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Standard Terminology Relating to Electrical Insulating Liquids and Gases [1]

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INTRODUCTION

The definitions contained in this terminology pertain to terms as they are used in conjunction with fluid insulating materials. Insofar as possible, the definitions are consistent with accepted general usage, and may also contain additional information deemed to be of value in testing of fluid insulating materials.

ac—symbol used to designate an electric voltage or current whose amplitude varies periodically as a function of time, its average value over one complete period being zero. One complete repetition of the wave pattern is referred to as a CYCLE, and the number of cycles occurring in one second is called the FREQUENCY, measured in hertz (Hz). For example, the electricity supplied by commercial utility companies in the United States is, in most localities, 60 Hz, although other frequencies may be encountered.

acid treating—a refining process in which an unfinished petroleum insulating oil is contacted with sulfuric acid to improve its color, odor, stability, and other properties.

ac loss characteristics—those properties of a dielectric or insulation system (such as dissipation factor, power factor, and loss index) that may be used as a measure of the power or energy losses that would result from the use of such material in an ac electric field.

additive—a chemical compound or compounds added to an insulating fluid for the purpose of imparting new properties or altering those properties which the fluid already has.

ambient temperature—the temperature of the surrounding atmosphere as determined by an instrument shielded from direct or reflected rays of the sun.

aniline point—the minimum temperature for complete miscibility of equal volumes of aniline and the sample under test. See ASTM Test Methods D 611, for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents.[2] Aniline point is a function of both molecular weight and composition. In comparing two samples of similar molecular weight, the aniline point can be used as a means of comparing aromatic content of the two samples. A product of high aniline point will be low in aromatics and naphthenes, and therefore high in paraffins.

API gravity—an arbitrary scale developed by the American Petroleum Institute and frequently used in reference to petroleum insulating oil. The relationship between API gravity and specific gravity 60/60°F is defined by the following:

$$\text{Deg API Gravity at } 60°\text{F} = 141.5/(\text{sp gr } 60/60°\text{F}) - 131.5$$

aromatics—that class of organic compounds which behave chemically like benzene. They are cyclic unsaturated organic compounds that can sustain an induced electronic ring current due to delocalization of electrons around the ring.

Discussion—Empirically, the aromatic portion of a mineral insulating oil can be estimated by correlation with physical properties (See D2140, Test Method for Carbon Type Composition of Insulating Oils of Petroleum Origin [2]), or by selective adsorption on clay-gel (See D2007, Test Method for Characteristic Groups in Rubber Extender and Processing Oils by the Clay-Gel Adsorption Chromatographic Method [2]).

askarel—a generic term for a group of synthetic, fire-resistant, chlorinated aromatic hydrocarbons used as electrical insulating liquids. They have a property under arcing conditions such that any gases produced will consist predominantly of noncombustible hydrogen chloride with lesser amounts of combustible gases.

atomic absorption—the absorption of radiant energy by ground state atoms. Substances when dispersed as an atomic vapor will absorb characteristic radiations identical to those which the same substances can emit. This property is the basis for analysis by atomic absorption spectroscopy.

*capacitivity***—**the same as **permittivity, relative.**

color—a quality of visible phenomena of insulating fluids, the numerical value for which is derived by comparing this quality using transmitted light with that of a series of numbered reference standards.

combustible gases—flammable gases formed from breakdown (partial or complete) of some insulating materials subjected to electrical or thermal stress, or both.

conductance—the ratio of the current carried through a material to the difference in potential applied across the

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[2] *Annual Book of ASTM Standards*, Vol 10.03.

material. It is the reciprocal of *resistance*. The unit is: (ohm) $^{-1}$ or siemens.

DISCUSSION—1—**Conductance** is a general term. Specific reference may be made to **conductance dc** and **conductance ac.**

DISCUSSION—2—For dielectrics the conductance may be dependent on the **electrification time.**

conductance, apparent dc—the dc conductance measured at the end of a specific electrification time. The "apparent dc conductance" is the reciprocal of the "apparent dc resistance." The unit is: (ohm) $^{-1}$ or siemens.

DISCUSSION—The term "apparent dc conductance" is used to distinguish the current-voltage relationship found in electrical insulating materials, where the current (leakage plus absorption) usually decreases with time, from the relationship found in metallic conductors where the steady-state current is reached in a fraction of a second.

conductance, dc—the ratio of the total current (in amperes) passing through a material to the dc voltage (in volts) applied between two electrodes that are in contact with, or immersed in a specimen. The "dc conductance" is the reciprocal of the "dc resistance." The unit is: (ohm) $^{-1}$ or siemens.

conductivity—the ratio of the current density carried through a specimen to the potential gradient paralleling the current. This is numerically equal to the conductance between opposite faces of a unit cube of liquid. It is the reciprocal of **resistivity.**

DISCUSSION—1—**Conductivity** is a general term. Specific reference may be made to **conductivity, dc.**

DISCUSSION—2—For dielectrics the conductivity may be dependent on the **electrification time.** (See also **conductivity, apparent dc volume** and **conductivity, dc volume.**)

conductivity, apparent dc volume—the "dc volume conductivity" measured at the end of a specified electrification time. It is the reciprocal of the apparent dc volume resistivity. The unit most commonly used is: (ohm-centimetre) $^{-1}$ or siemens per centimetre. The SI unit is (ohm-metre) $^{-1}$.

conductivity, dc—the ratio of the current density passing through a specimen at a given instant of time and under prescribed conditions, to the dc potential gradient paralleling the current. It is the reciprocal of the dc resistivity. In common practice the "dc conductivity" is numerically equal to the "dc conductance" between opposite faces of a centimetre cube of liquid. The unit is: (ohm-centimetre) $^{-1}$ or siemens per centimetre. The SI unit is: (ohm-metre) $^{-1}$.

DISCUSSION—The "dc conductivity" may contain components of both surface conductance and volume conductance, but, in general, surface effects are not common in measurements on fluid dielectrics. The property most commonly measured is either the "dc volume conductivity" or the "apparent dc volume conductivity."

conductivity, dc volume—the property of a material that permits the flow of electricity through its volume. It is numerically equal to the ratio of the steady-state current density to the steady direct voltage gradient parallel with the current in the material. The dc volume conductivity is the reciprocal of the dc volume resistivity. The unit commonly used is: (ohm-centimetre)$^{-1}$ or siemens per centimetre. The SI unit is (ohm-metre) $^{-1}$.

DISCUSSION—For electrical insulating materials the time required for the steady-state current to be reached may be very long; from several minutes to several months may be required.

corona—a luminous discharge due to ionization of the air surrounding an electrode, caused by the high electric field strength in the vicinity of the electrode, exceeding a certain critical (that is, threshold) value.

corona effect—light emitted in the UV range of the electromagnetic spectrum by electronically excited molecules that have reached a singlet state and have not consumed the absorbed energy by other physical process.

corona (partial discharge) inception voltage, *CIV*—the lowest voltage at which continuous partial discharge (or corona) exceeding a specified intensity is observed as the applied voltage is gradually increased. Where the applied voltage is alternating, the *CIV* is expressed as $1/\sqrt{2}$ of the peak voltage.

corona (partial discharge) extinction voltage, *CEV*—the highest voltage at which partial discharge (or corona) no longer exceeds a specified intensity as the applied voltage is gradually decreased from a value above the corona inception voltage. Where the applied voltage is alternating the CEV is expressed as $1/\sqrt{2}$ of the peak voltage.

corrosive sulfur—*n,* elemental sulfur and thermally unstable sulfur compounds in electrical insulating oil that can cause corrosion of certain transformer metals such as copper and silver.

dc—symbol used to designate an electric voltage or current whose amplitude does not vary periodically with respect to time, as for example the output of a chemical cell or that of a thermocouple. The term is also applied to the output of such devices as dynamos and rectifiers, whose amplitude is not strictly time-invariant.

dew-point temperature—the temperature (above 0°C) to which a gas or vapor must be cooled at constant pressure and constant water-vapor composition in order for saturation to occur.

DISCUSSION—At temperatures below 0°C, vapor may first be noticed in the form of frost. It is common to refer to the temperature at which this occurs as the frost-point temperature. Dew-point temperatures also exist for other gas or vapor systems in which saturation with respect to a substance other than water vapor can occur.

dielectric—a medium in which it is possible to maintain an electric field with little supply of energy from outside sources. 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—the potential difference at which electrical failure occurs in an electrical insulating material or insulation structure, under prescribed test conditions.

dielectric constant— See **dielectric constant, relative** (especially Note 2). (See also **permittivity** (especially Note 2).)

dielectric constant, absolute—the same as **permittivity.**

dielectric constant, relative—the same as **permittivity, relative.**

DISCUSSION—1—Current practice including international usage is to prefer the term *relative permittivity.*

DISCUSSION—2—Common usage has been to drop the term "relative" and simply use dielectric constant when the dimensionless ratio is the quantity being referred to.

dielectric failure—the failure of an element in a dielectric circuit that exists when the insulating element becomes conducting. This event may take the form of a gradual increase in current exceeding a specified value, but it usually takes the form of an almost instantaneous charge transfer accompanied by collapse of the insulating properties and partial of complete localized destruction of the dielectric medium. In the case of liquids and gases the failure may be self-healing.

dielectric strength—a property of an insulating material described by the average voltage gradient at which electric breakdown occurs under specific conditions of test.

dissipation factor, *D*—the ratio of the loss index to its relative permittivity or

$$D = \kappa''/\kappa'$$

It is also the tangent of its loss angle, δ, or the cotangent of its phase angle, θ. The dissipation factor is related to the power factor, *PF*, by the following equation:

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

DISCUSSION—It may be expressed as $D = \tan\delta = \text{cotan}\,\theta =$

$$G/\omega C_p = 1/\omega C_p R_p = \omega R_s C_s$$

where G is the equivalent parallel ac conductance, C_p is the parallel capacitance, R_p is the equivalent parallel ac resistance, C_s is the series capacitance, and R_s is the equivalent series resistance.

dissipation factor, dielectric—same as **dissipation factor.**

electric constant— the same as **permittivity of free space.**

electric creepage strength—the average voltage gradient under specific conditions of test and for a specific electrode configuration, at which dielectric failure occurs along the interface between a solid insulating material and the fluid in which it is immersed, or at the interface between two solids that are in close physical contact with each other but are not bonded chemically. Dielectric creepage failure may result in tracking.

electrical discharge—a discontinuous movement of electrical charges through an insulating medium, initiated by electron avalanches and supplemented by secondary processes.

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

fire point—the lowest temperature at which a specimen will sustain burning for 5 s under specified conditions of test.

flash point—the lowest temperature corrected to a barometric pressure of 101.3 kPa (760 mm Hg), at which application of a test flame causes the vapor of a specimen to ignite under specified conditions of test.

fluorescence—photoluminescence in which the emitted optical radiation results from direct transitions from a photo–excited singlet energy level to a lower singlet level, these transitions taking place generally within 10 nanoseconds after excitation.

free electrons—an electron, not directly associated with the structure of an atom or molecule, free to move under the influence of an applied electric or magnetic field.

furanic compounds—a class of chemical compounds characterized by the presence of heterocyclic structures consisting of a five-membered ring containing four carbon atoms and one oxygen atom. These compounds may be found dissolved in electrical insulating fluids, either as residual contaminants of refinery extraction processes in which furfural is used, or from the degradation of cellulose insulation.

gas chromatography, GC—all chromatographic methods in which the moving phase is gaseous. The stationary phase may be either a dry granular solid or a liquid supported by the granules or by the wall of the column, or both. Separation is achieved by differences in the partition-distribution of the components of a sample between the mobile and stationary phases, causing them to move through the column at different rates and from it at different times. (E 355)

gas–liquid chromatography, GLC—gas chromatographic method utilizing a liquid as the stationary phase, which acts as a solvent for the sample components.

gas–solid chromatography, GSC—gas chromatographic method utilizing an active (absorbant) solid as the stationary phase.

gassing tendency—the capability of an insulating liquid either to absorb or generate gases when exposed to voltage stress. The measure of the gassing tendency is the volume of gas evolved or absorbed per unit time by an insulating liquid subjected to electrical stress under prescribed conditions (by Method D 2300, Test Method for Gassing of Insulating Oils Under Electrical Stress and Ionization (Modified Pirelli Method) [2]). It is commonly expressed in units of microlitres per minute (µL/min) with a positive value indicating gas is evolved and a negative value indicating gas is absorbed. The SI unit is cubic millimetres per minute (mm^3/min).

DISCUSSION—The term *gassing* is sometimes used synonymously with either *gassing tendency* or *average gassing coefficient,* AGC.

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

hank—specifically, a coiled or looped bundle (as of yarn, rope or wire) ususally containing a definite aggregate measure of the material.

hydrogen treating—a refining process in which an unfinished petroleum insulating oil is contacted with hydrogen gas at elevated temperatures and pressures in the presence of a catalyst, to improve its color, odor, stability, and other properties.

inhibitor—any substance which when added to an electrical insulating fluid retards or prevents undesirable reactions.

insulating liquid, fluid or gas—a fluid (liquid or gaseous) which does not readily conduct electricity. Electrical insulating fluids typically provide both electrical insulation and heat transfer in electrical equipment.

insulating material—a material of relatively low electrical conductivity and high dielectric strength, usually used to support or provide electrical separation for conductors, in which a voltage applied between two points on or within the material produces a small and sometimes negligible current.

interfacial tension,, *n*—the force existing in a liquid-liquid phase interface that tends to diminish the area of the interface. This force, which is analogous to the surface tension of liquid-vapor interfaces, acts at each point on the interface in the plane tangent at that point. (*Compilation of ASTM Standard Definitions*, 7th Edition.)

loss angle, δ— the angle whose tangent is the dissipation factor or arctan κ''/κ'. It is also the difference between 90 deg and the phase angle.

loss angle, dielectric— same as **loss angle.**

loss index—the same as **loss index, dielectric.**

loss index, dielectric, $\kappa''(\epsilon_r'')$—the product of the "relative permittivity" and the dissipation factor and is a measure of the ac dielectric loss. It is also the magnitude of the imaginary part of the "relative complex permittivity."

DISCUSSION—It may be expressed as:

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

When SI units of watts, volts per metre, hertz, and cubic metres are used the constant has the value: 5.556×10^{-15}. More commonly, when units of watts, volts per centimetre, hertz, and cubic centimetres are used the constant has the value: 5.556×10^{-13}.

loss tangent—same as **dissipation factor.**

mineral insulating oil, *n*—an oil of mineral origin, refined from petroleum crude oil, possessing electrical insulating properties.

DISCUSSION—Mineral insulating oils are differentiated from oils derived by synthesis, or from animal or vegetable sources.

naphthenic oil—a term applied to mineral insulating oil derived from special crudes having very low, naturally occurring *n*-paraffin (wax) contents. Such an oil has a low natural pour point and does not need to be dewaxed nor does it usually require the use of a pour depressant.

neutralization value—a number used as a measure of the acidic or basic constituents present in an insulating liquid, usually expressed in terms of equivalent milligrams of potassium hydroxide per gram of sample.

oxidation inhibitor—any substance added to an insulating fluid to improve its resistance to deleterious attack in an oxidizing environment. For example, 2,6-ditertiary-butyl paracresol is sometimes added to petroleum insulating oil to improve its oxidation stability.

oxidation life—a measure of the ability of an insulating liquid to resist oxidation under a prescribed set of conditions. Often the changes in color, neutralization number, interfacial tension, initial appearance of sludge, or rate of sludge formation are the criteria used to measure this quality.

oxidation stability— see **oxidation life.**

paraffinic oil—a term applied to mineral insulating oil derived from crudes having substantial contents of naturally occurring *n*-paraffins (wax). Such an oil must be dewaxed and may need the addition of a pour depressant in order to exhibit a low pour point.

partial discharge—an electrical discharge that only partially bridges the insulation between conductors. It may or may not occur adjacent to a conductor.

permittivity, $\kappa(\epsilon)$—a factor giving the influence of an extensive, isotropic dielectric medium on the forces of attraction or repulsion between two electrified bodies (see Discussion 1 of this definition). It is the product of the "relative permittivity," $\kappa'(\epsilon_r)$, and the "permittivity of free space (vacuum)," κ_o (ϵ_o).

$$\kappa = \kappa' \cdot \kappa_o$$

The SI unit is: farad per metre (F/m);

where:

farad (F)	=	s^4A^2/m^2kg,
s	=	seconds,
A	=	amperes,
m	=	metres, and
kg	=	kilograms.

DISCUSSION—1—The permittivity appears in the equation for Coulomb's law on the forces of attraction of repulsion of point charges:

$$\text{Force} = Q_1Q_2/4\pi\kappa r^2$$

In SI units: Force is in newtons, *Q* is in coulombs, *r* is in metres, and κ is in farads per metre.

DISCUSSION—2—In older sources the incorrect term, dielectric constant, and the correct term, absolute dielectric constant, can be found applied to the factor in Coulomb's equation. Modern practice encourages the use of "permittivity."

permittivity, absolute— the same as **permittivity.**

permittivity, relative, $\kappa'(\epsilon_r)$—a dimensionless number, dependent upon the nature and condition of the dielectric medium and upon the frequency of the applied electromagnetic field. For a vacuum $\kappa' \equiv 1.0$. For other dielectrics it is the quotient obtained by dividing the equivalent parallel capacitance, C_p, of a given configuration of electrodes with a material as a dielectric by the capacitance, C_v, of the same configuration of electrodes with vacuum (or air for most practical purposes) as the dielectric:

$$\kappa' = C_p/C_v$$

DISCUSSION—1—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 resistance.

DISCUSSION—The "relative permittivity" is also the real part of the "relative complex permittivity."

DISCUSSION—In common usage the term "relative" is often dropped and the dimensionless ratio is called simply the permittivity. In order to avoid confusion the full term "relative permittivity" should be used.

permittivity, relative complex, $\kappa^*(\epsilon_r^*)$—the ratio of the admittance, *Y*, of a given set of electrodes with a material as dielectric to the admittance, Y_v, of the same configuration with vacuum as dielectric:

$$\kappa^* = Y/Y_v = Y/j\omega C_v = \kappa' - j\kappa''$$

where:

κ'	=	relative permittivity,
κ''	=	dielectric loss index, and
C_v	=	capacitance with vacuum as the dielectric.

permittivity of free space (vacuum), $\kappa_0(\epsilon_0)$—is defined by the following equation derived from wave theory:

$$\kappa_0 = 1/\mu_0 c^2 = 8.854 \times 10^{-12} \text{ farad per metre}$$

where: the magnetic permeability of free space,

$$\mu_0 = 4\pi \times 10^{-7} \text{ henry per metre; 1 henry} = \text{m}^2\text{kg/s}^2\text{A}^2$$

and the speed of electromagnetic waves in free space,

$$c = 2.998 \times 10^{8} \text{ metres per second.}$$

DISCUSSION—The units and values given above are consistent with current National Institute of Standards and Technology practice and the usage of SI units. Other systems of units exist and are in use: in one, $\kappa_0 \equiv 1.0$ and is dimensionless (electrostatic system) and in another $\mu_0 \equiv 1.0$ and is dimensionless (electromagnetic system). No universal agreement has been reached on this issue.

phase angle, θ—(*1*) the angle whose cotangent is the dissipation factor, arcot κ''/κ'. (*2*) The angular difference in the phase between the sinusoidal alternating voltage applied to a dielectric and the component of the resulting current have the same frequency as the voltage.

phase angle, dielectric— same as **phase angle.**

phase defect angle— same as **loss angle.**

polybutene oil—a family of branched-chain polyolefins made by the polymerization of a mixture of iso- and normal butenes. The products are colorless, viscous liquids and are used as cable oils and in capacitors because they are good dielectrics, impermeable to water vapor and gas, and resistant to oxidation. Other synonyms for polybutene are polybutylene, polyisobutylene, and polyisobutene.

polychlorinated biphenyl (PCB)**,** *n*—PCB's belong to a broad family of organic chemicals known as chlorinated hydrocarbons and are produced by attaching one or more chlorine atoms to a biphenyl molecule.

DISCUSSION—For purposes of simplicity, mono-chlorine atoms are included in this definition.

pour point—the lowest temperature at which a liquid can be observed to flow under specified conditions.

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

$$PF = W/VI$$

The power factor is related to the **dissipation factor,** *D*, as follows:

$$PF = D/\sqrt{1 + D^2}$$

power factor, dielectric— same as **power factor.**

programmed temperature gas chromatography, PTGC—utilized changes in column temperature with time.

quality factor, *Q*— the reciprocal of the dissipation factor (when applied to insulating materials).

reclaiming—the removal of contaminants and products of degradation such as polar, acidic, or colloidal materials from used electrical insulating liquids by chemical or adsorbent means.

DISCUSSION—Methods listed under *reconditioning* are usually performed in conjunction with reclaiming. Reclaiming typically includes treatment with clay or other absorbents.

reconditioning—the removal of insoluble contaminants, moisture, and dissolved gases from used electrical insulating liquids by mechanical means.

DISCUSSION—The typical means employed are settling, filtration, centrifugation, and vacuum dehydration or degassing.

relative density (specific gravity)—the ratio of a mass of a given volume of liquid at a given temperature to the mass of an equal volume of pure water at the same temperature. When reporting results, explicitly state the standard reference temperature, for example, relative density 15/15°C.

rerefining—the use of primary refining processes on used electrical insulating liquids to produce liquids that are suitable for further use as electrical insulating liquids.

DISCUSSION—Techniques may include a combination of distillation and acid, caustic, solvent, clay, or hydrogen treating and other physical and chemical means.

resistance—the ratio of the potential difference applied to a specimen to the current passed through by the applied potential. It is the reciprocal of **conductance**. The unit is ohm.

DISCUSSION—1—**Resistance** is a general term; specific reference may be made to "dc resistance" and "ac resistance."

DISCUSSION—2—For dielectrics the resistance may be dependent on the **electrification time**.

resistance, apparent dc—the dc resistance measured at the end of a specified electrification time. The "apparent dc resistance" is the reciprocal of the "apparent dc conductance." The unit is ohm.

DISCUSSION—The term "apparent dc resistance" is used to distinguish the current-voltage relationship found in electrical insulating materials, where the current (leakage plus absorption) usually decreases with time, from the relationship found in metallic conductors where the steady-state current is reached in a fraction of a second.

resistance, dc—the ratio of the dc voltage (in volts) to the total current (in amperes) carried through the material between two electrodes that are in contact with, or immersed in a specimen. The "dc resistance" is the reciprocal of the "dc conductance." The unit is ohm.

resistivity—the ratio of the potential gradient paralleling the current passing through the specimen, to the current density. This is numerically equal to the resistance between opposite faces of a unit cube. It is the reciprocal of **conductivity**. The unit commonly used is: ohm-centimetre. The SI unit is ohm-metre.

DISCUSSION—1—**Resistivity** is a general term and could refer to either "dc resistivity or "ac resistivity."

DISCUSSION—2—For dielectrics the resistivity may be dependent on the electrification time. (See also **resistivity, dc volume** and **resistivity, apparent dc volume**.

resistivity, apparent dc volume—the "dc volume resistivity" measured at the end of a specified electrification time. It is the reciprocal of the "apparent dc volume conductivity." The unit most commonly used is ohm-centimetre. The SI unit is ohm-metre.

resistivity, dc—the ratio of the dc potential gradient paralleling the current to the current density at a given instant in time and under prescribed conditions. It is the reciprocal of the" dc conductivity." In common practice the "dc resistivity" is numerically equal to the dc resistance between opposite faces of a centimeter cube of liquid. The unit is ohm-centimetre. The SI unit is ohm-metre.

DISCUSSION—The "dc resistivity" may contain components of both surface resistance and volume resistance, but, in general, surface effects are not common in measurements on fluid dielectrics. The property most commonly measured is the "dc volume resistivity" or the" apparent dc volume resistivity."

resistivity, dc volume—the property of a material that impedes the flow of electricity through its volume. It is numerically equal to the ratio of: the steady direct voltage gradient parallel to the current; to the steady-state current density within the material. It is the reciprocal of the *dc volume conductivity*. In common usage where the voltage gradient is in volts per centimetre and the current density is in amperes per square centimetre, the unit of dc volume resistivity is (ohm-centimetre). The SI unit is ohm-metre.

DISCUSSION—For electrical insulating materials the time required for the steady-state current to be reached may be very long: from several minutes to several months may be required.

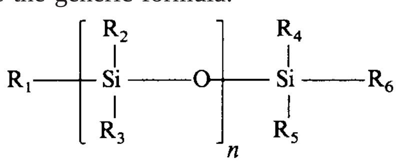
room temperature—a temperature in the range from 20 to 30°C (68 to 86°F).

DISCUSSION—The term "room temperature" is usually applied to an atmosphere of unspecified relative humidity.

scavenger—a chemically active substance which consumes or deactivates an undesirable substance in a system or mixture.

shield—a conductive protective member, partly or wholly enclosing one or more elements of electric equipment or test specimen, for the purpose of reducing or eliminating the electric or magnetic flux, or both, within or beyond that element or elements.

silicone fluid—a generic term for a family of relatively inert liquid organosiloxane polymers used as electrical insulation. They have the generic formula:



where the attached R groups may be H, methyl, vinyl, phenyl, alkyl, or substituted phenyl or alkyl radicals.

solvent extraction—a process used in refining some mineral insulating oils in which an unrefined or a partially refined petroleum distillate is contacted countercurrently with an immiscible solvent so as to selectively remove undesirable materials from the mineral oil.

DISCUSSION—Solvents typically used for mineral insulating oils include phenol, furfural, and liquid sulfur dioxide. Solvent extraction is most frequently used in combination with other refining processes such as hydrotreating, acid-treating, or clay-treating.

specific gravity—see **relative density**.

*specific inductive capacity***—**the same as **permittivity, relative**.

storage factor—a name formerly used at times for the *quality factor*.

tan δ *(tangent delta)***—** same as **dissipation factor**.

transformer oil, oxidation inhibited—a suitably refined mineral insulating oil to which an oxidation inhibitor has been added.

DISCUSSION—It is Canadian practice to consider transformer oils containing 2,6-di-*tert*-butyl-para cresol in concentrations of no more than 0.08 %, by weight, as being uninhibited.

transformer oil, uninhibited—a suitable refined mineral insulating oil containing no additives and only such as remain in the oil.

DISCUSSION—It is Canadian practice to consider transformer oils containing 2,6-di-*tert*-butyl-para cresol in concentrations of no more than 0.08 %, by weight, as being uninhibited.

*viscosity***—**same as **viscosity, absolute**.

viscosity, absolute, η—the ratio of shear stress to shear rate. It is the property of internal resistance of a fluid that opposes the relative motion of adjacent layers. The unit most commonly used for insulating fluids is the centipoise.

*viscosity, coefficient of***—** same as **viscosity, absolute**.

*viscosity, dynamic***—** same as **viscosity, absolute**.

viscosity, kinematic—the quotient of the absolute (dynamic) viscosity divided by the density, η/ρ, both at the same temperature. For insulating liquids the unit most commonly used is the centistokes (100 cSt = 1 St).

viscosity, Saybolt Universal—the efflux time in seconds of 60 mL of sample flowing through a calibrated Saybolt Universal orifice under specified conditions.

water content,, *n*—the water content of a substance, as measured under specified conditions. (*Compilation of ASTM Standard Definitions*, 7th Edition.)

wax appearance point—the temperature at which wax or other solid substances first begin to separate from the liquid oil when it is cooled under prescribed conditions (Refer to D3117, Test Method for Wax Appearance Point of Distillate Fuels [3]).

DISCUSSION—Wax appearance is closely related to the *cloud point* observed in Method D 2500, Test Method for Cloud Point of Petroleum Oils. [4]

wax content of insulating oil—the amount of solid material that separates from a mixture of liquid oil and a suitable wax antisolvent (methyl ethyl ketone, sec-butyl acetate, etc.) under prescribed test conditions.

[3] *Annual Book of ASTM Standards*, Vol 05.03.
[4] *Annual Book of ASTM Standards*, Vol 05.02.