IEC TS 62332-3

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TECHNICAL SPECIFICATION

SPECIFICATION TECHNIQUE

colour inside

Electrical insulation systems (EIS) – Thermal evaluation of combined liquid and solid components – Part 3: Hermetic motor-compressors

Systèmes d'isolation électrique (SIE) – Évaluation thermique de composants liquides et solides combinés – Partie 3: Motocompresseurs hermétiques

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ELECTRICAL INSULATION SYSTEMS (EIS) – THERMAL EVALUATION OF COMBINED LIQUID AND SOLID COMPONENTS –

Part 3: Hermetic motor-compressors

FOREWORD

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Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62332-3, which is a Technical Specification, has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems.

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

Enquiry draft	Report on voting
112/353/DTS	112/362/RVC

Full information on the voting for the approval of this Technical Specification 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.

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 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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- reconfirmed,
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INTRODUCTION

This part of IEC 62332, which is a Technical Specification, describes a method for the thermal evaluation of electrical insulation systems (EIS) for electrotechnical products with combined liquid and solid components. IEC TS 62332-1 covers general test requirements. IEC TS 62332-2 covers a simplified test method which can be used as a screening test prior to conducting IEC TS 62332-1 testing or can be used as a quality control test to evaluate minor product changes. This part of IEC 62332 covers the evaluation and qualification of electrical insulation materials (EIM) and EIS which are applied to motor-compressors for the refrigerator or air conditioner. This document contains the evaluation items which are important to maintain the equipment performances in the refrigerator oil and refrigerant at high temperature and high pressure.

This document has been prepared in conjunction with IEC 60335-2-34.

IEC TS 62332-3 is applicable to EIM and EIS evaluation for hermetic motor-compressors which are applied to the refrigerator and the air conditioner. The main procedures consist in the evaluation of EIM and EIS endurance for refigerator and oil at high temperature and high pressure. It describes how to evaluate the mechanical, thermal and chemical degradation of the performances of EIM which have deep relation to keep the sound condition of the equipment.

This simplified Technical Specification provides a test method for sealed tube testing. The sealed tube should contain all the primary EIM elements in relative component ratios which compare with the actual electrotechnical device.

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ELECTRICAL INSULATION SYSTEMS (EIS) – THERMAL EVALUATION OF COMBINED LIQUID AND SOLID COMPONENTS –

Part 3: Hermetic motor-compressors

1 Scope

This part of IEC 62332, which is a Technical Specification, is applicable to EIM and EIS containing solid and liquid components where the refrigerant, oil and thermal stresses are the dominant ageing factor, 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 60216-1, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

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

IEC 60216-4-1:2006, *Electrical insulating materials – Thermal endurance properties – Part 4-1: Ageing ovens – Single-chamber ovens*

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

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 60317-0-1, *Specifications for particular types of winding wires – Part 0-1: General requirements – Enamelled round copper wire*

IEC 60505, *Evaluation and qualification of electrical insulation systems*

IEC 60674-2, *Specification for plastic films for electrical purposes. Part 2: Methods of test*

IEC 60684-2, *Flexible insulating sleeving – Part 2: Methods of test*

IEC 60851-5, *Winding wires – Test methods – Part 5: Electrical properties*

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

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IEC 61857-21:2009, *Electrical insulation systems – Procedures for thermal evaluation – Part 21: Specific requirements for general-purpose models – Wire-wound applications*

IEC 62021 (all parts), *Insulating liquids – Determination of acidity*

ISO 178, *Plastics – Determination of flexural properties*

ASTM D4603, *Standard Test Method for Determining Inherent Viscosity of Poly(Ethylene Terephthalate) (PET) by Glass Capillary Viscometer*

3 Terms and definitions

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

ISO and IEC 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

3.1
acidity
quantity of base, expressed in milligrams of potassium hydroxide per gram of sample, required to titrate potentiometrically or colourimetrically a test portion in a specified solvent to the end point

[SOURCE: IEC 62021-3: 2014, 3.1]

3.2
breakdown voltage
voltage at which a specimen suffers destructive discharges under the prescribed test conditions

Note 1 to entry: It is used in tests with continuously rising voltage.

3.3
extract
substance or resource obtained from a given element by a special method

3.4
thermal ageing factor
thermal stress that causes irreversible changes in the EIS

3.5
interfacial tension
adhesive forces between the liquid phase of one substance and either a solid, liquid or gas phase of another substance

3.6
autoclave
sealed tube
sealed container partially filled with the liquid EIM and which includes the solid EIM in relative component ratios which compare with the actual electrotechnical device

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3.7
blister
small foam which is produced in the inner enamel layer of a winding wire

4 Electrical insulation material (EIM) evaluation

4.1 General description

This test procedure is useful for evaluating the chemical compatibility of insulation material (EIM) with the liquid (oil) and refrigerant at high temperature and high pressure.

The reference and candidate EIM shall be exposed to test periods at selected elevated temperatures and pressures. These test periods consist of a specific time exposure at the selected temperature and pressure followed by diagnostic tests.

A specific material is sealed in a stainless steel autoclave, subjected to a specified thermal ageing cycle and then subjected to each test. Candidate autoclave test results are then compared to the reference autoclave test results for qualification of the acceptability of the candidate EIM.

The test system consists of the following elements:

- autoclaves;
- ageing ovens;
- test objects.

4.2 Test equipment

4.2.1 Autoclave

Each autoclave is a container constructed of stainless steel. The size or the volume shall be determined by the size or the volume of the test objects, oil and refrigerant, excluding the electric resistance test and extract test. In general, 300 cm^3 to 500 cm^3 volume of autoclave is convenient and enough for each EIM test.

Either one or both ends of the cell shall be fitted with removable, sealable bolt-on covers.

The autoclave parts shall be provided for the pressure gage, pressure relief system, needle valve and gas sealing packing.

For specific details, see Figure 1.

Figure 1 – Autoclave example for ageing test of EIM

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4.2.2 Ageing oven

An air circulating oven or oil bath can be used.

In case of an air circulating oven, the ovens used shall meet the requirements of IEC 60216-4-1:2006, 5.2 to 5.4 (temperature difference, fluctuation on variation).

In case of an oil bath, the oil level shall be maintained at a level high enough to provide appropriate heat transfer during the test. The oil shall have enough thermal endurance for the ageing test in this case.

4.3 Specimen

4.3.1 General

The following EIMs and components are applied as test subjects and evaluated by each diagnostic test as shown in Table 1.

Table 1 – Hermetic motor-compressor EIM and diagnostic test items

	Winding wire	Varnish	Film	Molding part	Tube	Tie cord	Oil	Refrigerant	Process oil[a]
Breakdown voltage	○	○	○		○				
Dielectric constant (ε)			○						
Electric resistivity							○	○	
Effect to electric resistivity of oil						○			
Effect to electric resistivity of refrigerant						○			
Tensile strength			○			○			
Flexual strength				○					
Elongation			○						
Blister	○								
Molecular weight change			○						
Extract	○	○	○	○	○	○			
Acidity							○		
Metal Surface contamination									○

Key:

○ = EIM that is applied to the qualification test.

[a] For example: winding wire winding lubricant, iron punching oil, die casting oil.

4.3.2 Determination of component shape, volume or weight of EIM

Excluding the resistance test and the extract test, the specimen shall be prepared as follows:

a) Winding wire:

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- breakdown voltage: specimen shall be prepared in accordance with IEC 60851-5,
- relative permittivity (ε_r) and dielectric loss (tanδ): in accordance with IEC 60250,
- blister test: 100 mm in length,
- extract test: see 4.4.2.

b) Varnish:

- breakdown voltage: if included in the EIS, the impregnating varnish shall be applied to the winding wire samples as twisted pair and cured in accordance with the manufacturer's specifications,
- extract test: see 4.4.2.

c) Film:

- breakdown voltage: size 250 mm × 250 mm,
- relative permittivity (ε_r): size 100 mm × 100 mm,
- tensile strength and elongation: width = 10 mm to 25 mm, length = 100 mm,
- molecular weight; about 1,0 g,
- extract test: see Clause B.3

d) Molding part:

- bending strength: apply the practical part which is used in the compressor,
- extract test: see Clause B.3.

e) Tube:

- breakdown voltage: enough length that it does not cause flashover when the surface test pole length is 100 mm,
- extract test: see Article B.3.

f) Tie cord:

- tensile strength and elongation: enough length to chuck when the elongation measurement is 25 mm long,
- effect on the electric resistance of oil: the same ratio of the weight to the oil in the compressor is applied,
- effect on the electric resistance of refrigerant: the same ratio of the weight to the refrigerant in the compressor is applied,
- extract test: see Clause B.3.

g) Metallic part:

- surface contamination test: capillary tube longer than 100 mm ,
- see Clause B.4.

h) Oil:

- half the volume of the autoclave container shall be supplied for each ageing test,
- after the ageing, the test subject shall be removed from the autoclave and the oil shall be supplied to each diagnostic test.

i) Refrigerant:

- the refrigerant weight which is supplied to the autoclave shall be decided by the ageing pressure at the ageing temperature. The relation between the temperature and the pressure depends on the quality of each refrigerant.

NOTE The amount of the refrigerant ratio to the oil is different according to the ageing test temperatures for keeping the settled autoclave inner pressure.

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4.3.3 Reference test subject

The reference test subject shall be composed of EIMs that have an established performance in combination with the same compressor component, oil and refrigerant.

4.4 Test procedures

4.4.1 General test procedure

The general test procedure shall be applied to the evaluation tests, excluding the electrical resistance of refrigerant test and extract test.

A three-temperature ageing test shall be completed to establish the thermal rating of the new EIM. A reference EIM shall be used to validate the testing of the candidate EIM.

A simplified single-point ageing can also be conducted for the purpose of quality control, minor product changes or for screening prior to a full three-point evaluation. The setup would be similar to that described for the three-point ageing.

While a complete thermal index may not be determined based on such a single-point test, this test could be used to understand the expected capability of a proposed candidate EIS without the time and effort of completing a full evaluation.

4.4.2 Preparation of the autoclave

The preparation of the autoclave assembly is as follows.

a) Cleaning of the autoclave: it shall be filled with an effective solvent, such as acetone, for 24 h or longer, scrubbed well with a detergent brush, rinsed thoroughly with tap water and then with distilled water, and finally dried.

b) Drying of the autoclave: the taps, nuts, and bolts shall be conditioned for at least 1 h in an oven maintained at 105 °C ± 2 K, and shall then be removed from the oven and the samples immediately inserted.

c) Setting of the specimen: the twisted pairs of wire shall be prepared in accordance with IEC 60851-5 before insertion in the autoclave. The other materials shall then be positioned inside the autoclave, avoiding contact with each other, if possible, so that there is no sticking during the ageing period.

d) The twisted pair shall be set up in the autoclave so that half of the twisted part is immersed into the oil. In case there are other EIMs, it is better to separate into two groups. One of the group (about half the amount of the specimen) shall be kept in oil, and the effect of oil checked.

e) Drying of the specimen: after the EIMs are set in the autoclave, the tube, gaskets, taps, nuts and bolts shall be dried for at least 1 h in an oven maintained at 105 °C ± 2 K. Certain materials may require additional conditioning to remove all moisture, if agreed upon by interested parties. Higher temperatures and times may be used to condition these materials prior to insertion in the autoclave.

f) Supplying of the oil: the oil is supplied into the autoclave. Oil volume is at about half the volume of the autoclave's inner volume. In this case, the water content of the oil shall be controlled.

g) Assembly of the autoclave: immediately after the supplying of the oil, the autoclave shall be closed, to prevent the oil from absorbing water.

h) Supplying of the refrigerant: in the autoclave a vacuum of 1 000 Pa to 2 000 Pa is generated and the pre-fixed amount of refrigerant is supplied.

i) Pressure control: the autoclave is inserted into the oven or the oil bath and the temperature is maintained at a settled temperature. After the autoclave temperature has settled, the autoclave pressure is set to the settled pressure by controlling the refrigerant

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amount using the needle valve of the autoclave. Inspection of the autoclave sealing could be done by checking the pressure gauge.

4.4.3 Ageing

The autoclave shall be placed in the pre-heated thermal conditioning oven. The thermal conditioning oven shall not be opened during the conditioning cycle as this can affect the thermal ageing of the EIS under evaluation.

The ageing temperature and time shall be in accordance with IEC 60216-1.

The ageing temperature shall be selected at the temperature where the refrigerant oil or refrigerant is stable.

4.4.4 Opening procedure

After thermal conditioning of the autoclave, the oven shall be turned off and allowed to cool to room temperature before the autoclave is removed.

The autoclave shall be kept sealed, prior to evaluation, which is not to be delayed for more than three days. The autoclave shall then be opened and the EIMs components carefully removed and separated so as to reduce mechanical damage.

4.5 Diagnostic test

4.5.1 General

Samples of both the solid insulation and the liquid insulation shall be tested prior to start-up. After the ageing, each property of the solid insulation and the liquid shall be measured. Changes between the initial and final states shall be used to determine the amount of degradation occurring during the testing cycle. The results of the initial moisture content measurements shall be used to determine whether or not the materials are adequately dried prior to start-up.

4.5.2 Solid insulation materials

At start-up, the solid insulation samples shall be tested using one or more diagnostic tests to be chosen by the equipment technical committee to determine the end of life. Additional tests may be used for monitoring purposes. Evaluation tests and their method are shown in Table 2.

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Table 2 – Diagnostic test and its method for solid insulation

	Evaluation test	Test EIM	Test method
Electric property	Breakdown voltage	Winding wire	IEC 60317-0-1
		Varnish	IEC 60317-0-1
		Film	IEC 60674-2
		Tube	IEC 60684-2
	Relative permittivity (ε_r)	Film	IEC 60250
	Effect on oil electric resistivity Effect on refrigerant electric resistivity	Tie cord	Clause B.1
Mechanical property	Tensile strength	Film	IEC 60674-2
		Tie cord	IEC 60684-2
	Elongation	Film	IEC 60674-2
	Flexural strength	Molding part	ISO 178[a]
	Blister	Winding wire	Clause B.2
Chemical property	Extract	Winding wire	Clause B.3
		Varnish	
		Film	
		Molding part	
		Tie cord	
	Molecular weight	Film	ASTM D4603
	Metal surface contamination	EIMs and process oil	Clause B.4

NOTE For solid insulation which includes enamel coated wires, most of the above test methods are not appropriate. In such cases, the key characteristic to monitor for the enamel coated wires is the dielectric strength retention. There has only been limited experience using such coated wires with this test method.

[a] The support span shall be decided by the examiner.

4.5.3 Liquid insulation material (refrigerant oil)

At start-up, the liquid insulation pre-conditioned according to 4.4.2 shall be tested using one or more diagnostic tests to be chosen by the equipment technical committee to determine the end of life. Additional tests may be used for monitoring purposes. Examples of typical diagnostic test for liquids are as follows (see Table 3):

Table 3 – Diagnostic test and its method for liquid insulation

Evaluation test	Test EIM	Test method
Electric resistivity	Oil	IEC 60247
	Refrigerant	IEC 60247
Acidity	Oil	IEC 62021 (all parts)

Documents
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Full document details: IEC TS 62332-3 2016