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INTERNATIONAL STANDARD

CEI
IEC
156

Deuxième édition
Second edition
1995-07

Isolants liquides – Détermination de la tension de claquage à fréquence industrielle – Méthode d'essai

Insulating liquids – Determination of the breakdown voltage at power frequency – Test method

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et pour les appareils électromédicaux,

- la CEI 878: *Symboles graphiques pour équipements électriques en pratique médicale.*

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and for medical electrical equipment,

- IEC 878: *Graphical symbols for electromedical equipment in medical practice.*

The symbols and signs contained in the present publication have either been taken from IEC 27, IEC 417, IEC 617 and/or IEC 878, or have been specifically approved for the purpose of this publication.

IEC publications prepared by the same technical committee

The attention of readers is drawn to the end pages of this publication which list the IEC publications issued by the technical committee which has prepared the present publication.

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Bureau Central de la Commission Electrotechnique Internationale 3, rue de Varembé Genève, Suisse

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSULATING LIQUIDS – DETERMINATION OF THE BREAKDOWN VOLTAGE AT POWER FREQUENCY – TEST METHOD

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters, prepared by technical committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

International Standard IEC 156 has been prepared by IEC technical committee 10: Fluids for electrotechnical applications.

This second edition cancels and replaces the first edition published in 1963 and constitutes a technical revision.

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

DIS	Report on voting
10/338/DIS	10/346/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.

INTRODUCTION

As normally applied, breakdown voltage of insulating liquids is not a basic material property but an empirical test procedure intended to indicate the presence of contaminants such as water and solid suspended matter, and the advisability of carrying out drying and filtration treatment.

The breakdown voltage value of insulating liquids strongly depends on the particular set of conditions used in its measurement. Therefore, standardized testing procedures and equipment are essential for the unambiguous interpretation of test results.

The method described in this International Standard applies to either acceptance tests on new deliveries of insulating liquids, or testing of treated liquids prior to or during filling into electrical equipment, or to the monitoring and maintenance of oil-filled apparatus in service. It specifies rigorous sample-handling procedures and temperature control that should be adhered to when certified results are required. For routine tests, especially in the field, less stringent procedures may be practicable and it is the responsibility of the user to determine their effect on the results.

INSULATING LIQUIDS – DETERMINATION OF THE BREAKDOWN VOLTAGE AT POWER FREQUENCY – TEST METHOD

1 Scope

This International Standard specifies the method for determining the dielectric breakdown voltage of insulating liquids at power frequency. The test portion, contained in a specified apparatus, is subjected to an increasing a.c. electrical field by means of a constant rate of voltage rise until breakdown occurs.

The method applies to all types of insulating liquids of nominal viscosity up to 350 mm^2s^{-1} at 40 °C. It is appropriate both for acceptance testing on unused liquids at the time of their delivery and for establishing the condition of samples taken in monitoring and maintenance of equipment.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 52: 1960, *Recommendations for voltage measurement by means of sphere-gaps (one sphere earthed)*

IEC 60, *High-voltage test techniques*

IEC 475: 1974, *Method of sampling liquid dielectrics*

3 Electrical apparatus

The electrical apparatus consists of the following units:

a) Voltage regulator

b) Step-up transformer

c) Switching system

d) Energy limiting devices

Two or more of these units may be integrated in any equipment system.

3.1 *Voltage regulator*

Uniform increase of voltage with time by manual means is difficult and, for this reason, automatic control is essential.

Voltage control may be achieved by one of the following methods:

a) Variable ratio auto-transformer

b) Electronic regulator

c) Generator-field regulation

d) Induction regulator

e) Resistive type voltage divider

3.2 *Step-up transformer*

The test voltage is obtained by using a step-up transformer supplied from an a.c. (48 Hz to 62 Hz) voltage source whose value is gradually increased. The controls of the variable low-voltage source shall be capable of varying the test voltage smoothly, uniformly and without overshoots or transients. Incremental increases (produced, for example, by a variable auto-transformer) shall not exceed 2 % of the expected breakdown voltage.

The voltage applied to the electrodes of the liquid-filled cell shall have an approximately sinusoidal waveform, such that the peak factor is within the following limits: 1,41 ± 0,07.

The centre-point of the secondary winding of the transformer should be connected to earth.

3.3 *Current-limiting resistors*

To protect the equipment and to avoid excessive decomposition of the liquid at the instant of breakdown, a resistance limiting the breakdown current may be inserted in series with the test cell.

The short-circuit current of the transformer and associated circuits shall be within the range of 10 mA to 25 mA for all voltages higher than 15 kV. This may be achieved by a combination of resistors in either or both the primary and secondary circuits of the high- voltage transformer.

3.4 *Switching system*

3.4.1 *Basic requirements*

The circuit shall be opened automatically if an established arc occurs. The primary circuit of the step-up transformer shall be fitted with a circuit-breaker operated by the current resulting from the breakdown of the sample, and shall break the voltage within 10 ms. The circuit may be opened manually if a transient spark (audible or visible) occurs between the electrodes.

NOTE – The sensitivity of the current-sensing element depends on the energy-limiting device employed and only approximate guidance can be given. Normally, triggering of cut-off by a current of 4 mA maintained for 5 ms is acceptable, while fast energy-limiting (see 3.4.2) triggering by a transient current of 1 A maintained for 1 µs has been found satisfactory.

3.4.2 *Special requirements for silicone liquids*

Silicone liquids can give rise to solid decomposition products through the action of electric discharges, which may cause gross errors in the observed results. In such cases, all feasible steps shall be taken to minimize the energy available for dissipation in the breakdown discharge.

Whilst current limiting as above, combined with isolation of the step-up transformer primary within 10 ms, is adequate for hydrocarbons. More satisfactory performance for silicone liquids is obtained by short circuiting of the primary circuit of the transformer by a low-impedance or by use of a low-voltage device for detection of breakdown acting within a few microseconds. This device may be of either analogue (for example, modulating amplifier) or switching (for example, thyristor) type. By the use of this device, the output voltage of the step-up transformer shall be reduced to zero within 1 ms of detection of breakdown, and shall not thereafter increase again until the next step of the test sequence is commenced.

3.5 *Measuring device*

For the purpose of this standard, the magnitude of the test voltage is defined as its peak value divided by $\sqrt{2}$.

This voltage may be measured by means of a peak-voltmeter or by means of another type of voltmeter connected to the input or output side of the testing transformer, or to a special winding provided thereon; the instrument then used shall be calibrated against a standard up to the full voltage which it is desired to measure.

A method of calibration which has been found satisfactory is the use of a transfer standard. This is an auxiliary measuring device which is connected in place of the test cell between the high-voltage terminals to which it presents the same impedance as the filled test cell. The auxiliary device is separately calibrated against a primary standard, for example, a sphere gap in accordance with IEC 52 (see also IEC 60).

4 Test assembly

4.1 *Test cell*

The volume of the cell shall be between 350 ml and 600 ml.

The cell shall be made of material that is electrically insulating, transparent and chemically inert, resistant to the insulating liquid and the cleaning agents which may be used.

The cell shall be provided with a cover and shall be designed to permit easy removal of the electrodes for cleaning and maintenance.

Examples of suitable cell designs are given in figures 1 and 2.

4.2 *Electrodes*

The electrodes shall be made either of brass, bronze or austenitic stainless steel. They shall be polished and, in shape, either spherical (12,5 mm to 13,0 mm diameter) as shown in figure 1 or partially spherical of the shape and dimensions given in figure 2. The axis of the electrode system shall be horizontal, and at least 40 mm below the surface of the test liquid in the cell. No part of the electrode shall be closer than 12 mm to the cell wall or stirrer. The gap between the electrodes shall be 2,50 mm ± 0,05 mm.

The electrodes shall be examined frequently for pitting or other damage, and shall be maintained or replaced as soon as such damage is observed.

4.3 *Stirring* (optional)

The test may be conducted with or without stirring. Differences between tests with or without stirring have not been found statistically significant. A stirrer, however, may be convenient especially with apparatus capable of automatic operation.

Stirring may be achieved by means of a two-bladed impeller of effective diameter 20 mm to 25 mm, axial depth 5 mm to 10 mm, rotating at a speed of 250 r.p.m to 300 r.p.m. The impeller shall not entrain air bubbles and preferably rotate in such a direction that the resulting liquid flow is directed downward. It shall be constructed so that it is easily cleaned.

Stirring by means of a magnetic bar (20 mm to 25 mm in length and 5 mm to 10 mm in diameter) is an acceptable alternative when there is no risk of removing magnetic particles.

The dimensions of the stirring device shall conform to the clearance requirements in 4.2.

5 Preparation of electrodes

New electrodes, pitted electrodes, electrodes which have not been properly stored for a considerable time shall be cleaned by the following procedure:

- clean all surfaces with a suitable volatile solvent and allow the solvent to evaporate;
- polish with fine abrasive powder (for example, jeweller's rouge) or abrasive paper or cloth (for example, crocus cloth);
- after polishing, clean with petroleum spirit (reagent quality: boiling range 60 °C - 80 °C) followed by acetone (reagent quality);
- assemble the electrodes in the cell, fill with a clean, unused insulating liquid of the type to be tested next, and raise the electrode voltage to breakdown 24 times.

6 Test assembly preparation

It is recommended that a separate test cell assembly be reserved for each insulating liquid type.

Test assemblies shall be stored in a dry place, covered and filled with dry insulating liquid of the type in regular use in the cell.

On change of the type of liquid under test, remove all residues of the previous liquid with an appropriate solvent, rinse the assembly with clean, dry liquid of the same type as that to be tested, drain and refill.

7 Sampling

7.1 *Sample containers*

Sample size should be approximately three times the capacity of the test cell.

Appropriate sample containers shall comply with IEC 475. An amber glass bottle is the preferred container. Clear glass bottles may be used but they shall be shielded from direct light until ready to be tested. Plastic containers which are not attacked by the liquid to be tested may be used, but these shall not be used more than once. For sealing, screw caps with polyolefine or polytetrafluoroethylene insert are preferred.

Containers and caps shall be cleaned by washing with a suitable solvent to remove residues of an earlier sample. Containers shall next be rinsed with acetone, traces of which shall be removed by blowing with warm air.

After cleaning, containers shall be immediately capped and kept sealed until used.

7.2 *Sampling technique*

Sampling of new and used insulating liquids shall be carried out in full compliance with procedures detailed in IEC 475.

When sampling, containers should be almost filled with sample, leaving about 3 % of the container volume as free air space.

Breakdown voltage is extremely sensitive to the slightest contamination of the sample by water and particulate matters. Special reference is made to precautions necessary to avoid contamination of the sample and the need for trained personnel and experienced supervision.

Unless otherwise required, the sample is taken where the liquid is likely to be most contaminated, usually at the lowest point of the container holding it.

8 Condition of the sample

The test is carried out, unless otherwise specified, on the sample as received without drying or degassing.

At the time of test, the temperatures of the test liquid and ambient air shall not differ by more than 5 °C and for referee tests the liquid temperature shall be 20 °C ± 5 °C.

9 Test procedure

9.1 *Sample preparation*

Immediately before filling the test cell, the sample container is gently agitated and turned over several times in such a way as to ensure as far as possible a homogeneous distribution of the impurities contained in the liquid without causing the formation of air bubbles.

Unnecessary exposure to the ambient air of the sample shall be avoided.

9.2 *Filling of the cell*

Immediately before commencing the test, drain the test cell and rinse the walls, electrodes and other component parts, with the test sample. Drain and slowly fill with the test sample avoiding the formation of air bubbles.

Measure and record the temperature of the liquid.

Position the cell in the test equipment and start the stirrer if used.

9.3 *Application of voltage*

The first application of voltage is started approximately 5 min after completion of filling and checking that no air bubbles are visible in the electrode gap.

Apply voltage to the electrodes and uniformly increase voltage from zero at the rate of 2,0 kV s^{-1} ± 0,2 kV s^{-1} until breakdown occurs. The breakdown voltage is the maximum voltage reached at the time the circuit is opened either automatically (established arc) or manually (visible or audible discharge detected).

Record the value.

Carry out six breakdowns on the same cell filling allowing a pause of at least 2 min after each breakdown before re-application of voltage. Check that no gas bubbles are present within the electrode gap. If a stirrer is used, it shall run continuously throughout the test.

Calculate the mean value of the six breakdowns in kilovolts.

10 Report

Report the mean value, in kilovolts, of the six breakdowns as the test result.

The report shall also include: the sample identification, the value of each individual breakdown, the type of electrodes used, the frequency of the test voltage, the temperature of the liquid, the use of a stirrer (if any).

11 Test data dispersion

The scatter of individual breakdown voltages has been found to be very dependent on the value of the result. The graphical representation of figure 3 indicates the values of standard deviation/mean ratio which have been found in a large body of test data in several laboratories using transformer oil.

The full line in the graph shows the distribution of the median value of SD/mean as a function of the value of the mean. The dotted lines indicate the expected 95 % range of values of SD/mean as a function of the value of the mean.

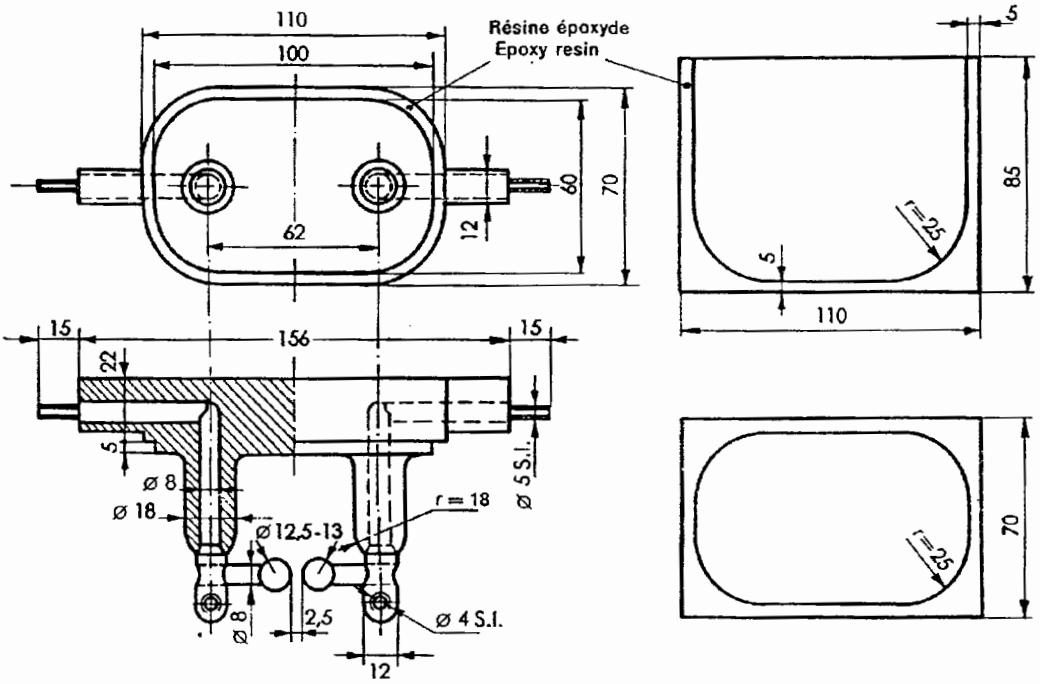

Figure 1 – Exemple d'une cellule et d'électrodes sphériques appropriées
Example of suitable cell and spherical electrodes

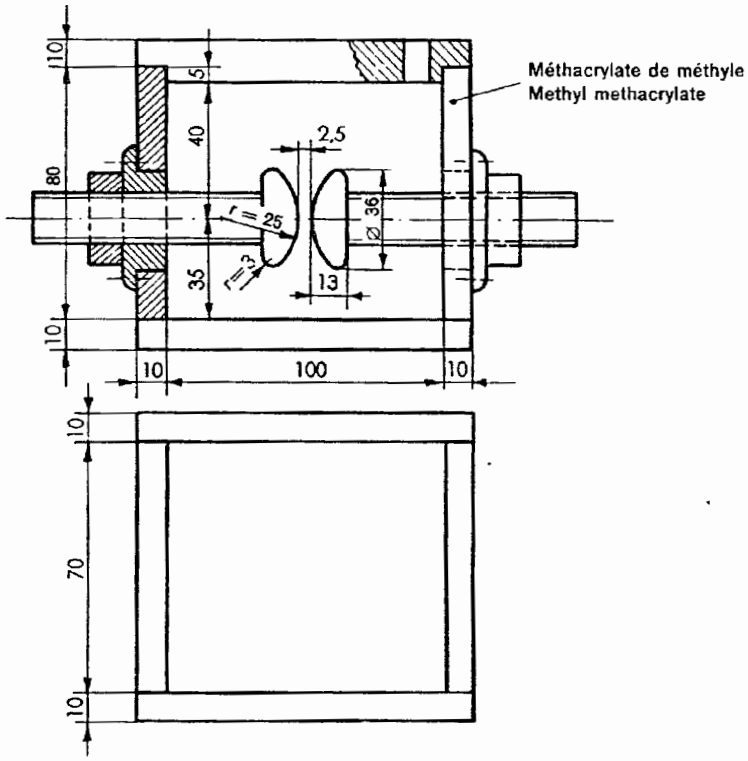

Figure 2 – Exemple d'une cellule et d'électrodes hémisphériques appropriées
Example of suitable cell and partially spherical electrodes

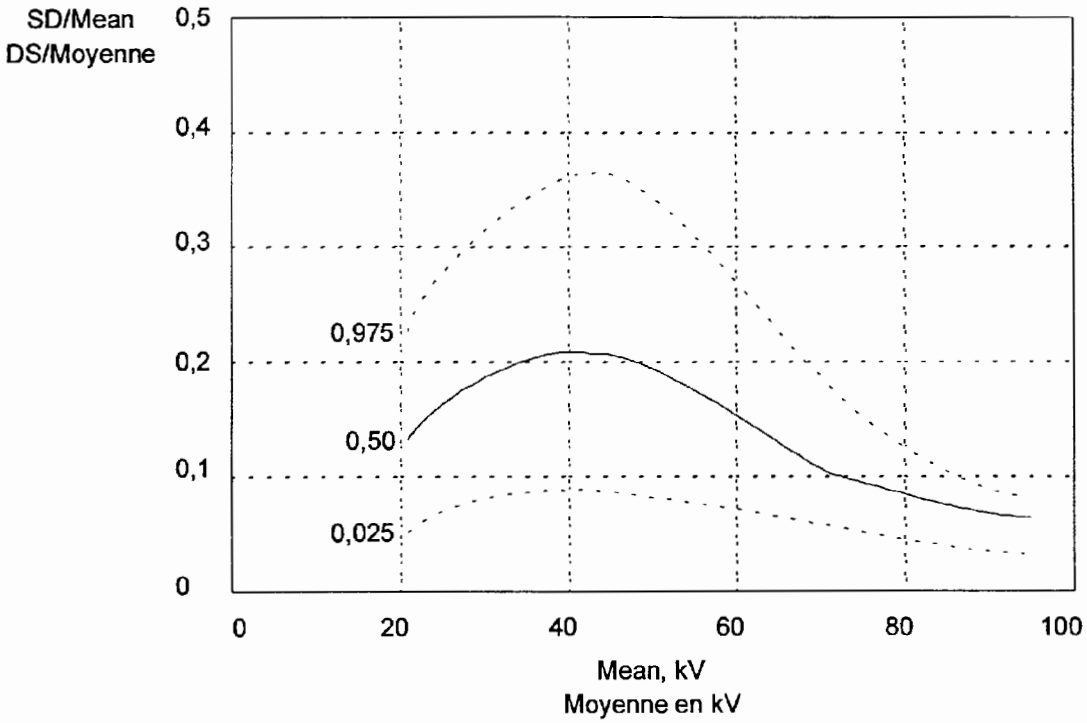

Figure 3 – Représentation graphique du coefficient de variation (rapport de l'écart type à la valeur moyenne) en fonction de la moyenne de tension de claquage
Graphical representation of coefficient of variation (standard deviation/ mean ratio) versus mean breakdown voltage

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Would you please take a minute to answer the survey on the other side and mail or fax to:

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Tell us why you have the standard. (check as many as apply). I am:

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- ☐ involved in testing
- ☐ with a government agency
- ☐ in industry
- ☐ other .....

3.
This standard was purchased from:

.....

4.
This standard will be used (check as many as apply):

- ☐ for reference
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- ☐ to develop a new product
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- ☐ to use in a tender
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- ☐ for a lawsuit
- ☐ for quality assessment
- ☐ for certification
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5.
This standard will be used in conjunction with (check as many as apply):

- ☐ IEC
- ☐ ISO
- ☐ corporate
- ☐ other (published by .....)
- ☐ other (published by .....)
- ☐ other (published by .....)

6.
This standard meets my needs (check one):

- ☐ not at all
- ☐ almost
- ☐ fairly well
- ☐ exactly

7.
Please rate the standard in the following areas as (1) bad, (2) below average, (3) average, (4) above average, (5) exceptional (0) not applicable:

- ☐ clearly written
- ☐ logically arranged
- ☐ information given by tables
- ☐ illustrations
- ☐ technical information

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- ☐ internal use
- ☐ sales information
- ☐ product demonstration
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9.
In what medium of standard does your organization maintain most of its standards (check one):

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- ☐ microfilm/microfiche
- ☐ mag tape
- ☐ CD ROM
- ☐ floppy disk
- ☐ on line

9A.
If your organization currently maintains part or all of its standards collection in electronic media please indicate the format(s).

- ☐ raster image
- ☐ full text

10.
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- ☐ mag tape
- ☐ CD ROM
- ☐ floppy disk
- ☐ on line

10A.
For electronic media which format will be chosen (check one):

- ☐ raster image
- ☐ full text

11.
My organization is in the following sector (e.g. engineering, manufacturing)

.....

12.
Does your organization have a standards library:

- ☐ Yes
- ☐ No

13.
If you said yes to 12 then how many volumes:

.....

14.
Which standards organizations published the standards in your library (e.g. ISO, DIN, ANSI, BSI, etc.):

.....

15.
My organization supports the standards-making process by (check as many as apply):

- ☐ buying standards
- ☐ using standards
- ☐ membership in standards organizations
- ☐ serving on standards development committees
- ☐ other .....

16.
My organization uses (check one):

- ☐ French text only
- ☐ English text only
- ☐ Both English/French text

17.
Other comments:

.....

.....

.....

.....

.....

18.
Please give us information about you and your company

name: .....

job title: .....

company: .....

address: .....

.....

.....

.....

No. employees at your location: .....

turnover/sales: .....

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La CEI se préocupe de savoir comment ses normes sont accueillies et utilisées. Les réponses que nous procurera cette enquête nous aideront tout à la fois à améliorer nos normes et les informations qui les concernent afin de toujours mieux répondre à votre attente.

Nous aimerions que vous nous consacriez une petite minute pour remplir le questionnaire joint que nous vous invitons à retourner au:

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Nous vous remercions de la contribution que vous voudrez bien apporter ainsi à la Normalisation Internationale.

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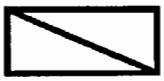

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- ☐ chargé d'effectuer des essais
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- ☐ dans l'industrie
- ☐ autres. . . . . .

3.
Où avez-vous acheté cette norme?

. . . . . .

4.
Comment cette norme sera-t-elle utilisée? (plusieurs réponses possibles)

- ☐ comme référence
- ☐ dans une bibliothèque de normes
- ☐ pour développer un produit nouveau
- ☐ pour rédiger des spécifications
- ☐ pour utilisation dans une soumission
- ☐ à des fins éducatives
- ☐ pour un procès
- ☐ pour une évaluation de la qualité
- ☐ pour la certification
- ☐ à titre d'information générale
- ☐ pour une étude de conception
- ☐ pour effectuer des essais
- ☐ autres- - - - - - - - - - - - - - - - -

5.
Cette norme est-elle appelée à être utilisée conjointement avec d'autres normes? Lesquelles? (plusieurs réponses possibles):

- ☐ CEI
- ☐ ISO
- ☐ internes à votre société
- ☐ autre (publiée par. . . . .)
- ☐ autre (publiée par. . . . .)
- ☐ autre (publiée par. . . . .)

6.
Cette norme répond-elle à vos besoins?

- ☐ pas du tout
- ☐ à peu près
- ☐ asez bien
- ☐ parfaitement

7.
Nous vous demandons maintenant de donner une note à chacun des critères ci-dessous (1, mauvais; 2, en-dessous de la moyenne; 3, moyen; 4, au-dessus de la moyenne; 5, exceptionnel; 0, sans objet)

- ☐ clarté de la rédaction
- ☐ logique de la disposition
- ☐ tableaux informatifs
- ☐ illustrations
- ☐ informations techniques

8.
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- ☐ des renseignements commerciaux
- ☐ des démonstrations de produit
- ☐ autres . . . . . .

9.
Quel support votre société utilise-t-elle pour garder la plupart des ses normes?

- ☐ papier
- ☐ microfilm/microfiche
- ☐ bandes magnétiques
- ☐ CD-ROM
- ☐ disquettes
- ☐ abonnement à un serveur électronique

9A.
Si votre société conserve en totalité ou en partie sa collection de normes sous forme électronique, indiquer la ou les formats:

- ☐ format tramé (ou image balayée ligne par ligne)
- ☐ texte intégral

10.
Sur quels supports votre société prévoit-elle de conserver sa collection de normes à l'avenir (plusieures réponses possibles):

- ☐ papier
- ☐ microfilm/microfiche
- ☐ bande magnétique
- ☐ CD-ROM
- ☐ disquette
- ☐ abonnement à un serveur électronique

10A.
Quel format serait retenu pour un moyen électronique? (une seule réponse)

- ☐ format tramé
- ☐ texte intégral

11.
A quel secteur d'activité appartient votre société? (par ex. ingénierie, fabrication)

. . . . . .

12.
Votre société possède-t-elle une bibliothèque de normes?

- ☐ Oui
- ☐ Non

13.
En combien de volumes dans le cas affirmatif ?

. . . . . .

14.
Quelles organisations de normalisation ont publiées les normes de cette bibliothèque ? (ISO, DIN, ANSI, BSI, etc.):

. . . . . .

15.
Ma société apporte sa contribution à l'élaboration des normes par les moyens suivants (plusieurs réponses possibles):

- ☐ en achetant des normes
- ☐ en utilisant des normes
- ☐ en qualité de membre d'organisations de normalisation
- ☐ en qualité de membre de comités de normalisation
- ☐ autres . . . . . .

16.
Ma société utilise:
(une seule réponse)

- ☐ des normes en français seulement
- ☐ des normes en anglais seulement
- ☐ des normes bilingues anglais/français

17.
Autres observations:

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. . . . . .

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. . . . . .

18.
Pourriez-vous nous donner quelques informations sur vous-même et votre société?:

nom: . . . . . .

fonction: . . . . . .

nom de la société: . . . . . .

adresse: . . . . . .

. . . . . .

. . . . . .

. . . . . .

nombre d'employés: . . . . . .

chiffre d'affaires: . . . . . .

Publications de la CEI préparées par le Comité d'Etudes n° 10

156 (1995) Méthode pour la détermination de la rigidité électrique des huiles isolantes.

247 (1978) Mesure de la permittivité relative, du facteur de dissipation diélectrique et de la résistivité (en courant continu) des liquides isolants.

296 (1982) Spécification des huiles minérales isolantes neuves pour transformateurs et appareillage de connexion. Modification n° 1 (1986).

376 (1971) Spécifications et réception de l'hexafluorure de soufre neuf.

376A (1973) Premier complément: Section treize: Taux d'huile minérale.

376B (1974) Deuxième complément: Article 26.

422 (1989) Guide de maintenance et de surveillance des huiles minérales isolantes en service dans les matériels électriques.

465 (1988) Spécification pour huiles minérales isolantes neuves pour câbles à circulation d'huile.

475 (1974) Méthode d'échantillonnage des diélectriques liquides.

480 (1974) Guide relatif au contrôle de l'hexafluorure de soufre (SF_6) prélevé sur le matériel électrique.

567 (1992) Guide d'échantillonnage de gaz et d'huile dans les matériels électriques immergés, pour l'analyse des gaz libres et dissous.

588: — Askarels pour transformateurs et condensateurs.

588-1 (1977) Première partie: Généralités.

588-2 (1978) Deuxième partie: Méthodes d'essai.

588-3 (1977) Troisième partie: Spécifications pour askarels neufs.

588-4 (1979) Quatrième partie: Guide pour la maintenance des askarels dans les transformateurs.

588-5 (1979) Cinquième partie: Essai éliminatoire pour déterminer la compatibilité des matériaux avec les askarels pour transformateurs.

588-6 (1979) Sixième partie: Essai éliminatoire pour déterminer les effets des matériaux sur les askarels pour condensateurs.

590 (1977) Détermination de la teneur en hydrocarbures aromatiques des huiles isolantes minérales neuves.

599 (1978) Interprétation de l'analyse des gaz dans les transformateurs et autres matériels électriques remplis d'huile, en service.

628 (1985) Gassing des isolants liquides sous contrainte électrique et ionisation.

666 (1979) Détection et dosage d'additifs antioxydants spécifiques présents dans les huiles isolantes.

733 (1982) Dosage de l'eau dans les huiles isolantes, dans les papiers et cartons imprégnés d'huile.

814 (1985) Dosage de l'eau dans les diélectriques liquides par titration coulométrique de Karl Fischer automatique.

836 (1988) Spécifications pour liquides silicones pour usages électriques.

867 (1993) Isolants liquides – Spécifications pour liquides neufs à base d'hydrocarbures aromatiques de synthèse.

897 (1987) Méthodes de détermination de la tension de claquage au choc de foudre des liquides isolants.

(Suite)

IEC publications prepared by Technical Committee No. 10

156 (1995) Method for the determination of the electric strength of insulating oils.

247 (1978) Measurement of relative permittivity, dielectric dissipation factor and d.c. resistivity of insulating liquids.

296 (1982) Specification for unused mineral insulating oils for transformers and switchgear. Amendment No. 1 (1986).

376 (1971) Specification and acceptance of new sulphur hexafluoride.

376A (1973) First supplement: Section Thirteen: Mineral oil content.

376B (1974) Second supplement: Clause 26.

422 (1989) Supervision and maintenance guide for mineral insulating oils in electrical equipment.

465 (1988) Specification for unused insulating mineral oils for cables with oil ducts.

475 (1974) Method of sampling liquid dielectrics.

480 (1974) Guide to the checking of sulphur hexafluoride (SF_6) taken from electrical equipment.

567 (1992) Guide for the sampling of gases and of oil from oil-filled electrical equipment and for the analysis of free and dissolved gases.

588: — Askarels for transformers and capacitors.

588-1 (1977) Part 1: General.

588-2 (1978) Part 2: Test methods.

588-3 (1977) Part 3: Specifications for new askarels.

588-4 (1979) Part 4: Guide for maintenance of transformer askarels in equipment.

588-5 (1979) Part 5: Screening test for compatibility of materials and transformer askarels.

588-6 (1979) Part 6: Screening test for effects of materials on capacitor askarels.

590 (1977) Determination of the aromatic hydrocarbon content of new mineral insulating oils.

599 (1978) Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service.

628 (1985) Gassing of insulating liquids under electrical stress and ionization.

666 (1979) Detection and determination of specified antioxidant additives in insulating oils.

733 (1982) Determination of water in insulating oils, and in oil-impregnated paper and pressboard.

814 (1985) Determination of water in insulating liquids by automatic coulometric Karl Fischer titration.

836 (1988) Specifications for silicone liquids for electrical purposes.

867 (1993) Insulating liquids – Specifications for unused liquids based on synthetic aromatic hydrocarbons.

897 (1987) Methods for the determination of the lightning impulse breakdown voltage of insulating liquids.

(Continued)

Publications de la CEI préparées par le Comité d'Etudes n° 10 *(Suite)*

944 (1988) Guide de maintenance des liquides silicones pour transformateurs.

962 (1988) Guide de maintenance et d'emploi des huiles lubrifiantes de pétrole pour turbines à vapeur.

963 (1988) Spécification pour polybutènes neufs.

970 (1989) Méthodes de détermination du nombre et de la taille des particules dans les isolants liquides.

978 (1989) Guide de maintenance et d'emploi des fluides de régulation esters phosphates de triaryle pour turbine.

997 (1989) Détermination des polychlorobiphényles (PCB) dans les huiles minérales isolantes par chromatographie en phase gazeuse (CPG) sur colonnes remplies.

1039 (1990) Classification générale des isolants liquides.

1065 (1991) Méthode d'évaluation des propriétés d'écoulement à basse température des huiles minérales isolantes après vieillissement.

1099 (1992) Spécifications pour esters organiques de synthèse à usages électriques.

1100 (1992) Classification des isolants liquides selon le point de feu et le pouvoir calorifique inférieur.

1125 (1992) Isolants liquides neufs à base d'hydrocarbures – Méthodes d'essai pour évaluer la stabilité à l'oxydation.

1144 (1992) Méthode d'essai pour la détermination de l'indice d'oxygène des isolants liquides.

1181 (1993) Matériaux isolants imprégnés – Application de l'analyse des gaz dissous (DGA) lors d'essais en usine de matériels électriques.

1197 (1993) Isolants liquides – Propagation linéaire de la flamme – Méthode d'essai utilisant un ruban en fibres de verre.

1198 (1993) Huiles minérales isolantes – Méthodes pour la détermination du 2-furfural et ses dérivés.

1203 (1992) Esters organiques de synthèse à usages électriques – Guide de maintenance des esters pour transformateurs dans les matériels.

1221 (1993) Produits pétroliers et lubrifiants – Fluides de régulation pour turbines, esters phosphates de triaryle (catégorie ISO-L-TCD) – Spécifications.

1294 (1993) Isolants liquides – Détermination de la tension d'apparition des décharges partielles (TADP) – Méthode d'essai.

IEC publications prepared by Technical Committee No. 10 *(Continued)*

944 (1988) Guide for the maintenance of silicone transformer liquids.

962 (1988) Maintenance and use guide for petroleum lubricating oils for steam turbines.

963 (1988) Specification for unused polybutenes.

970 (1989) Methods for counting and sizing particles in insulating liquids.

978 (1989) Maintenance and use guide for triaryl phosphate ester turbine control fluids.

997 (1989) Determination of polychlorinated biphenyls (PCBs) in mineral insulating oils by packed column gas chromatography (GC).

1039 (1990) General classification of insulating liquids.

1065 (1991) Method for evaluating the low temperature flow properties of mineral insulating oils after ageing.

1099 (1992) Specifications for unused synthetic organic esters for electrical purposes.

1100 (1992) Classification of insulating liquids according to fire-point and net calorific value.

1125 (1992) Unused hydrocarbon-based insulating liquids – Test methods for evaluating the oxidation stability.

1144 (1992) Test method for the determination of oxygen index of insulating liquids.

1181 (1993) Impregnated insulating materials – Application of dissolved gas analysis (DGA) to factory tests on electrical equipment.

1197 (1993) Insulating liquids – Linear flame propagation – Test method using a glass-fibre tape.

1198 (1993) Mineral insulating oils – Methods for the determination of 2-furfural and related compounds.

1203 (1992) Synthetic organic esters for electrical purposes – Guide for maintenance of transformer esters in equipment.

1221 (1993) Petroleum products and lubricants – Triaryl phosphate ester turbine control fluids (category ISO-L-TCD) – Specifications.

1294 (1993) Insulating liquids – Determination of the partial discharge inception voltage (PDIV) – Test procedure.

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