Designation: D8180 – 23

Standard Specification for Rerefined Mineral Insulating Liquid Used in Electrical Apparatus[1]

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1. Scope

1.1 This specification covers rerefined previously used mineral insulating liquid of petroleum origin for reuse as an insulating and cooling medium in new and existing power and distribution electrical apparatus, such as transformers, regulators, reactors, liquid filled circuit breakers, switchgear, and attendant equipment.

1.2 This specification is intended to define a rerefined mineral insulating liquid that is functionally interchangeable and miscible with existing mineral insulating liquids, is compatible with existing apparatus, and with appropriate field maintenance[2] will satisfactorily maintain its functional characteristics in its application in electrical equipment. This specification applies only to rerefined mineral insulating liquid as received prior to any processing. Liquids that undergo treatment in-situ are not covered by this specification.

1.3 Formulated rerefined mineral insulating liquids may contain additives such as inhibitors, passivators, pour point depressants, flow modifiers, gassing tendency modifiers, and other compounds. This specification will address some of these but not all. It is the responsibility of the supplier to disclose information concerning the presence of all known additives and their concentration to the user.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester

D97 Test Method for Pour Point of Petroleum Products

D117 Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Liquids

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents

D923 Practices for Sampling Electrical Insulating Liquids

D924 Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids

D971 Test Method for Interfacial Tension of Insulating Liquids Against Water by the Ring Method

D974 Test Method for Acid and Base Number by Color-Indicator Titration

D1275 Test Method for Corrosive Sulfur in Electrical Insulating Liquids

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)

D1524 Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field

D1533 Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration

D1816 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes

[1] This specification is under the jurisdiction of ASTM Committee D27 on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee D27.01 on Mineral.

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[2] Refer to the Institute of Electrical and Electronic Engineers, Inc. (IEEE) C 57.106. Guide for Acceptance and Maintenance of Insulating Mineral Oil in Equipment. Available from IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 0888 – 4141, USA Phone: +1 732 981 0600.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D1903 Practice for Determining the Coefficient of Thermal Expansion of Electrical Insulating Liquids of Petroleum Origin, and Askarels
D2112 Test Method for Oxidation Stability of Inhibited Mineral Insulating Oil by Pressure Vessel
D2300 Test Method for Gassing of Electrical Insulating Liquids Under Electrical Stress and Ionization (Modified Pirelli Method)
D2440 Test Method for Oxidation Stability of Mineral Insulating Oil
D2668 Test Method for 2,6-*di-tert*-Butyl- *p*-Cresol and 2,6-*di-tert*-Butyl Phenol in Electrical Insulating Oil by Infrared Absorption
D2717 Test Method for Thermal Conductivity of Liquids (Withdrawn 2018)[4]
D2766 Test Method for Specific Heat of Liquids and Solids (Withdrawn 2018)[4]
D2864 Terminology Relating to Electrical Insulating Liquids and Gases
D3300 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Under Impulse Conditions
D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D4059 Test Method for Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography
D4768 Test Method for Analysis of 2,6-Ditertiary-Butyl Para-Cresol and 2,6-Ditertiary-Butyl Phenol in Insulating Liquids by Gas Chromatography
D5837 Test Method for Furanic Compounds in Electrical Insulating Liquids by High-Performance Liquid Chromatography (HPLC)
D5949 Test Method for Pour Point of Petroleum Products (Automatic Pressure Pulsing Method)
D5950 Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)
D6892 Test Method for Pour Point of Petroleum Products (Robotic Tilt Method)
D7042 Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)

2.2 *IEC Standards:*[5]

IEC 60666 Detection and Determination of Specific Additives in Mineral Insulating Oils

2.3 *Energy Institute Standards:*[6]

IP 346 Determination of polycyclic aromatics in unused lubricating base oils and asphaltene free petroleum fraction – Dimethyl sulphoxide extraction refractive index method

3. Terminology

3.1 *Definitions:*

3.1.1 *additives, n*—chemical compounds added to an insulating liquid for the purpose of imparting new properties or altering properties which the liquid already has.

3.1.1.1 *Discussion*—Further information on additives can be found in IEC 60666.

3.1.2 *properties, n*—those characteristics of mineral insulating liquid which are required for the design, manufacture, and operation of the apparatus.

3.1.2.1 *Discussion*—These properties are listed in Section 5.

3.1.3 *reclaimed mineral insulating liquid, n*—reference Terminology D2864 for more information.

3.1.4 *reconditioned mineral insulating liquid, n*—reference Terminology D2864 for more information.

3.1.5 *rerefined mineral insulating liquid, n*—reference Terminology D2864 for more information.

3.1.6 *Type I rerefined mineral liquid, n*—liquid for apparatus where normal oxidation resistance is required; some liquids may require the addition of a suitable oxidation inhibitor to achieve this.

3.1.7 *Type II rerefined mineral liquid, n*—liquid for apparatus where greater oxidation resistance is required; this is usually achieved with the addition of a suitable oxidation inhibitor.

3.1.7.1 *Discussion*—During processing of inhibited mineral insulating liquid under vacuum and elevated temperatures, partial loss of inhibitor and volatile portions of mineral liquid may occur. The common inhibitors, 2,6-ditertiary-butyl paracresol (DBPC/BHT) and 2,6-ditertiary-butyl phenol (DBP), are more volatile than transformer liquid. If processing conditions are too severe, oxidation stability of the liquid may be decreased due to loss of inhibitor. The selectivity for removal of moisture and air in preference to loss of inhibitor and liquid is improved by use of a low processing temperature.

3.1.7.2 *Discussion*—Conditions that have been found satisfactory for most inhibited mineral insulating liquid processing are:

Temperature, °C	Minimum Pressure Pa	Minimum Pressure Torr, Approximate
40	5	0.04
50	10	0.075
60	20	0.15
70	40	0.3
80	100	0.75
90	400	3.0
100	1000	7.5

3.1.7.3 *Discussion*—If temperatures higher than those recommended for the operating pressure are used, the liquid should be tested for inhibitor content and inhibitor added as necessary to return inhibitor content to its initial value. Attempts to dry apparatus containing appreciable amounts of free water may result in a significant loss of inhibitor even at the conditions recommended above.

3.1.8 Other definitions of terms related to this specification are given in Terminology D2864.

3.1.9 More information on tests related to this specification can be found in Guide D117.

[4] The last approved version of this historical standard is referenced on www.astm.org.

[5] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, 1st floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, https://www.iec.ch.

[6] Available from Energy Institute, 61 New Cavendish St., London, W1G 7AR, U.K., http://www.energyinst.org.

4. Sampling and Testing

4.1 Take all liquid samples in accordance with Practices D923.

4.2 Make each test in accordance with the latest revision of the ASTM or IP test method specified in Section 5.

4.3 The liquid shall meet the requirements of Section 5 at the unloading point.

NOTE 1—Because of the different needs of the various users, items relating to packaging, labeling, and inspection are considered to be subject to supplier and user's agreement.

NOTE 2—In addition to all other tests listed herein, it is sound engineering practice for the apparatus manufacturer to perform an evaluation of new types of insulating liquids in insulation systems, prototype structures, or full-scale apparatus, or any combination thereof, to ensure suitable service life.

4.4 The supplier shall make known to the user the generic type and amount of any additive used, for assessing any potential detrimental reaction with other materials in contact with the liquid.

4.5 Due to differences in rerefining processes, some rerefined liquids could contain levels of metals subject to regulation under local, state, and national regulations. The need for this testing should be discussed between supplier and user.

5. Property Requirements

5.1 Mineral insulating liquid conforming to this specification shall meet the property limits given in Table 1. The significance of these properties is discussed in Appendix X2.

TABLE 1 Property Requirements

Property	Limit		ASTM and IP Test Methods
	Type I	Type II	
Physical:			
Aniline point, min, °C	63[A]	63[A]	D611
ASTM Color, max	0.5	0.5	D1500
Flash point, min, °C	145	145	D92
Interfacial tension, min, mN/m	40	40	D971
Pour point, max, °C	–40	–40	D97 or D5949 or D5950 or D6892[B]
Relative Density (Specific gravity), 15 °C/15 °C, max	0.91	0.91	D1298 or D4052[C]
Viscosity max, mm^2/s, at:			
100 °C	3.0	3.0	D445 or D7042
40 °C	12.0	12.0	
0 °C	76.0	76.0	
Visual examination	clear and bright	clear and bright	D1524
Electrical:			
Dielectric breakdown voltage at 60 Hz:			D1816
VDE electrodes, min, kV 1 mm gap	20[D]	20[D]	
2 mm gap	35[D]	35[D]	
Dielectric breakdown voltage, impulse conditions, negative polarity point, min, kV	145	145	D3300
Gassing tendency, max, µL/minute	+30	+30	D2300
Dissipation factor (or power factor), at 60 Hz max, %:			D924
25 °C	0.05	0.05	
100 °C	0.30	0.30	
Chemical:[F]			
Oxidation stability (acid-sludge test)			D2440
72 h:			
sludge, max, % by mass	0.15	0.1	
Total acid number, max, mg KOH/g	0.5	0.3	
164 h:			
sludge, max, % by mass	0.3	0.2	
Total acid number, max, mg KOH/g	0.6	0.4	
Oxidation stability (rotating pressure vessel), min, minutes	—	195	D2112
Oxidation inhibitor content, max, % by mass	0.08[E]	0.30[F]	D4768 or D2668[G]
Corrosive sulfur	noncorrosive	noncorrosive	D1275
Water, max, mg/kg	35	35	D1533
Neutralization number, total acid number, max, mg, KOH/g	0.03	0.03	D974
Furanic Compounds, max, µg/L	25	25	D5837
PCB content, mg/kg	not detectable	not detectable	D4059
PCA Extract Content, below, % by mass	3.0	3.0	IP 346[H]

[A] The value shown represents current knowledge.
[B] In case of dispute, Test Method D97 shall be used as the referee method.
[C] In case of dispute, Test Method D1298 shall be used as the referee method.
[D] These limits by Test Method D1816 are applicable only to as received rerefined liquid (see X2.2.1.1).
[E] Provisions to purchase totally uninhibited liquid shall be negotiated between supplier and user.
[F] Minimum requirements of inhibitor for Type II liquid will be agreed to between supplier and user.
[G] Both 2,6-ditertiary-butyl para-cresol (DBPC/BHT) and 2,6-ditertiary butylphenol (DBP) have been found to be suitable oxidation inhibitors for use in liquids meeting this specification. Preliminary studies indicate both Test Methods D2668 and D4768 are suitable for determining concentration of either inhibitor or their mixture.
[H] IP 346 is a method to extract and gravimetrically determine Polycyclic Aromatics (PCA) using DMSO extraction which have been determined to be carcinogenic or cancer causing.

6. Keywords

6.1 mineral; reclaimed; reconditioned; rerefined

APPENDIXES

(Nonmandatory Information)

X1. SUPPLEMENTARY DESIGN INFORMATION

X1.1 The following values are typical for presently used mineral insulating liquids. For liquids derived from paraffinic or mixed-base crudes, the apparatus designer needs to know that these properties have not changed.

Property	Typical Values	ASTM Test Method
Coefficient of expansion, /°C from 25 °C to 100 °C	0.0007 to 0.0008	D1903
Relative Permittivity (Dielectric Constant), 25 °C	2.2 to 2.3	D924
Specific heat, J/(kg·°C), 20 °C	1800	D2766
Thermal conductivity, W/(m·°C), from 20 °C to 100 °C	0.13 to 0.17	D2717

X2. SIGNIFICANCE OF PROPERTIES OF MINERAL INSULATING LIQUID

X2.1 Physical Properties

X2.1.1 *Aniline Point*—The aniline point of a mineral insulating liquid indicates the solvency of the liquid for materials that are in contact with the liquid. It may relate to the impulse and gassing characteristics of the liquid.

X2.1.2 *ASTM Color*—A low color number is an essential requirement for inspection of assembled apparatus in the tank. An increase in the color number during service is an indicator of deterioration of the mineral insulating liquid.

X2.1.3 *Flash Point*—The safe operation of the apparatus requires an adequately high flash point.

X2.1.4 *Interfacial Tension*—A high value for rerefined mineral insulating liquid indicates the absence of undesirable polar contaminants. This test is frequently applied to service-aged liquids as an indicator of the degree of deterioration or contamination, or both.

X2.1.5 *Pour Point*—The pour point of mineral insulating liquid is the lowest temperature at which the liquid will just flow and many of the factors cited under viscosity apply. The pour point of –40 °C may be obtained by the use of suitable distillates, refining processes, the use of appropriate long life additives, or any combination thereof. If a pour point additive is used, it is necessary to make known the amount and chemical composition.

X2.1.6 *Relative Density (Specific Gravity)*—The specific gravity of a mineral insulating liquid influences the heat transfer rates and may be pertinent in determining suitability for use in specific applications. In extremely cold climates, specific gravity has been used to determine whether ice, resulting from freezing of water in liquid-filled apparatus, will float on the liquid and possibly result in flashover of conductors extending above the liquid level.

X2.1.7 *Viscosity*—Viscosity influences the heat transfer and, consequently, the temperature rise of apparatus. At low temperatures, the resulting higher viscosity influences the speed of moving parts, such as those in power liquid filled circuit breakers, switchgear, load tap changer mechanisms, pumps, and regulators. Viscosity controls mineral insulating liquid processing conditions, such as dehydration, degasification and filtration, and liquid impregnation rates. High viscosity may adversely affect the starting up of apparatus in cold climates (for example, spare transformers and replacements).

X2.1.8 *Visual Examination*—A simple visual inspection of mineral insulating liquid may indicate the absence or presence of undesirable contaminants. If such contaminants are present, more definitive testing is recommended to assess their effect on other functional properties.

X2.2 Electrical Properties

X2.2.1 *Dielectric Breakdown Voltage, 60 Hz*—The dielectric breakdown voltage of a mineral insulating liquid indicates its ability to resist electrical breakdown at power frequencies in electrical apparatus.

X2.2.1.1 *Dielectric Breakdown—VDE Electrodes*—The VDE method (Test Method D1816) is sensitive to contaminants, such as water, dissolved gases, cellulose fibers, and conductive particles in liquid. Processing involves filtering, dehydration, and degassing, which generally improve the breakdown strength of the liquid.

X2.2.2 *Dielectric Breakdown Voltage-Impulse*—The impulse strength of liquid is critical in electrical apparatus. The impulse breakdown voltage of liquid indicates its ability to resist electrical breakdown under transient voltage stresses (lightning and switching surges). The functional property is sensitive to both polarity and electrode geometry.

X2.2.3 *Dissipation Factor*—Dissipation factor (power factor) is a measure of the dielectric losses in liquid. A low dissipation factor indicates low dielectric losses and a low level of contaminants.