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Electrical insulation systems (EIS) - Thermal evaluation of combined liquid and solid components -
Part 1: General requirements

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CONTENTS

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Electrical insulation systems (EIS) - Thermal evaluation of combined liquid and solid components - Part 1: General requirements

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 TS 62332-1:2011. 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 TS 62332-1 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems. It is a Technical Specification.

This third edition cancels and replaces the second 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) Modifications have been made based on an extensive test series conducted using this methodology based on the first edition. This included updating expected times and temperatures to use in order to get useful results, as well as making the range of equipment covered more broad. The method now covers electrotechnical devices using different sealing systems, as well as devices using enamel covered wires.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
112/716/DTS	112/723/RVDTS

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 Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62332 series, published under the general title *Electrical insulation systems (EIS) -Thermal evaluation of combined liquid and solid components*, can be found on the IEC website.

The committee has 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, or

– revised.

INTRODUCTION

This document specifies a method for the thermal evaluation of electrical insulation systems (EISs) for electrotechnical products with combined liquid and solid components. This document covers general test requirements. It is intended that subsequent parts ~~should~~ will cover specific product test requirements.

Prior to this document, the procedure for determining the thermal endurance of insulation systems for liquid-immersed products involved one of two processes: firstly, sealed-tube ageing and, secondly, ageing of full-scale models.

The ageing of full-scale models is impractical, especially for larger products, such as power transformers. Similarly, the use of sealed-tube ageing is not practical when testing components having drastically different thermal capabilities. For example, testing of a system with a solid material with an RTI of 200 °C with a liquid having a 130 °C thermal capability cannot be performed efficiently. Accelerated ageing temperatures which ~~fairly~~ significantly age the liquid will result in extremely long ageing times for the solid. Accelerated ageing temperatures which ~~fairly~~ significantly age the solid will result in extreme, or even hazardous, ageing of the liquid.

This document specifies an accelerated thermal ageing procedure and model that allows for the solid materials to be aged at temperatures separate from the liquid ageing temperatures, all in the same apparatus. The model acts more in the true-life ageing mode of insulation systems, where solid insulation near the active parts is exposed to much higher temperatures than the major volume of liquid in the equipment. The model contains all the primary EIS elements, and in relative component ratios which compare with actual electrotechnical products.

The model has a dual temperature capability that allows independent control of the temperatures of the solid and liquid components by the use of separate circuits. A detailed bibliography is provided.

~~This technical specification has been prepared in conjunction with TC 14, Power transformers. Any comments or suggestions from other technical committees to make this technical specification more general are welcome.~~

Further useful information can be found in IEC 60076-6 [1], IEC 60076-7 [2], IEC 60076-14 [3], IEC 60641-2 [4], [5], [6], [7] and[8].

1 Scope

This document specifies a dual-temperature test procedure for the thermal evaluation and qualification of electrical insulation systems (EISs).

This document is applicable to EISs containing solid and liquid components where the thermal ~~stress is the dominant~~ ageing factor is dominant, without restriction to voltage class.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60085:2007, *Electrical insulation – Thermal evaluation and designation*~~

~~IEC 60156, *Insulating liquids – Determination of the breakdown voltage at power frequency – Test method*~~

~~IEC 60216-2:2005, *Electrical insulating materials – Thermal endurance properties – Part 2: Determination of thermal endurance properties of electrical insulating materials – Choice of test criteria*~~

IEC 60216-3, *Electrical insulating materials - Thermal endurance properties - Part 3: Instructions for calculating thermal endurance characteristics*

IEC 60216-5, *Electrical insulating materials - Thermal endurance properties - Part 5: Determination of relative thermal endurance index (RTE) of an insulating material*

~~IEC 60243-1, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*~~

~~IEC 60247, *Insulating liquids – Measurement of relative permittivity, dielectric dissipation factor (tan δ) and d.c. resistivity*~~

~~IEC 60250, *Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths*~~

IEC 60296, *Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear*

IEC 60422, *Mineral insulating oils in electrical equipment - Supervision and maintenance guidance*

~~IEC 60450, *Measurement of the average viscometric degree of polymerization of new and aged cellulosic electrically insulating materials*~~

IEC 60505~~:2004~~, *Evaluation and qualification of electrical insulation systems*[1]

~~IEC 60554-2, *Cellulosic papers for electrical purposes – Part 2: Methods of test*~~

~~[1] A fourth edition of IEC 60505 is currently in preparation.~~

~~IEC 60567, *Oil-filled electrical equipment – Sampling of gases and of oil for analysis of free and dissolved gases – Guidance*~~

~~IEC 60599, *Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis*~~

~~IEC 60763-2, *Specification for laminated pressboard – Part 2: Methods of test*~~

~~IEC 60814, *Insulating liquids – Oil-impregnated paper and pressboard – Determination of water by automatic coulometric Karl Fischer titration*~~

~~IEC 61198, *Mineral insulating oils – Methods for the determination of 2-furfural and related compounds*~~

~~IEC 61620, *Insulating liquids – Determination of dielectric dissipation factor by measurement of the conductance and capacitance – Test method*~~

~~IEC 61857-1:2008, *Electrical insulation systems – Procedures for thermal evaluation – Part 1: General requirements – Low voltage*~~

~~IEC 62021-1, *Insulating liquids – Determination of acidity – Part 1: Automatic potentiometric titration*~~

~~ISO 287, *Paper and board – Determination of moisture content of a lot – Oven-drying method*~~

~~ISO 1924 (all parts), *Paper and board – Determination of tensile properties*~~

~~ISO 2049, *Petroleum products – Determination of colour (ASTM scale)*~~

~~ASTM D971-99a, *Standard test method for interfacial tension of oil against water by the ring method*~~

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60505 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp

3.1
electrical insulation system
EIS
insulating structure containing one or more electrical insulating materials (EIMs) together with associated conducting parts employed in an electrotechnical device

~~NOTE EIMs with different temperature indices (ATE RTE according to IEC 60216-5) may be combined to form an EIS, which has a thermal class that may be higher or lower than that of any of the individual components according to IEC 60505.~~

~~[IEC 60505:2004, definition 3.1.1]~~

Note 1 to entry: EIMs with different temperature indices (temperature index (TI), temperature index by analytical test (TIA) or relative thermal index (RTI)) as specified in IEC 60216-5 [10]) can be combined to form an EIS, which

has a thermal class (3.4) that can be higher or lower than that of any of the individual components as specified in IEC 60505 [11].

[SOURCE: IEC 60505:2011 [9], 3.1.1, modified – Note 1 to entry has been added.]

3.2
candidate EIS
EIS (3.1) under evaluation to determine its service capability with regard to thermal stresses

3.3
reference EIS
evaluated and established EIS (3.1) with either a known service experience record or a known comparative functional evaluation as a basis

3.4
thermal class
designation of an EIS (3.1) that is equal to the numerical value of the maximum temperature in degrees Celsius for which the EIS (3.1) is appropriate according to Table 1 of IEC 60085:2007 [12]

Note 1 to entry: An EIS (3.1) ~~may~~ can be subjected to operating temperatures exceeding its thermal class, which can result in shorter expected life.

3.5
assigned thermal endurance
ATE
<electrical insulation system (EIS)> numerical value of the temperature in degrees Celsius for the reference EIS (3.3) as derived from known service experience or a known comparative functional evaluation

3.6
relative thermal endurance
RTE

<electrical insulation system (EIS)> numerical value of the temperature in degrees Celsius for the candidate EIS (3.2) which is relative to the known ATE (3.5) of a reference EIS (3.3), when both EISs (3.1) are subjected to the same ageing and diagnostic procedures in a comparative test

3.7
test object
piece of original equipment, a representation (model) of equipment, a component of or part of equipment, including the EIS (3.1), intended for use in a functional test

3.8
thermal ageing factor
thermal stress that causes irreversible changes in the EIS (3.1)

3.9
diagnostic test
periodic application of a specified level of a diagnostic factor to a test object (3.7) to determine whether the end-point criterion (3.10) has been reached

3.10
end-point criterion
selected value of either a property or a change of property that defines the end-of-life (3.11)

[SOURCE: IEC 61857-1:2008 [13], 3.11, modified – In the definition, "selected" has been added, "defining" has been replaced with "that defines", and "of a test object in a functional test" has been deleted.]

3.11
end-of-life
end of a test object's (3.7) life, as determined by any selected component meeting its end-point criterion (3.10)

3.12
ageing cell
sealed container partially filled with the liquid electrical insulating material (EIM) and in which are mounted the test object (3.7), liquid immersion heaters and thermocouples for control and monitoring

4 Thermal ageing test apparatus

4.1 General description

The thermal ageing test apparatus shall be designed to allow the separate ageing of solid and liquid components. The reference EIS and candidate EIS shall be exposed to test periods at selected elevated temperatures. These test periods consist of a specific time exposure at the selected temperature followed by diagnostic tests.

The test system consists of the following elements:

– ageing cells;
– power supply;
– control system;
– safety system;
– sampling system;
– monitoring or data collection system.

4.2 Construction of the test apparatus

4.2.1 Ageing cells

Each ageing cell is a container constructed of stainless steel; the size is determined by the size of the test object. The ageing cell volume shall include the space required for thermal expansion of the liquid at ageing temperatures. The two ends of the ageing cell shall be fitted with removable, sealable bolt-on covers. The test object is mounted within the ageing cell.

Ports shall be provided for

– sampling of the liquid,
– pass-through of electrical circuits for heating of the active parts,
– monitoring and control elements,
– immersion heaters,
– gas blanketing and associated pressure-relief system.

The design of the ageing cell shall be configured to maintain the thermocouples controlling the liquid and the solid component of the test objects immersed in the liquid under all ageing temperatures. See also 5.3.3.

For specific details, see Figure 1.

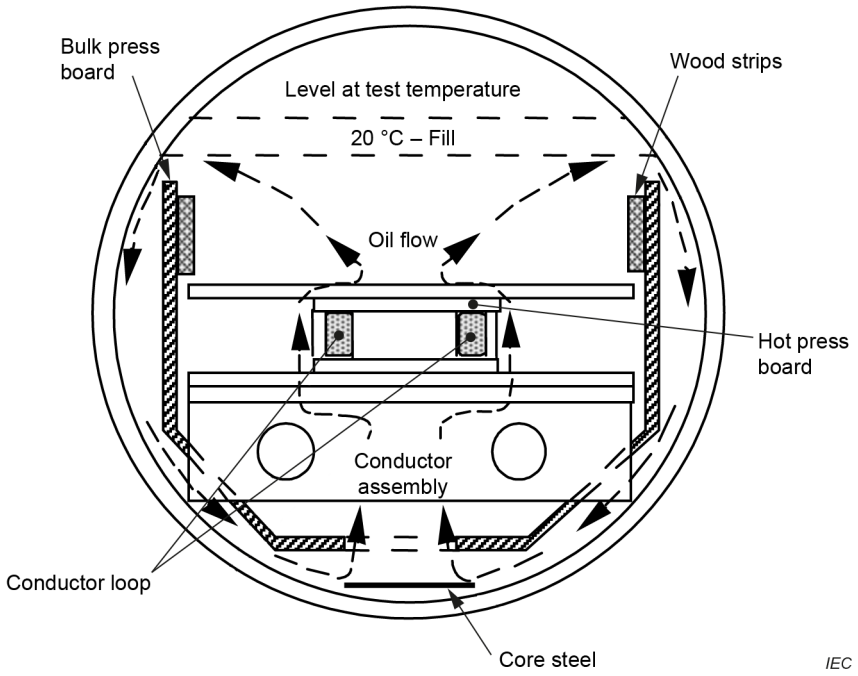

Figure 1 – Ageing cell cross-section

4.2.2 Immersion heaters

Immersion heaters shall have thermal capability to maintain the temperature of the test liquid within the temperature range defined by the test procedure.

4.2.3 Power supply

Separate power supplies shall be provided to independently establish the defined temperatures in the liquid and the test object:

– current through the test object shall establish the required temperature defined by the test procedure;

– the power capacity shall comply with 4.2.2.

For safety reasons, ageing cells shall be connected to earth.

4.2.4 Control circuit system

Automatic monitoring with thermal sensors controls the temperatures of the test object and liquid. A control feedback circuit shall be used to maintain each temperature within ±2 K.

4.2.5 Gas blanketing system

A gas blanketing system shall be provided which simulates the insulation system used in the electrotechnical product being evaluated. This can be a sealed nitrogen system, which maintains a gas blanket over the liquid in the ageing cell for the purpose of eliminating the possibility of oxidation of the liquid, or it ~~could~~ can be a system simulating a desiccated air system. In each case, the gas blanket in each ageing cell shall be regulated to maintain a positive pressure.

4.2.6 Safety system

A pressure-relief valve shall be installed on each ageing cell to prevent the internal cell pressure ~~to raise~~ rising above equipment capability.