, and which are included in I&C systems important to safety in accordance with IAEA terminology.

Any software used for data acquisition, data qualification, or data analysis for transmitter testing or condition monitoring system for pressure transmitter is classified according to IEC 62138 depending on its functionality as specified in IEC 61226. The qualification of the software for the digital data processing is beyond the scope of this standard.

Additional condition monitoring system for ageing management of the pressure transmitters is classified according to IEC 61226 with respect to its functionality. If classified, the software installed in the monitoring system complies with IEC 62138 for its B or C categorised function.

Regarding environmental qualification, the requirements of IEC 60780 apply. For assessing the performance of transmitters in the safety system instrument channel, the IEC 62385 methods, IEC 61888 requirements and IEC 60671 surveillance testing requirements apply.

Pressure measurements may be used for the measurement of other parameters that can be related to pressure, e.g., level or flow. Interfaces which include sensing lines, condensing pots, and primary (e.g., flow) elements between process and transmitters are within the scope of this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60780, *Nuclear power plants – Electrical equipment of the safety system – Qualification*

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

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

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

IEC 62385:2007, *Nuclear power plants – Instrumentation and control important to safety – Methods for assessing the performance of safety system instrument channels*

IEC 62465:2010, *Nuclear power plants – Instrumentation and control important to safety – Management of ageing of electrical cabling 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

Note 1 to entry: The parameter may be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence.

3.2
ageing assessment

evaluation of appropriate information for determining the effects of ageing on the current and future ability of systems, structures, and components to function within acceptance criteria in all operating conditions (e.g., in normal conditions and after design basis events)

[SOURCE: IEC 62465:2010, 3.2]

3.3
ageing management
engineering, operations and maintenance actions to control within acceptable limits ageing degradation of structures, systems or components.

[SOURCE: IAEA Safety Glossary, 2007 edition]

3.4
allowable value
a limiting value that the trip setpoint may have when tested periodically, beyond which appropriate action shall be taken

[SOURCE: IEC 61888:2002, 3.1]

3.5
analytical limit
limit of a measured or calculated variable established by the safety analysis to ensure that a safety limit is not exceeded. The margin between the analytical limit (of the setpoint) and the safety limit allows to take into account:

– the response time of the instrument channel,

– the range of transients due to the considered accident.

[SOURCE: IEC 61888:2002, 3.2]

3.6
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 realised by standards

3.7
commissioning test
test of a device or equipment, carried out on the site, to prove the correctness of installation and operation

3.8
condition monitoring
continuous or periodic tests, inspections, measurement or trending of the performance or physical characteristics of structures, systems and components to indicate current or future performance and the potential for failure

[SOURCE: IAEA Safety Glossary, 2007 Edition]

3.9
drift
variation in transmitters or instrument channel output that may occur between calibrations that cannot be related to changes in the process variable or environmental conditions

[SOURCE: IEC 62385:2007, 3.7]

3.10
environmental stress
factor influencing at least one ageing mechanism of the system which is not caused by the change of its physical state

Note 1 to entry: In this standard, to apply this definition pressure transmitters are considered as systems.

[SOURCE: IEC 62465:2010, 3.9, modified]

3.11
impulse line
sensing line
piping or tubing connecting the process to the sensor; impulse lines/sensing lines are usually used to connect pressure, level, and flow transmitters to the process

Note 1 to entry: They vary in length from a few metres to a few hundred metres. Sensing lines may also include isolation and root valves and other piping hardware along their length.

[SOURCE: IEC 62385:2007, 3.8]

3.12
pressure transmitter
PT
pressure, level, and flow transmitters that are based on the principle of pressure or differential pressure measurement, and are collectively referred in this standard as pressure transmitters, pressure sensors, PT, or just transmitters

[SOURCE: IEC 62385:2007, 3.14]

3.13
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

[SOURCE: IAEA Safety Glossary, 2007 edition]

3.14
response time
period of time necessary for a component to achieve a specified output state from the time that it receives a signal requiring it to assume that output state

[SOURCE: IAEA Safety Glossary, 2007]

3.15
routine test
conformity test made on each individual item during or after manufacture

3.16
test interval
elapsed time between the initiation of identical tests on the same sensor and signal processing device, logic assembly or final actuation device

[SOURCE: IEC 60671:2007, 3.13]

3.17
turn down factor
TDF
URL (Upper Range Limit) divided by the calibrated span of the device, which is a ratio, i.e. dimensionless quality

[SOURCE: ISA67.04.02]

3.18
type test
conformity test made on one or more items representative of the production

3.19
verification
process of ensuring that an equipment fulfils the specified conditions

Note 1 to entry: The IEC 61513 verification definition which applies to activities differs and reads “confirmation by examination and by provision of objective evidence that the results of an activity meet the objectives and requirements defined for this activity”. This verification definition applies not to activities but to equipment.

3.20
system validation
confirmation by examination and provision of other evidence that a system fulfils in its entirety the requirement specification as intended (functionality, response time, fault tolerance, robustness)

Note 1 to entry: In this standard, to apply this definition pressure transmitters are considered as systems.

[SOURCE: IEC 61513:2011, 3.59]

4 Abbreviations

AFV	As-found Value
ALV	As-left Value
AV1	Allowable Value
AV2	Analytical Value
DBE	Design Basis Event
EUT	Equipment Under Test
FT	Flow Transmitter
LT	Level Transmitter
M&TE	Measurement and Test Equipment
NPP	Nuclear Power Plant
PT	Pressure Transmitter
QA	Quality Assurance
TDF	Turn Down Factor
URL	Upper Range Limit
V&V	Verification and Validation

5 Background

5.1 General

Transmitters in NPPs can suffer degradation due to ageing. For example, transmitters can drift and degrade due to ageing and malfunction during plant operation or in accident and post-accident conditions. Therefore, it is necessary to monitor, test or calibrate, and inspect transmitters to assess ageing mechanisms predicted at the design stage, to help identify unanticipated behaviour or degradation that might occur in service, and to identify needed corrective actions.

5.2 Type of transmitter and interface

5.2.1 Type of transmitters

The ways that pressure transmitter ages depend to some extent on how pressure is converted to a physical displacement, the type of sensor used to measure this displacement, and the type of electronics that they use.

Electro-mechanical type pressure sensors are generally used for process – i.e. pressure, level or flow – measurement within the safety system of NPPs. Pressure transmitters use elastic sensing parts and direct display indicator or transmitting line to signal processing instrumentation. The commonly used parts for the sensing element are a diaphragm, bellows or Bourdon tube.

The displacement of the diaphragm, bellows, or Bourdon tube is typically measured by:

a) a variable resistance strain gauge,

b) a variable capacitance metal plate,

c) a variable inductance created by changing air gap permeance,

d) a differential transformer with moving core,

e) a wired potentiometer with sliding contact, or

f) a piezo-electric sensor.

A sealed pressure sensing part has a fluid medium isolated from process fluid. This type of sensor provides a degree of damping of the pressure variation and may eliminate rapid fluctuations

5.2.2 Interface between sensing part and process

5.2.2.1 Sensing line for pressure transmitters

Sensing lines (instrumentation line or impulse line) are tubes that connect the process to be measured to the sensing part of pressure transmitters. Sensing line may contain liquid or gas.

5.2.2.2 Primary elements for flow measurement

Where pressure transmitters are used for measurement of flow, a primary element (mechanical devices) that creates the differential pressure that is related to flow is needed. The primary element may be an orifice plate, a venturi tube, a pipe elbow, or a flow nozzle. The differential pressure transmitter with a primary element is defined as flow transmitters (FT).

5.2.2.3 Reference leg for level measurement

Where pressure transmitters are used for measurement of level, a reference leg with condensation pot that creates the head pressure as a reference level of full tank is needed. The differential pressure between reference leg tap (high-pressure side) and tank tap (low-pressure side) is inversely proportional to the level of tank. The differential pressure transmitter with a reference leg is defined as level transmitters (LT).

5.3 Reasons for transmitter ageing management

Ageing of pressure transmitters can cause measurement errors, erratic signals, spikes, noise, degradation of response time, and other anomalies that may affect plant operation or safety. Ageing can also invalidate the environmental qualification of pressure transmitters that are required to operate in harsh environments during accident conditions. Such effects may affect individual transmitters or result in common cause failure of transmitters. There are also problems such as loss of fill fluid due to ageing, which can occur in pressure transmitters leading to performance degradation. In transmitters, transfer agent such as oil may be used. Any leakage of oil can lead to calibration change, response time increases, and loss of linearity. In other transmitters where oil is used for lubrication and other purposes, leakage of oil is not as detrimental to transmitter performance. Both calibration changes and response time degradation due to oil loss can be identified using the online-monitoring techniques mentioned in this standard. Examples of ageing effects that can cause calibration failure, slow response time or total failure of PTs are summarised in Table 1 (this information is also provided in Table B.1 of IEC 62342:2007 and the related research report *Sensor Performance and Reliability* listed in the bibliograhy).