

Measurement of the average viscometric degree of polymerization of new and aged cellulosic electrically insulating materials

The European Standard EN 60450:2004, incorporating amendment A1:2007, has the status of a British Standard

ICS 17.220.99; 29.035.01

National foreword

This British Standard is the UK implementation of EN 60450:2004, incorporating amendment A1:2007. It is identical with IEC 60450:2004, incorporating amendment 1:2007. It supersedes BS 7836:1996 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1] <A1>. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by [A1] <A1>.

The UK participation in its preparation was entrusted by Technical Committee GEL/15, Insulating material, to Subcommittee GEL/15/5, Methods of test.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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**Measurement of the average viscometric degree of polymerization
of new and aged cellulosic electrically insulating materials
(IEC 60450:2004)**

Mesure du degré de polymérisation
moyen viscométrique des matériaux
isolants cellulosiques neufs et vieillis
à usage électrique
(CEI 60450:2004)

Messung des durchschnittlichen
viskosimetrischen Polymerisationsgrades
von neuen und gealterten
cellulosehaltigen Elektroisierstoffen
(IEC 60450:2004)

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 15E/229/FDIS, future edition 2 of IEC 60450, prepared by SC 15E, Methods of test, of IEC TC 15, Insulating materials, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60450 on 2004-06-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2005-03-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2007-06-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60450:2004 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 112/49/CDV, future amendment 1 to IEC 60450:2004, prepared by IEC TC 112, Evaluation and qualification of electrical insulating materials and systems, was submitted to the IEC-CENELEC Parallel Unique Acceptance Procedure and was approved by CENELEC as amendment A1 to EN 60450:2004 on 2007-06-01.

The following dates were fixed:

- latest date by which the amendment has to be
implemented at national level by publication of
an identical national standard or by endorsement (dop) 2008-03-01
- latest date by which the national standards conflicting
with the amendment have to be withdrawn (dow) 2010-06-01

Endorsement notice

The text of amendment 1:2007 to the International Standard IEC 60450:2004 was approved by CENELEC as an amendment to the European Standard without any modification.

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INTRODUCTION

Experience has indicated the need for an improved description of the experimental method for the reproducible determination of the average viscometric degree of polymerization of new and aged cellulosic electrically insulating material.

The major error appears to arise from oxidative degradation occurring during processing and effluxing. Other significant factors include the need to ensure that all of the material is dissolved and used, as well as the effect of the speed of effluxing.

MEASUREMENT OF THE AVERAGE VISCOMETRIC DEGREE OF POLYMERIZATION OF NEW AND AGED CELLULOSIC ELECTRICALLY INSULATING MATERIALS

1 Scope

This International standard describes a standardized method for the determination of the average viscometric degree of polymerization ($\overline{DP}_v$) of new and aged cellulosic electrically insulating materials. It may be applied to all cellulosic insulating materials such as those used in transformer, cable or capacitor manufacturing.

The methods described can also be used for the determination of the intrinsic viscosity of solutions of chemically modified kraft papers, provided that these dissolve completely in the selected solvent.

Caution should be taken if the method is applied to loaded kraft papers.

NOTE Within a sample of material, all the cellulose molecules do not have the same degree of polymerization so that the mean value measured by viscometric methods is not necessarily the same as that which may be obtained by, for instance, osmotic or ultra centrifuging methods.

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

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

ISO 3105, *Glass capillary kinematic viscometers – Specifications and operating instructions*

3 Terms, definitions and symbols

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

3.1 Terms and definitions

3.1.1

degree of polymerization of a cellulose molecule

number of anhydrous- β -glucose monomers, $C_6H_{10}O_5$, in the cellulose molecule

NOTE Figure 1 shows the chemical structure of cellulose.

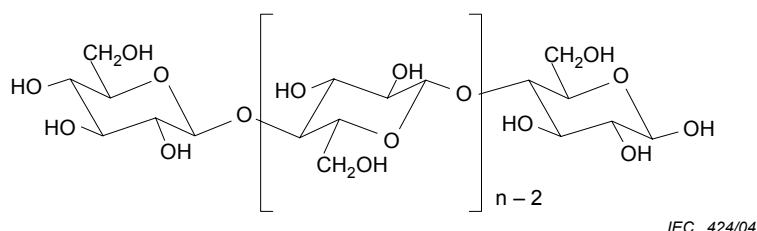


Figure 1 – Chemical structure of cellulose

3.1.2**Cuen**

1 mol/l aqueous solution of bis(ethylenediamine)copper(II) hydroxide

$\text{Cu}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2(\text{OH})_2$. [CAS 14552-35-3]¹

NOTE In some countries the abbreviation CED is used for bis(ethylenediamine)copper(II) hydroxide.

3.1.3**paper**

cellulosic electrically insulating material, such as paper, presspaper, pressboard and components made thereof

NOTE In the present document such paper is termed "paper".

3.2 Symbols

Symbols used in this standard are shown in Table 1.

Table 1 – Symbols

Symbol	Definition
α	Mark Houwink constant of the cellulose monomer
c_{Cu}	Molarity of copper in Cuen solution
c_{En}	Molarity of ethylenediamine in Cuen solution
C_0, C_1 and C_2	Constants for viscometer tubes 0, 1 and 2 respectively
c	Concentration of solution
$\overline{DP}_v$	Average viscometric degree of polymerization
ν	Kinematic viscosity of solution
ν_0	Kinematic viscosity of solvent
K	Mark Houwink characteristic constant of the polymer/solvent system
k	Constant in Martin's formula
m_D	Mass of dry paper
m_T	Mass of swollen paper in tared vessel
$m_{\text{H}_2\text{O}}$	Mass of added water
$\rho_{\text{H}_2\text{O}}$	Density of water
$\nu_{\text{H}_2\text{O}}$	Volume of added water
ν_{Cu}	Volume of added Cuen
$[\eta]$	Intrinsic viscosity
η_s	Specific viscosity
t_{1A}, t_{1B}	Efflux time for tests A and B on dissolved specimen 1
t_{2A}, t_{2B}	Efflux time for tests A and B on dissolved specimen 2
t_{0A}, t_{0B}	Efflux time for tests A and B on pure solvent
t_0	Efflux time for diluted Cuen solvent (50 % Cuen and 50 % water)
t_S	Efflux time for Cuen dissolved specimen

¹ Chemical Abstracts Service (CAS) Registry numbers®