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An American National Standard

Standard Terminology Relating to Electrical Insulation[1]

This standard is issued under the fixed designation D 1711; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This terminology is used in connection with testing and specifying solid electrical insulating materials. Modifications to this terminology, reflecting common usage, may appear in particular test methods, material specifications, practices, or other standards. Included herein are terms pertinent to general applications, electrical insulating papers, mica, mica processing, processed mica forms, hookup wire insulation, and partial discharge (corona).

1. Scope

1.1 This terminology is a compilation of technical terms used in conjunction with testing and specifying solid electrical and electronic insulating materials in standards under the jurisdiction of Committee D-9 on Electrical and Electronic Insulating Materials.

1.2 It is intended that all definitions in this terminology are identical to definitions of the same terms as printed in standards of originating technical subcommittees, with the exceptions of: (*1*) deletion of any part of the Discussion included in another standard that refers specifically to the use of a term in that standard; (*2*) figure numbers and corresponding references; and (*3*) in this terminology, a parenthetical addition of a reference to one or more technical standards in which the term is used and the year in which the term was added to this compilation.

1.3 Symbols may be included as part of the representation of terms, where appropriate.

1.4 It is not intended that this terminology include descriptions of terms or symbols (except as noted in 1.3). Acronyms and abbreviations referring directly to defined terms may be included.

1.5 Revisions and additions to the definitions in this terminology are to be made as a product of a collaborative effort between Subcommittee D09.94 and the various technical subcommittees of Committee D-9, with Subcommittee D09.94 providing editorial advice to the technical subcommittees. New definitions and revision of existing definitions must first be approved by the cognizant technical subcommittee (or subcommittees) before inclusion in this terminology.

2. Referenced Documents

2.1 *ASTM Standards:*

D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies[2]

D 150 Test Methods for AC Loss Characteristics and Permittivity Dielectric Constant of Solid Electrical Insulation[2]

D 3426 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials Using Impulse Waves[3]

D 3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials[3]

2.2 *Other Standards:*

ANSI/ASQC A2-1987[4]

3. Terminology

acceptable quality level (AQL), *n*—the maximum percent nonconforming which, for purposes of sampling inspection, can be considered satisfactory as a process average.

acceptance number, *n*—the maximum allowable number of nonconformities for a given AQL and sample size (lot-sample size).

air chain, *n—in mica*, a series of air inclusions in the form of a chain or streak.

arc propagation, *n*—the movement of an electric arc from its point of inception to another location. (1996) **D 3032**

arc tracking, *n*—the process producing tracks when arcs occur on or close to the insulation surface.

Arrhenius plot, *n*—a graph of the logarithm of thermal life as a function of the reciprocal of absolute temperature.

DISCUSSION—This is normally depicted as the best straight line fit, determined by least squares, of end points obtained at aging temperatures. It is important that the slope, which is the activation energy of the degradation reaction, be approximately constant within the selected temperature range to ensure a valid extrapolation.

[1] This terminology is under the jurisdiction of ASTM Committee D-9 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.94 on Editorial.

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[2] *Annual Book of ASTM Standards*, Vol 10.01.

[3] *Annual Book of ASTM Standards*, Vol 10.02.

[4] Available from American National Standards Association, 11 W. 42nd St., 13th Floor, New York, NY 10036.

ash content of paper, *n*—the solid residue remaining after combustion of the paper under specified conditions, expressed as a percentage of the dry mass of the original paper. (1996) **D 202**

average discharge (corona) current (*I_t*), *n*—the sum of the absolute magnitudes of the individual discharges during a certain time interval divided by that time interval.

DISCUSSION—When the discharges are measured in coulombs and the time interval in seconds, the calculated current will be in amperes.

$$I_t = \frac{\sum_{t_0}^{t_1} Q_1 + Q_2 + - - - - - - - Q_n}{t_1 - t_0} \quad (1)$$

where:

I_t = average current, A,
t_0 = starting time, s,
t_1 = completion time, s, and
Q_1, Q_2, Q_n = partial discharge quantity in a corona pulse 1 through *n*, C.

binder tape—see **core wrap (binder tape).**

bond strength, *n*—a measure of the force required to separate surfaces which have been bonded together. (1996) **D 2519, D 3145, D 4882**

braid, *n*—(*1*) woven metallic wire used as a shield for insulated conductors and cables.

(*2*) A woven fibrous protective outer covering over an insulated conductor or cable.

breakdown voltage—see **dielectric breakdown voltage.**

bursting strength of paper, *n*—the hydrostatic pressure required to produce rupture of a circular area of the material under specified test conditions. (1996) **D 202**

cable wrap, *n*—paper used for mechanical protection or for space-filling (rather than as electrical insulation) in low-voltage cables with nonmetallic sheaths.

capacitance, *C*, *n*—that property of a system of conductors and dielectrics which permits the storage of electrically separated charges when potential differences exist between the conductors.

DISCUSSION—Capacitance is the ratio of a quantity, *q*, of electricity to a potential difference, *V*. A capacitance value is always positive. The units are farads when the charge is expressed in coulombs and the potential in volts:

$$C = q/V \quad (2)$$

capacitor tissue, *n*—very thin (5 to 50 µm) pure, nonporous paper used as the dielectric in capacitors, usually in conjunction with an insulating liquid.

coating powder, *n*—a heat-fusible, finely-divided solid resinous material used to form electrical insulating coatings. (1996) **D 2967, D 3214**

concentricity, *n*—the ratio, expressed in percent, of the minimum wall thickness to the maximum wall thickness.

concentric-lay conductor, *n*—a conductor composed of a central core surrounded by one or more layers of helically laid strands.

DISCUSSION—In the most common type of concentric-lay conductor, all strands are of the same size and the central core is a single strand.

conductance, insulation, *n*—the ratio of the total volume and surface current between two electrodes (on or in a specimen) to the dc voltage applied to the two electrodes.

DISCUSSION—Insulation conductance is the reciprocal of insulation resistance.

conductance, surface, *n*—the ratio of the current between two electrodes (on the surface of a specimen) to the dc voltage applied to the electrodes.

DISCUSSION—(Some volume conductance is unavoidably included in the actual measurement.) Surface conductance is the reciprocal of surface resistance.

conductance, volume, *n*—the ratio of the current in the volume of a specimen between two electrodes (on or in the specimen) to the dc voltage applied to the two electrodes.

DISCUSSION—Volume conductance is the reciprocal of volume resistance.

conducting material (conductor), *n*—a material within which an electric current is produced by application of a voltage between points on, or within, the material.

DISCUSSION—The term "conducting material" is usually applied only to those materials in which a relatively small potential difference results in a relatively large current since all materials appear to permit some conduction current. Metals and strong electrolytes are examples of conducting materials.

conductivity, surface, *n*—the surface conductance multiplied by that ratio of specimen surface dimensions (distance between electrodes divided by the width of electrodes defining the current path) which transforms the measured conductance to that obtained if the electrodes had formed the opposite sides of a square.

DISCUSSION—Surface conductivity is expressed in siemens. It is popularly expressed as siemens/square (the size of the square is immaterial). Surface conductivity is the reciprocal of surface resistivity.

conductivity, volume, *n*—the volume conductance multiplied by that ratio of specimen volume dimensions (distance between electrodes divided by the cross-sectional area of the electrodes) which transforms the measured conductance to that conductance obtained if the electrodes had formed the opposite sides of a unit cube.

DISCUSSION—Volume conductivity is usually expressed in siemens/centimetre or in siemens/metre and is the reciprocal of volume resistivity.

conductor, *n*—a wire, or combination of wires not insulated from each other, suitable for carrying electric current. (1996) **D 1676**

continuous partial discharges (continuous corona), *n*—discharges that recur at rather regular intervals; for example on approximately every cycle of an alternating voltage or at least once per minute for an applied direct voltage.

core wrap (binder tape), *n*—paper used to wrap groups of insulated wire into cable configuration prior to sheathing.

DISCUSSION—Usually, this term is applied to telephone communication cables in which core wrap is not regularly subjected to voltage stress, but may be exposed to surges from lightning strokes or other accidental events.

corona, *n*—visible partial discharges in gases adjacent to a conductor.

DISCUSSION—This term has also been used to refer to partial discharges in general.

critical property, *n*—a quantitatively measurable characteristic which is absolutely necessary to be met if a material or product is to provide satisfactory performance for the intended use.

DISCUSSION—In some situations, specification requirements coincide with customer usage requirements. In other situations, they may not coincide, being either more or less stringent. More stringent sampling (for example, smaller AQL values) is usually used for measurement of characteristics which are considered critical. The selection of sampling plans is independent of whether the term defect or nonconformity is appropriate.

cross grains or reeves, *n—in mica*, tangled laminations causing imperfect cleavage.

crude mica—mica as mined; crude crystals with dirt and rock adhering.

crystallographic discoloration, *n—in mica*, discoloration appearing as bands of lighter or darker shades of basic color of a block of mica. (1996)

DISCUSSION—Such bands are generally parallel to the crystallographic faces of the crystal from which the block was separated.

defect, *n*—a departure of a quality characteristic from its intended level, or state, that occurs with a severity sufficient to cause an associated product or service not to satisfy intended normal, or reasonably foreseeable, usage requirements.

DISCUSSION—The terms "defect" and "nonconformity" and their derivatives are used somewhat interchangeably in the historical and current literature. Nonconformity objectively describes the comparison of test results to specification requirements, while the term defect has a connotation of predicting the failure of a product or service to perform its intended function in use. Since this latter connotation is often unintended, the term nonconformity is preferred in full consensus standards. The selection of any sample plan is independent of whether the term defect or nonconformity is appropriate.

The term defect may be appropriate for specifications mutually agreed upon by a producer and a user where specific use conditions are clearly understood. Even in these cases however, use the term defect with caution and consider substituting the term nonconformity.

For additional comments, see ANSI/ASQC A2-1987 that also states: "When a quality characteristic of a product or service is "evaluated" in terms of conformance to specification requirements, the use of the term nonconformity is appropriate."

dielectric, *n*—a medium in which it is possible to maintain an electric field with little supply of energy from outside sources.

DISCUSSION—The energy required to produce the electric field is recoverable, in whole or in part. A vacuum, as well as any insulating material, is a dielectric.

dielectric breakdown voltage (electric breakdown voltage), *n*—the potential difference at which dielectric failure occurs under prescribed conditions, in an electrical insulating material located between two electrodes. (See also Test Method D 149, Appendix X1.)

DISCUSSION—The term **dielectric breakdown voltage** is sometimes shortened to "breakdown voltage."

dielectric constant—see **relative permittivity.**

dielectric failure (under test), *n*—an event that is evidenced by an increase in conductance in the dielectric under test limiting the electric field that can be sustained.

dielectric strength, *n*—the voltage gradient at which dielectric failure of the insulating material occurs under specific conditions of test.

dip encapsulation (a type of conformal coating), *n*—an embedding process in which the insulating material is applied by immersion and without the use of an outer container.

DISCUSSION—The coating so formed generally conforms with the contour of the embedded part.

dissipation factor (loss tangent) (tan δ), *D*, *n*—the ratio of the loss index to its relative permittivity or

$$D = \kappa''/\kappa' \tag{3}$$

It is also the tangent of its loss angle, δ, or the cotangent of its phase angle, θ. (See Fig. 1 and Fig. 2.)

DISCUSSION—a:

$$D = \tan\delta = \cot\theta = X_p/R_p = G/\omega C_p = 1/\omega C_p R_p \tag{4}$$

where:

G = equivalent ac conductance,
X_p = parallel reactance,
R_p = equivalent ac parallel resistance,
C_p = parallel capacitance, and
ω = $2\pi f$ (sinusoidal wave shape assumed).

The reciprocal of the dissipation factor is the quality factor, *Q*, sometimes called the storage factor. The dissipation factor, *D*, of the capacitor is the same for both the series and parallel representations as follows:

$$D = \omega R_s C_s = 1/\omega R_p C_p \tag{5}$$

The relationships between series and parallel components are as follows:

$$C_p = C_s/(1 + D^2) \tag{6}$$

$$R_p/R_s = (1 + D^2)/D^2 = 1 + (1/D^2) = l + Q^2$$

DISCUSSION—b: *Series Representation*—While the parallel representation of an insulating material having a dielectric loss (Fig. 3) is usually the proper representation, it is always possible and occasionally desirable to represent a capacitor at a single frequency by a capacitance, C_s, in series with a resistance, R_s (Fig. 4 and Fig. 2).

drainage, *n—of an insulating varnish*, a measure of the variation in thickness from top to bottom of a varnish film obtained on the surface of a vertically dipped coated panel after a specified time and temperature. (1996) **D 115**

dressed crude mica, *n*—crude mica from which the dirt and rock have been mainly removed. (1996)

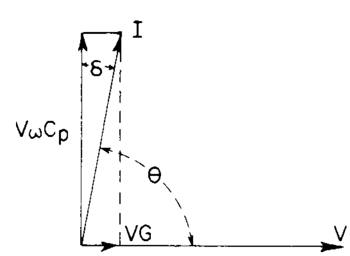

FIG. 1 Vector Diagram for Parallel Circuit

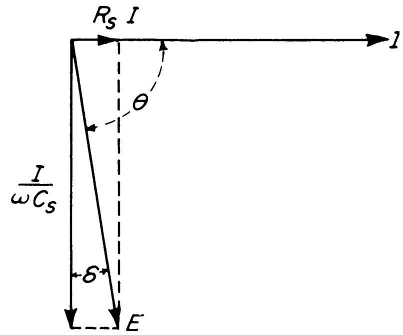

FIG. 2 Vector Diagram for Series Circuit

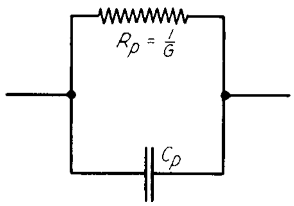

FIG. 3 Parallel Circuit

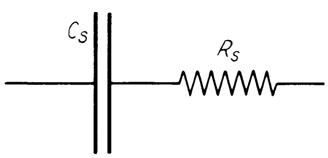

FIG. 4 Series Circuit

DISCUSSION—Some small pieces of inferior mica are produced and separated at this stage. This by-product is called splitting block, and can be used for the production of splittings.

electric breakdown voltage—see **dielectric breakdown voltage.**

electric field strength, *n*—the magnitude of the vector force on a point charge of unit magnitude and positive polarity.

electric strength—see **dielectric strength.**

electrification time, *n*—the time during which a steady direct potential is applied to electrical insulating materials before the current is measured.

electrolytic capacitor paper, *n*—very pure, porous paper, 17 to 100 µm thick, used to separate the metallic electrodes in electrolytic capacitors.

embedding, *n*—a general term for all methods of surrounding or enclosing components and assemblies with a substantial thickness of electrically insulating solid or foam material with voids and interstices between the parts substantially filled. See **potting, encapsulation,** and **dip encapsulation.**

encapsulation, *n*—an embedding process utilizing removable molds or other techniques in which the insulating material forms the outer surfaces of the finished unit.

erosion, electrical, *n*—the progressive wearing away of electrical insulation by the action of electrical discharges.

erosion resistance, electrical, *n*—the quantitative expression of the amount of electrical erosion under specific conditions.

excess electrostatic charge, *n*—the algebraic sum of all positive and negative electric charges on the surface of, or in, a specific volume.

failure—see **dielectric failure.**

films, *n*—trimmed mica split to specific ranges of thickness under 0.15 mm processed from block and thins.

flashover, *n*—a disruptive electrical discharge at the surface of electrical insulation or in the surrounding medium, which may or may not cause permanent damage to the insulation.

flash point, *n*—the lowest temperature of a specimen, corrected to a pressure of 760 mm Hg (101.3 kPa), at which application of an ignition source causes any vapor from the specimen to ignite under specified conditions of test. (1996) **D 115**

flat cable, *n*—any cable with two smooth or corrugated, but essentially flat, surfaces.

flat conductor, *n*—a conductor with a width-to-thickness ratio arbitrarily chosen as 5 to 1 or greater.

flat conductor cable, *n*—a cable of flat conductors.

FR, *n*—a designation noting that an electrical insulating material has been subjected to a standard test for flammability and has a rating in accordance with that standard.

DISCUSSION—The designation **FR**, when used in describing materials, does not imply flame or fire resistance.

full-impulse-voltage wave, *n*—an aperiodic transient voltage that rises rapidly to a maximum value, then falls less rapidly to zero.

gel time, *n—of solventless varnish*, the time required, at a specified temperature, for a solventless varnish to be transformed from a liquid state to a gel, as measured with a suitable gel time apparatus. (1996) **D 3056**

group AQL, *n*—the AQL assigned to a group of material properties.

DISCUSSION—See 5.2.2 of Practice D 3636 for additional information about the meaning of AQL.

guard electrode, *n*—one or more electrically conducting elements, arranged and connected in an electric instrument or measuring circuit so as to divert unwanted conduction or displacement currents from, or confine wanted currents to, the measurement device.

hard mica, *n*—mica which when slightly bent shows no tendency to delaminate.

DISCUSSION—Thick pieces will give a hard sound when tapped or dropped on a hard surface.

harness, *n*—one or more hookup bundles tied, clamped, or otherwise fitted together for final installation; used for interconnecting electrical circuits.

herringbones, *n—in mica*, numerous rulings that intersect to form a series of “V’s” with included angles of about 120°.

hookup bundle, *n*—a group of insulated conductors or hookup cables grouped into an assembly prior to installation, usually with multiple breakouts.

hookup cable, *n*—two or more insulating conductors in a common covering, or two or more insulated conductors twisted or molded together without a common covering, or one or more insulated conductors with a conductive shield with or without an outer covering.

hookup wire, *n*—an insulated conductor that is used to make point-to-point connections in an electrical or electronic system.

impregnation time of paper, *n*—the time in seconds required for a liquid of specified composition and viscosity to penetrate completely from one face of a sheet of paper to the other under certain prescribed conditions. (1996) **D 202**

inclusions, *n*—foreign matter in the mica.

air inclusions appear by transmitted light as grayish areas and as silvery areas by reflected light. These are gaseous inclusions.

clay inclusions appear by any light as areas of blue, gray, brown, etc., and are intrusions of earthy materials.

mineral inclusions appear by transmitted light as areas of deep distinct and highly saturated colors such as black, brown, green, red, and so forth. These are concentrated metallic oxides.

vegetable and smokey inclusions appear by transmitted light as areas of pastel colors of low to medium saturation such as pale yellow, pale brown, pale green, and so forth. These are dispersed metallic oxides. The term“ vegetable” is a misnomer.

infrared, *adj*—pertaining to the region of the electromagnetic spectrum from approximately 0.78 to 300 µm. (1996) **D 3288**

insulated conductor, *n*—a conductor covered by a layer or layers of insulating material and whose prime function is to carry current in an electric circuit.

insulating material (insulator), *n*—a material in which a voltage applied between two points on or within the material produces a small and sometimes negligible current.

insulation resistance—see **resistance, insulation.**

interlayer paper—see **layer insulation.**

ionization, *n*—the process by which electrons are lost from or transferred to neutral molecules or atoms to form positively or negatively charged particles.

jacket, *n*—an integral covering (sometimes fabric, reinforced), which is applied over the insulation, core, shield, or armor of a cable and whose prime function is to provide mechanical or environmental protection for the component(s) that it covers.

layer insulation, *n*—paper, 5 to 1200 µm thick, used to insulate between layers of conductors in transformers or other inductive apparatus.

loss angle (phase defect angle), δ, *n*—the angle whose tangent is the dissipation factor or arctan κ''/κ'. It is also the difference between 90° and the phase angle.

DISCUSSION—The relation of phase angle and loss angle is shown in Fig. 1 and Fig. 2. Loss angle is sometimes called the phase defect angle.

loss factor—obsolete term; see **loss index.**

loss index, κ″ (ϵ_r''), *n*—the magnitude of the imaginary part of the relative complex permittivity. It is the product of the relative permittivity and dissipation factor.

DISCUSSION—a—It may be expressed as

$$\kappa'' = \kappa' D$$
$$= \text{power loss}/(E^2 \times f \times \text{volume} \times \text{constant})$$

When the units are watts, volts per centimetre, hertz, and cubic centimetres, the constant has the value 5.556×10^{-13}.

DISCUSSION—b—Loss index is the term agreed upon internationally. In the United States κ″ was formerly called the loss factor.

lot, *n*—an entity of electrical insulating material or product which, insofar as is practicable, consists of a single type, grade, class, size, or composition that was manufactured under essentially the same conditions and is available to the user for sampling at one time.

lot number, *n*—the number used by a producer to identify an entity of electrical insulating material or product.

magnet wire—a metal electrical conductor, covered with electrical insulation, for use in the assembly of electrical inductive apparatus such as coils for motors, transformers, generators, relays, magnets, and so forth.

DISCUSSION—The electrical insulation is usually composed of a film covering formed from a magnet wire enamel applied over a bare conductor. In some specific applications, fibrous coverings, either taped or linear filament served, are also used as electrical insulation.

mica splittings, *n*—trimmed or untrimmed mica split to thickness under 0.003 mm produced from block, thins, and splitting block. (1996)

DISCUSSION—*Bookform splittings* are arranged and supplied in the form of individual books or bunches, each comprised of consecutive splittings obtained from the same piece of block or thins. They are generally dusted with mica powder to offset residual cohesive effects.

Loose splittings are of heterogeneous shapes not arranged in any particular order, but packed loosely in bulk form.

Loose with powder splittings are loose splittings which are dusted with mica powder.

moderately conductive, *adj*—describes a solid material having a volume resistivity between 1 and 10 000 000 Ω–cm.

neper, *n*—a division of the logarithmic scale wherein the number of nepers is equal to the natural logarithm of the scalar ratio of either two voltages or two currents.

DISCUSSION—The neper is a dimensionless unit. One neper equals 0.8686 bel. With I_x and I_y denoting the scalar values of two currents and *n* being the number of nepers denoted by their scalar ratio, then:

$$n = \ln\ (I_x/I_y) \tag{7}$$

where:
ln = logarithm to the base e.

nonconforming unit, *n*—a unit of product containing at least one nonconformity.

nonconformities per hundred units, *n*—a calculated ratio of nonconforming units to the number of units inspected, the quotient being multiplied by 100 (see **percent nonconforming**).

nonconformity, *n*—a departure of a quality characteristic from its intended level or state that occurs with a severity sufficient to cause a test result not to meet a specification requirement. (1996)

nonvolatile matter, *n*—*in insulating varnish*, that portion of a varnish which is not volatilized when exposed to specified conditions. (1996)

DISCUSSION—The value obtained is not necessarily equal to the calculated solids incorporated during compounding. **D 115**

oil resistance, *n*—*of insulating varnish*, a measure of the retention of properties after exposure to a specified oil under specified conditions of test. (1996) **D 115**

partial discharge apparent power loss (P_a), *n*—the summation over a period of time of all corona pulse amplitudes multiplied by the rms test voltage.

$$P_a = I_t V_s \quad (8)$$

where:
P_a = apparent power loss in time interval ($t_1 - t_0$), W,
I_t = average corona current, A, and
V_s = applied rms test voltage, V.

partial discharge (corona), *n*—an electrical discharge that only partially bridges the insulation between conductors.

DISCUSSION—A transient gaseous ionization occurs in an insulation system if the voltage stress exceeds a critical value, and this ionization produces partial discharges.

partial discharge (corona) energy (W), *n*—the energy drawn from the test voltage source as the result of an individual discharge.

DISCUSSION—Energy is the product of the magnitude Q of that discharge and the instantaneous value V of the voltage across the test specimen at the inception of the discharge. Thus the discharge energy of the *i*th pulse is:

$$W_i = Q_i V_i \quad (9)$$

where:
W_i = discharge energy, W·s(J),
Q_i = partial discharge magnitude, and
V_i = instantaneous value of the applied test voltage at the time of the discharge, V.

partial discharge (corona) extinction voltage (CEV), *n*—the highest voltage at which partial discharges above some stated magnitude no longer occur as the applied voltage is gradually decreased from above the inception voltage.

DISCUSSION—Where the applied voltage is alternating, the CEV is expressed as $1/\sqrt{2}$ of the peak voltage. Many test and specimen parameters can affect this value, and in some cases reproducibility may be difficult to achieve. (See also the Discussion for partial discharge (corona) inception voltage (CIV), which follows.)

partial discharge (corona) inception voltage (CIV), *n*—the lowest voltage at which continuous partial discharges above some stated magnitude (which may define the limit of permissible background noise) occur as the applied voltage is gradually increased.

DISCUSSION—Where the applied voltage is alternating, the CIV is expressed as $1/\sqrt{2}$ of the peak voltage. Many test and specimen parameters can affect this value, and in some cases reproducibility may be difficult to achieve. Many factors may influence the value of the CIV and CEV including the rate at which the voltage is increased or decreased as well as the previous history of the voltage applied to the specimen. In many cases it may be difficult to obtain the same value with subsequent tests. Moreover, the "continuous" character of the partial discharges is sometimes quite difficult to define, and an arbitrary judgement in this respect may lead to different values of the CIV or CEV.

partial discharge (corona) level, *n*—the magnitude of the greatest recurrent discharge during an observation of continuous discharges.

partial discharge (corona) power loss (P), *n*—the summation of the energies drawn from the test voltage source by individual discharges occurring over a period of time, divided by that time period.

$$P = \frac{1}{T}\sum_{i=1}^{i=m} Q_i V_i \quad (10)$$

where:
P = discharge power, W,
T = time period, s,
m = number of the final pulse during T, and
$Q_i V_i$ = discharge energy of the *i*th pulse.

DISCUSSION—When pulse height analysis is used, the summation over a period of time of pulses above a preset level of corona usually determined by background noise multiplied by the instantaneous test voltage at the time of the pulses in the specimen is approximately equal to:

$$P = \sum_{j=1}^{i} n_j Q_{tj} V_j \quad (11)$$

where:
P = pulse discharge power loss, W,
n_j = recurrence rate of the *j*th discharge pulse in pulses/second,
Q_{tj} = corresponding value of the partial discharge quantity in coulombs for the particular pulse,
V_j = instantaneous value of the applied voltage in volts at which the *j*th discharge pulse takes place.

If the assumption is made that $V_j \Delta C_j \simeq C_t \Delta V_j$ (where ΔC_j is incremental capacitance rise in C_t due to the drop ΔV_j in V_j as a result of the *j*th discharge), then the preceding summation must be multiplied by ½. However, this assumption is not usually borne out in practice.

partial discharge (corona) pulse rate (n), *n*—the average number of discharge pulses that occur per second or in some other specified time interval.

DISCUSSION—The pulse count may be restricted to pulses above a preset threshold magnitude, or to those between stated lower and upper magnitude limits.

partial discharge pulse, *n*—a voltage or current pulse that occurs at some designated location in a circuit as a result of a partial discharge.

partial discharge pulse voltage (V_t), *n*—the terminal pulse voltage resulting from a partial discharge represented as a voltage source suddenly applied in series with the capacitance of the insulation system under test, and that would be detected at the terminals of the system under open-circuit conditions.

partial discharge quantity (terminal corona charge) (Q_t), *n*—the magnitude of an individual discharge in an insulation system expressed in terms of the charge transfer measured at the system terminals.

DISCUSSION—The measured charge is in general not equal to the charge transferred at the discharge site, and does have a relation to the discharge energy. For a small specimen that can be treated as a simple lumped capacitor, it is equal to the product of the capacitance of the insulation system and the partial discharge pulse voltage, that is:

$$Q_t = C_t V_t \quad (12)$$

where:
Q_t = partial discharge quantity, C,

C_t = capacitance of the specimen insulation system, F, and
V_t = peak value of the partial discharge pulse voltage appearing across C_t, V.

peak value (of an impulse voltage wave), *n*—the maximum value of voltage.

percent nonconforming, *n*—a calculated ratio of nonconforming units to the number of units inspected, the quotient being multiplied by 100. (1996)

permittivity—see **relative permittivity**

phase angle, θ, *n*—the angle whose cotangent is the dissipation factor, arccot κ″/κ′ and is also the angular difference in the phase between the sinusoidal alternating voltage applied to a dielectric and the component of the resulting current having the same frequency as the voltage.

DISCUSSION—The relation of phase angle and loss angle is shown in Fig. 1 and Fig. 2. Loss angle is sometimes called the phase defect angle.

potting, *n*—an embedding process for parts that are assembled in a container (or "can") into which the insulating material is poured, and the container remains an integral part of the finished unit as the outer surface.

powder coating, *n*—a coating produced by the use of a heat-fusible coating powder. (1996) **D 3214**

power cable insulating paper, *n*—paper used, in conjunction with an insulating liquid, as the primary electrical insulation on conductors for transmission of electric energy.

power factor, *PF*, *n*—the ratio of the power in watts, *W*, dissipated in a material to the product of the effective sinusoidal voltage, *V*, and current, *I*, in volt-amperes.

DISCUSSION—Power factor may be expressed as the cosine of the phase angle θ (or the sine of the loss angle δ).

$$PF = W/VI = G/\sqrt{G^2 + (\omega C_p)^2} = \sin\delta = \cos\theta \quad (13)$$

When the dissipation factor is less than 0.1, the power factor differs from the dissipation factor by less than 0.5 %. Their exact relationship may be found from the following relationships:

$$PF = D/\sqrt{1 + D^2} \quad (14)$$

$$D = PF/\sqrt{1 - (PF)^2}$$

primary insulation, *n*—the first layer of two or more layers of insulating materials over a conductor.

DISCUSSION—The prime function of primary insulation is to act as an electrical barrier.

primary jacket, *n*—a layer of insulating material applied over the primary insulation for the purpose of providing mechanical protection for the primary insulation.

pseudoglow discharge, *n*—a type of partial discharge characterized by pulses of relatively small amplitude, and generally, a long rise time.

DISCUSSION—As a result of the upper frequency limitation in the Fourier frequency spectrum, pseudoglow discharges are not readily detected by conventional partial-discharge-pulse detectors. Pseudoglow discharges are also characterized by a diffused glow that cannot be distinguished from that due to true-glow discharge.

pulse discharge, *n*—a type of partial-discharge phenomenon characterized by a spark-type breakdown.

DISCUSSION—The resultant detected pulse discharge has a short rise time and its Fourier frequency spectrum may extend beyond 100 MHz. Such a pulse discharge may be readily detected by conventional pulse detectors that are generally designed for partial-discharge measurements within the frequency band from 30 kHz to several MHz.

pulseless-glow discharge, *n*—a type of partial-discharge phenomenon characterized by a diffused glow.

DISCUSSION—The overall voltage waveform across a gap-spacing undergoing a pulseless-glow discharge does not indicate the presence of any abrupt voltage falls except for the two at the beginning of each half cycle (for example, thyratron behavior). Although discharge energy is expended over the pulseless region, a conventional partial-discharge-pulse detector will give no indication of this as it will only respond to the two initiating breakdowns.

quadratic rate, *n*—the sum of the squares of the individual discharge magnitudes during a certain time interval divided by that time interval and expressed as $(\text{coulombs})^2$ per second.

quality factor, *Q*, *n*—the reciprocal of the dissipation factor.

DISCUSSION—(Formerly, this term has, at times, been called storage factor.)

reactive monomer, *n*—*in solventless electrical varnish*, a substance that, when added to a resin, will combine chemically with that resin under specified conditions. (1996) **D 3312**

rejection number, *n*—the minimum number of nonconformities for a given AQL and sample size (lot sample size) which will subject a lot to rejection.

relative complex permittivity (relative complex dielectric constant) (relative complex capacitivity), κ^*, ϵ_r^*, *n*—the ratio of the admittance of a given configuration of the material to the admittance of the same configuration with vacuum as dielectric:

$$\kappa^* = Y/Y_v = Y/j\omega C_v = \kappa' - j\kappa'' \quad (15)$$

where *Y* is the admittance with the material and $j\omega C_v$ is the admittance with vacuum.

DISCUSSION—In common usage the word "relative" is frequently dropped.

relative permittivity (relative dielectric constant) (SIC) $\kappa'(\epsilon_r)$, *n*—the real part of the relative complex permittivity. It is also the ratio of the equivalent parallel capacitance, C_p, of a given configuration of electrodes with a material as a dielectric to the capacitance, C_v, of the same configuration of electrodes with vacuum (or air for most practical purposes) as the dielectric:

$$\kappa' = C_p/C_v \quad (16)$$

DISCUSSION—a—In common usage the word "relative" is frequently dropped.

DISCUSSION—b—Experimentally, vacuum must be replaced by the material at all points where it makes a significant change in capacitance. The equivalent circuit of the dielectric is assumed to consist of C_p, a capacitance in parallel with conductance (See Fig. 3).

DISCUSSION—c—C_x is taken to be C_p, the equivalent parallel capacitance as shown in Fig. 3.

DISCUSSION—d—The series capacitance is larger than the parallel capacitance by less than 1 % for a dissipation factor of 0.1, and by less than 0.1 % for a dissipation factor of 0.03. If a measuring circuit yields results in terms of series components, the parallel capacitance must be calculated from Eq 5 of Test Methods D 150 before the corrections and permittivity are calculated.

DISCUSSION—e—The permittivity of dry air at 23°C and standard pressure at 101.3 kPa is 1.000536. Its divergence from unity, $\kappa' - 1$, is inversely proportional to absolute temperature and directly proportional to atmospheric pressure. The increase in permittivity when the space is saturated with water vapor at 23°C is 0.00025, and varies approximately linearly with temperature expressed in degrees Celsius, from 10 to 27°C. For partial saturation the increase is proportional to the relative humidity.

resistance, insulation, *n*—the ratio of the dc voltage applied to two electrodes (on or in a specimen) to the total volume and surface current between them.

DISCUSSION—Insulation resistance is the reciprocal of insulation conductance.

resistance, surface, *n*—the ratio of the dc voltage applied to two electrodes (on the surface of a specimen) to the current between them.

DISCUSSION—(Some volume resistance is unavoidably included in the actual measurement.) Surface resistance is the reciprocal of surface conductance.

resistance, volume, *n*—the ratio of the dc voltage applied to two electrodes (on or in a specimen) to the current in the volume of the specimen between the electrodes.

DISCUSSION—Volume resistance is the reciprocal of volume conductance.

resistivity, surface, *n*—the surface resistance multiplied by that ratio of specimen surface dimensions (width of electrodes defining the current path divided by the distance between electrodes) which transforms the measured resistance to that obtained if the electrodes had formed the opposite sides of a square.

DISCUSSION—Surface resistivity is expressed in ohms. It is popularly expressed also as ohms/square (the size of the square is immaterial). Surface resistivity is the reciprocal of surface conductivity.

resistivity, volume, *n*—the volume resistance multiplied by that ratio of specimen volume dimensions (cross-sectional area of the electrodes divided by the distance between electrodes) which transforms the measured resistance to that resistance obtained if the electrodes had formed the opposite sides of a unit cube.

DISCUSSION—Volume resistivity is usually expressed in ohm-centimetres (preferred) or in ohm-metres and is the reciprocal of volume conductivity.

rope-lay conductor, *n*—a conductor composed of a central core surrounded by one or more layers of helically laid groups of strands.

DISCUSSION—This kind of conductor differs from a concentric-lay conductor in that the main wires are themselves stranded. In the most common type of rope-lay conductor, all strands are the same size and the central core is a concentric-lay conductor.

rough or burred edge, *n—in mica,* a frayed or serrated edge usually 0.8 mm deep or greater, or an edge turned up or down as caused by trimming with scissors, and so forth, or by rubbing the edge against sandpaper, stone, and so forth.

round conductor flat cable, *n*—a flat cable made with parallel, round conductors in the same plane.

sample, *n*—one or more units of product taken from a lot without regard to the quality of the unit. (Also often termed lot sample).

sample size, *n*—the number of units of product taken to make up the sample.

DISCUSSION—Practice D 3636 uses only lot sample sizes and not lot sizes since the discriminatory power of any sampling plan is independent essentially of the size of the lot. The sample size selected by the user for a given acceptable quality level (AQL) is optional depending upon the degree of protection desired by the user against the acceptance of nonconforming lots.

scintillation, *n*—the multiple discharges or small arcs that originate in the more conductive areas of the insulation surface, and span less conductive areas.

DISCUSSION—The surface conductance may be produced by either dry or wet contamination. In wet contaminated areas in particular, the leakage current may selectively heat and dry small surface areas to produce the conditions conducive to discharge.

separator paper, *n*—thin paper applied to a stranded conductor to prevent migration of extruded insulation into the strands and, subsequently, to facilitate stripping of the insulating material from the conductor.

serving, *n—on magnet wire or conductor*, a uniform wrapping of insulation around a conductor. (1996) **D 3353**

shield, *n*—a conducting layer placed around an insulated conductor or cable to limit the penetration of electric or electromagnetic fields.

DISCUSSION—A shield can be braided or served wires, foil wrap, foil-backed tape, a metallic tube or conductive polymeric compositions.

shield, electric or magnetic, *n*—a conductive protective component that encloses, in whole or in part, one or more elements of electric equipment or test specimen in order to reduce or eliminate the electric or magnetic flux, or both, within or beyond that element or elements.

soft mica, *n*—mica which when slightly bent shows a tendency to delaminate.

DISCUSSION—Thick pieces will give a dull sound when tapped or dropped on a hard surface.

solid conductor, *n*—a conductor consisting of one strand.

solvent-soluble material in paper, *n*—the mass of material that can be extracted from a dry specimen by a specified solvent under prescribed conditions, expressed as a percentage of the original dry mass. (1996) **D 202**

stains—see **inclusions.**

storage factor—see **quality factor,** *Q*.

surface resistance—see **resistance, surface.**

DISCUSSION—For a fixed electrode separation, the measured surface resistance of a given hookup wire decreases as the diameter increases.

tangle sheet, *n*—a piece of mica that splits well in places but tears in others, producing a large percentage of partial films.

DISCUSSION—Sometimes the term is applied to intergrowth of mica crystals.

temperature index, *n*—a number which permits comparison of the temperature/time characteristics of an electrical insulating material, or a simple combination of materials, based on the temperature in degrees Celsius which is obtained by extrapolating the Arrhenius plot of life versus temperature to a specified time, usually 20 000 h.

test measurement, *n*—a quantitative expression of one value determined for a property of interest by a single application of a specified test procedure.

test result, *n*—the value that expresses the level of a property of the test unit.

DISCUSSION—A test result may sometimes be a single test measurement but usually a test result is computed from several test measurements.

test specimen, *n*—a portion of a test unit upon which one or more test measurements are made.

test unit, *n*—a fraction of a unit of product from which one or more test specimens are taken for each property.

DISCUSSION—If the unit of product is of insufficient size to meet the requirements of a testing method: (*1*) sample adjacent units of product and aggregate units of product for the test unit or, (*2*) obtain a test unit of sufficient size, and representative of the unit of product, from the producer.

thermal endurance, *n*—an expression for the stability of an electrical insulating material, or a simple combination of materials, when maintained at elevated temperatures for extended periods of time.

thermal life, *n*—the time necessary for a specific property of a material, or a simple combination of materials, to degrade to a defined end point when aged at a specified temperature.

thermal life curve, *n*—a graphical representation of thermal life at a specified aging temperature in which the value of a property of a material, or a simple combination of materials, is measured at room temperature and the values plotted as a function of time.

thick edge, *n*—a mica splitting with an edge or end thicker than 1½ times the maximum thickness measured at any other point on the splitting or if the thickness of the edge or end exceeds the maximum average thickness allowed for the grade of splittings.

thickness, *n—of an electrical insulating material*, the perpendicular distance between the two surfaces of interest, determined in accordance with a standard method.

thick splitting—a mica splitting whose thickness in the major portion of its area (or over the entire area) exceeds the following:

(*1*) A bookform splitting that exceeds the maximum average thickness allowed for the grade.

(*2*) A loose splitting that exceeds 0.03 mm in thickness.

(*3*) A loose with powder splitting that exceeds 0.025 mm in thickness.

thin splitting, *n*—a mica splitting whose thickness in the major section of its area, or over the entire area, is less than the minimum average for the grade.

time constant, *n*—the time required for the magnitude of change in a signal to reach a value of 63.2 % of its final value in response to a step function input.

DISCUSSION—A time constant can be pertinent to electrical, thermal, mechanical, or chemical systems:

$$\left(\frac{e-1}{e}\right) = 0.632 = 63.2\ \% \tag{17}$$

time of drying, *n—of insulating varnish*, the time required for a film of varnish to dry to a tackfree state under specified conditions. (1996) **D 115**

track, *n*—a partially conducting path of localized deterioration on the surface of an insulating material.

tracking, *n*—the process that produces tracks as a result of the action of electric discharges on or close to the insulation surface.

tracking, contamination, *n*—tracking caused by scintillations that result from the increased surface conduction due to contamination.

tracking resistance, *n*—the quantitative expression of the voltage and the time required to develop a track under specified conditions.

trimmed block, *n*—dressed crude mica that has been split into thickness of 0.18 mm and over, and has side trimming done to remove irregularities, imperfections, and residues of dirt and rock.

DISCUSSION—Two by-products are obtainable: splitting block and thins that are trimmed mica under 0.18 mm. Thins can be sold as such, or used for the production of films or splittings.

Half-trimmed mica is trimmed on two sides with at least two thirds of the pieces trimmed on two adjacent sides, the balance of the pieces trimmed on the two parallel long sides, and with no cracks extending into the area by which the piece is graded. The foregoing does not apply to sizes 6 and 5½ in which at least one of any two trimmed sides must be free of cracks, and no cracks may extend into the area by which the piece is graded.

Full-trimmed mica is trimmed on all sides with all cracks and cross grains, or reeves removed.

turn insulating paper, *n*—paper used to insulate conductors that will become coils in a transformer or other inductive apparatus. The conductors are commonly rectangular in cross section.

unit of product, *n*—an entity of electrical insulating material or product for inspection to determine its classification as conforming or non-conforming.

DISCUSSION—A unit of product is established by the user and may or may not be the same as a unit of purchase, supply, production, or shipment. Some examples of a unit of product are:

Bag	Case	Reel
Barrel	Container	Roll
Bin	Cop	Sheet
Bobbin	Drum	Skid
Box	Length	Spool
Bundle	Pad	Tank
Car	Pail	Tank compartment
Carton	Pallet	Truckload

varnish, electrical insulating, *n*—a liquid resin system that is applied to and cured on electrical components providing electrical, mechanical, and environmental protection.

DISCUSSION—There are two types of electrical insulating varnish: solvent-containing and solventless. The solvent-containing varnish is a solution, dispersion, or emulsion of a polymer or mixture of polymers in a volatile, nonreactable liquid. The solventless type is a liquid resin system free of volatile, nonreactable solvents.

V-cuts, *n—in mica*, edge cuts in the form of a "V" with an included angle of 120° or less.

virtual-front time (of an impulse-voltage wave), *n*—a time equal to 1.67 times the interval t_f between the instants when the voltage is 0.3 and 0.9 times the peak value. (See t_1 of Fig. 1 shown in Test Method D 3426)

virtual origin (of an impulse voltage wave), *n*—the point of intersection (o_1) with the line of zero voltage of a line drawn through the points of 0.3 and 0.9 times the peak voltage on the front of an impulse voltage wave.

virtual-peak value (of an impulse-voltage wave), *n*—a value derived from a recording of an impulse wave on which high-frequency oscillations or overshoot of limited magnitude may be present.

DISCUSSION—If the oscillations have a magnitude of no more than 5 % of the peak value and a frequency of at least 0.5 MHz, a mean curve may be drawn, the maximum amplitude of which is the virtual-peak voltage. If the oscillations are of greater magnitude, the voltage wave is not acceptable for standard tests.

virtual time to half-value (of an impulse-voltage wave), *n*—the time interval (t_2) between the virtual origin (o_1) and the instant on the tail when the voltage has decreased to half the peak value.

water finish, *n*—compact glossy finish produced on one or both surfaces of a paper or paper-board by wetting with water as the sheet is being calendered.

wedge, *n—in mica*, a crystalline structure in a micablock, which upon splitting results in a yield of pieces thicker at one end than the other. (1996)

winding wire—see **magnet wire.**

DISCUSSION—Internationally, winding wire is the preferred term. In North America it has been common practice for many years to use the term "magnet wire."