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Nuclear power plants – Instrumentation and control important to safety – Electrical equipment condition monitoring methods – Part 4: Oxidation induction techniques



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL IMPORTANT TO SAFETY – ELECTRICAL EQUIPMENT CONDITION MONITORING METHODS –

Part 4: Oxidation induction techniques

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC/IEEE 62582-4:2011. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC/IEEE 62582-4 was prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation, in cooperation with Nuclear Power Engineering Committee of the IEEE, under the IEC/IEEE Dual Logo Agreement between IEC and IEEE. It is an International Standard.

This document is published as an IEC/IEEE Dual Logo standard.

This second edition cancels and replaces the first edition, published in 2011. This edition constitutes a technical revision.

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

a) Consideration of publication of IEC/IEEE 60780-323;

b) An example added in Annex B and update;

c) Annex C added.

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

Draft	Report on voting
45A/1435/FDIS	45A/1445/RVD

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

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

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

A list of all parts of IEC/IEEE 62582 series, under the general title *Nuclear power plants – Instrumentation and control important to safety – Electrical equipment condition monitoring methods*, can be found on the IEC website.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

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

This part of IEC/IEEE 62582 specifically focuses on oxidation induction methods for condition monitoring for the management of ageing of electrical equipment installed in nuclear power plants. The methods are primarily suited to samples taken from materials that are polyolefin-based, but they can also be used for some materials based on ethylene-propylene polymers and for some ethylene vinyl acetate materials.

This part 4 of IEC/IEEE 62582 is the fourth part of the IEC/IEEE 62582 series. ~~It contains detailed descriptions of condition monitoring based on oxidation induction measurements.~~

IEC/IEEE 62582 series is issued with a joint logo which makes it applicable to the management of ageing of electrical equipment qualified to IEEE as well as IEC Standards.

~~Historically, IEEE Std 323-2003 introduced~~ IEC/IEEE 60780-323 includes the concept and role that condition based qualification could be used in equipment qualification as an adjunct to qualified life. In equipment qualification, the condition of the equipment for which acceptable performance was demonstrated is the qualified condition. The qualified condition is the condition of equipment, prior to the start of a design basis event, for which the equipment was demonstrated to meet the design requirements for the specified service conditions.

Significant research has been performed on condition monitoring techniques and the use of these techniques in equipment qualification as noted in NUREG/CR-6704, Vol. 2 (BNL-NUREG-52610) JNES-SS-0903, 2009 and IAEA-TECDOC-1825:2017.

It is intended that this document be used by test laboratories, operators of nuclear power plants, systems evaluators, and licensors.

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

IEC/IEEE 62582-4 is the third level IEC SC 45A document tackling the specific issue of application and performance of oxidation induction measurements in the management of ageing of electrical instrument and control equipment in nuclear power plants.

IEC/IEEE 62582-4 is to be read in association with IEC/IEEE 62582-1, which provides background and guidelines for the application of methods for condition monitoring of electrical equipment important to safety of nuclear power plants.

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 document establishes no additional functional requirements for safety systems.

d) Description of the structure of the IEC SC45A 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 categorisation 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 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.~~

The IEC SC 45A standard series comprises a hierarchy of four levels. The top-level documents of the IEC SC 45A standard series are IEC 61513 and IEC 63046.

IEC 61513 provides general requirements for instrumentation and control (I&C) systems and equipment that are used to perform functions important to safety in nuclear power plants (NPPs). IEC 63046 provides general requirements for electrical power systems of NPPs; it covers power supply systems including the supply systems of the I&C systems.

IEC 61513 and IEC 63046 are to be considered in conjunction and at the same level. IEC 61513 and IEC 63046 structure the IEC SC 45A standard series and shape a complete framework establishing general requirements for instrumentation, control and electrical power systems for nuclear power plants.

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

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

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

The IEC SC 45A standards series consistently implements and details the safety and security principles and basic aspects provided in the relevant IAEA safety standards and in the relevant documents of the IAEA nuclear security series (NSS). In particular this includes the IAEA requirements SSR-2/1 , establishing safety requirements related to the design of nuclear power plants (NPPs), the IAEA safety guide SSG-30 dealing with the safety classification of structures, systems and components in NPPs, the IAEA safety guide SSG-39 dealing with the design of instrumentation and control systems for NPPs, the IAEA safety guide SSG-34 dealing with the design of electrical power systems for NPPs, the IAEA safety guide SSG-51 dealing with human factors engineering in the design of NPPs and the implementing guide NSS17 for computer security at nuclear facilities. The safety and security terminology and definitions used by the SC 45A standards are consistent with those used by the IAEA.

IEC 61513 and IEC 63046 have adopted a presentation format similar to the basic safety publication IEC 61508 with an overall life-cycle framework and a system life-cycle framework. Regarding nuclear safety, IEC 61513 and IEC 63046 provide the interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector. In this framework, IEC 60880, IEC 62138 and IEC 62566 correspond to IEC 61508-3 for the nuclear application sector.

IEC 61513 and IEC 63046 refer to ISO 9001 as well as to IAEA GSR part 2 and IAEA GS-G-3.1 and IAEA GS-G-3.5 for topics related to quality assurance (QA).

At level 2, regarding nuclear security, IEC 62645 is the entry document for the IEC/SC 45A security standards. It builds upon the valid high level principles and main concepts of the generic security standards, in particular ISO/IEC 27001 and ISO/IEC 27002; it adapts them and completes them to fit the nuclear context and coordinates with the IEC 62443 series. At level 2, IEC 60964 is the entry document for the IEC/SC 45A control rooms standards, IEC 63351 is the entry document for the human factors engineering standards and IEC 62342 is the entry document for the ageing management standards.

NOTE 1 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.

NOTE 2 IEC TR 64000 provides a more comprehensive description of the overall structure of the IEC SC 45A standards series and of its relationship with other standards bodies and standards.

NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL IMPORTANT TO SAFETY – ELECTRICAL EQUIPMENT CONDITION MONITORING METHODS –

Part 4: Oxidation induction techniques

1 Scope ~~and object~~

This part of IEC/IEEE 62582 specifies methods for condition monitoring of organic and polymeric materials in instrumentation and control systems using oxidation induction techniques in the detail necessary to produce accurate and reproducible measurements. It includes the requirements for sample preparation, the measurement system and conditions, and the reporting of the measurement results.

The different parts of IEC/IEEE 62582 are measurement standards, primarily for use in the management of ageing in initial qualification and after installation. IEC/IEEE 62582-1 includes requirements for the application of the other parts of the IEC/IEEE 62582 series and some elements which are common to all methods. Information on the role of condition monitoring in the qualification of equipment important to safety is found in ~~IEEE Std 323~~ IEC/IEEE 60780-323.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp
- IEEE Standards Dictionary Online: available at http://dictionary.ieee.org

3.1
Oxidation induction time
OIT
relative measure of a stabilised material's resistance to oxidative decomposition, determined by the calorimetric measurement of the time interval to the onset of exothermic oxidation of the material at a specified temperature in an oxygen atmosphere, under atmospheric pressure

Note 1 to entry: OIT is expressed in minutes (min).

3.2
Oxidation induction temperature
OITP
calorimetric measurement of the temperature of the onset of exothermic oxidation of the material when subjected to a specified heating rate in an oxygen atmosphere, under atmospheric pressure

Note 1 to entry: OITP is expressed in degrees Celsius (°C).

4 Abbreviated terms and acronyms

CSPE	chlorosulphonated polyethylene
DSC	differential scanning calorimeter
EPDM	ethylene propylene diene monomer
EPR	ethylene propylene rubber
EVA	ethylene vinyl acetate
OIT	oxidation induction time
OITP	oxidation induction temperature
PE	polyethylene
PEEK	poly ether ether ketone
PVC	poly vinyl chloride
STA	simultaneous thermal analyzer
XLPE	cross-linked polyethylene

5 General description

Oxidation induction methods are based on the detection of the oxidation exotherm that occurs when a sample is heated in the presence of oxygen. This exotherm is sensitive to the level of degradation in some organic and polymeric materials and can be used as an indicator of ageing. There are two oxidation induction methods available, based on the time required to reach the onset of oxidation at a constant temperature (oxidation induction time – OIT) or based on the temperature at the onset of oxidation during a constant temperature ramp rate (oxidation induction temperature – OITP). The two methods are complementary, in that OITP is often effective in those materials where OIT is difficult to determine. OIT and OITP decrease with increasing degradation. The methods are generally related to the amount of antioxidants present in the material. As degradation proceeds, these antioxidants are depleted. For material without antioxidants OIT is not suitable, but OITP may give a useful result. In general, OIT and OITP are used to measure the thermal stability of polymers under isothermal (OIT) and dynamic (OITP) heating conditions in oxygen.

6 Applicability and reproducibility

The oxidation induction method is primarily suited to samples taken from materials (such as cable jackets or insulation) that are polyolefin-based (e.g. PE, XLPE). It can also be used for some materials based on ethylene-propylene polymers (e.g. EPR, EPDM) and for some ethylene vinyl acetate (EVA) materials. Oxidation Induction techniques may not be applicable to high temperature polymers in some cases. It is not applicable to high temperature polymers, such asPEEK. The method can be applied to other materials but problems with interpretation of the results may reduce the effectiveness of the test.

The method is generally not suitable for chlorinated polymers (e.g. PVC, CSPE) because of the corrosive degradation products evolved during the measurements, which can damage the instrument. For these materials, smaller sample masses (1 mg to 2 mg) may enable the method to be used with care. In addition, some modern systems are designed with features that protect the equipment from volatile off gases. To determine if the equipment is protected or if additional protective components are needed, consult the equipment manufacturer.

The method is not suitable for field use in the nuclear power plant but uses samples taken from the plant, which are then measured in the laboratory. Each OIT measurement in the laboratory can take up to 90 min to complete for unaged samples, decreasing for heavily aged samples, whereas OITP measurements typically take 30 min to 40 min.