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IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment

IEEE Power Engineering Society

Sponsored by the
Transformers Committee



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**Transformers Committee
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IEEE Power Engineering Society**

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Abstract: Recommendations regarding oil tests and evaluation procedures are made in this guide; references are made to methods of reconditioning and reclaiming conventional petroleum (mineral) dielectric insulating oils; the levels at which these methods become necessary; and the routines for restoring oxidation resistance, where required, by the addition of oxidation inhibitors. The intent is to assist the power equipment operator in evaluating the serviceability of oil received in equipment, oil as received from the supplier for filling new equipment at the installation site, and oil as processed into such equipment; and to assist the operator in maintaining oil in serviceable condition. The mineral oil covered is used in transformers, reactors, circuit breakers, load tap changers, and voltage regulators.

Keywords: insulation testing, load tap changers, oil circuit breakers, oil insulation, power distribution maintenance, power transformer insulation, reactors, transformers, voltage regulators

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Introduction

(This introduction is not part of IEEE Std C57.106-2002, IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment.)

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Contents

1.	Overview	1
1.1	Scope	1
1.2	Purpose	2
2.	References	2
3.	Definitions	4
4.	Evaluation of mineral insulating oil	4
4.1	General	4
4.2	New oil properties	5
4.3	New oil properties—oil received in new equipment rated less than 230 kV	6
4.4	New oil properties—after filling into new equipment rated at 230 kV or higher	7
4.5	Percent saturation of water in mineral oil (see also clause on saturation of water in oil in IEEE Std 62-1995)	8
4.6	Mixtures of mineral insulating oil	10
4.7	Sampling	11
5.	Oil tests and their significance	11
5.1	Physical tests	12
5.2	Electrical tests	13
5.3	Chemical tests	15
6.	Handling and storage	16
6.1	Tanks	17
6.2	Oil quality protection in storage	17
6.3	Dikes and curbs	17
6.4	Processing oil for installation in apparatus	17
7.	Classification of service-aged insulating oil	18
7.1	General	18
7.2	Classification	18
8.	Insulating oil for circuit breakers	19
8.1	General	19
8.2	Testing	20
8.3	Reconditioning	23
9.	Insulating oil for load tap changers (LTCs)	23
9.1	General	23
9.2	Testing methods	24
9.3	Reconditioning	24
10.	Health and environmental care procedures for mineral insulating oil	25
10.1	Health issues	25
10.2	Leaks and spills	26
	Annex A (informative) Bibliography	27

IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment

1. Overview

The reliable performance of oil in insulation systems depends upon basic characteristics of the oil that can affect overall apparatus characteristics. These oil characteristics are integral parts of the equipment design of the manufacturer. Certain properties of mineral insulating oil have been determined as important for proper electrical equipment performance. Description of these properties and their recommended value ranges for new oil and for continued use of service-aged oils are included in this guide.

Mineral insulating oil that is received in electrical equipment will exhibit different characteristics from new oil received in bulk, which has not been in contact with apparatus construction materials.

Oil in service may contain dissolved gases that are useful in assessing the continued serviceability of certain types of transformers. It is not the intent of this guide to cover this subject, as that information is available in IEEE C57.104TM-1991¹.

This guide reflects the current state of the art and may differ from information contained in IEEE Std 62TM-1995, which was authored by the Power System Instrumentation and Measurements (PSIM) Committee.

Should instructions or product standards given by the manufacturer differ from recommendations made in this guide, the instructions of the manufacturer are to be given preference.

1.1 Scope

This guide applies to mineral oil used in transformers, load tap changers, voltage regulators, reactors, and circuit breakers. The guide discusses the following:

- a) Analytical tests and their significance for the evaluation of mineral insulating oil.
- b) The evaluation of new, unused mineral insulating oil before and after filling into equipment.
- c) Methods of handling and storage of mineral insulating oil.
- d) The evaluation of service-aged mineral insulating oil.
- e) Health and environmental care procedures for mineral insulating oil.

¹Information on references can be found in Clause 2.

The characteristics of the oils discussed in this guide do not include oil that is in factory fill lines, nor does this guide cover reclaimed oil installed in new equipment. The qualities of such oil, if used, should be agreed upon by the manufacturer and the user of the equipment.

1.2 Purpose

The purpose of this guide is to assist the user of the equipment in evaluating the serviceability of new, unused oil being received in equipment; oil as received for filling new equipment at the installation site; and oil as processed into equipment. It also assists the operator in maintaining the oil in serviceable condition.

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

ASTM D88-94 (1999), Standard Test Method for Saybolt Viscosity.²

ASTM D92-02, Standard Test Method for Flash and Fire Points by Cleveland Open Cup.

ASTM D97-02, Standard Test Method for Pour Point of Petroleum Products.

ASTM D445-01, Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the calculation of Dynamic Viscosity).

ASTM D611-01b, Standard Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents.

ASTM D664-01, Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration.

ASTM D877-00, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.

ASTM D923-97, Standard Practices for Sampling Electrical Insulating Liquids.

ASTM D924-99e1, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.

ASTM D971-99a, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.

ASTM D974-02, Standard Test Method for Acid and Base Number by Color-Indicator Titration.

ASTM D1275-96a, Standard Test Method for Corrosive Sulfur in Electrical Insulating Oils.

ASTM D1298-99, Standard Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.

ASTM D1500-98, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).

²ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (<http://www.astm.org/>).

ASTM D1524-94 (1999), Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.

ASTM D1533-00, Standard Test Methods for Water in Insulating Liquids by Coulometric Karl Fischer Titration.

ASTM D1816-97, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.

ASTM D2112-01a, Standard Test Method for Oxidation Stability of Inhibited Mineral Insulating Oil by Pressure Vessel.

ASTM D2161-93 (1999) e2, Standard Practice for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity.

ASTM D2285-99, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop-Weight Method.

ASTM D2300-00, Standard Test Method for Gassing of Insulating Liquids Under Electrical Stress and Ionization (Modified Pirelli Method).

ASTM D2440-99, Standard Test Method for Oxidation Stability of Mineral Insulating Oil.

ASTM D2668-96, Standard Test Method for 2, 6-Ditertiary-Butyl Para Cresol and 2, 6-Ditertiary-Butyl Phenol in Electrical Insulating Oil by Infrared Absorption.

ASTM D2945-90 (1998), Standard Test Method for Gas Content of Insulating Oils.

ASTM D3284-99, Standard Test Method for Combustible Gases in the Gas Space of Electrical Apparatus Using Portable Meters.

ASTM D3300-00, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Under Impulse Conditions.

ASTM D3487-00, Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus.

ASTM D3612-01, Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

ASTM D3613-98, Standard Practice for Sampling Insulating Liquids for Gas Analysis and Determination of Water Content.

ASTM D4059-00, Standard Test Method for Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography.

ASTM D4768-96, Standard Test Method for Analysis of 2, 6-Ditertiary-Butyl Para-Cresol and 2, 6-Ditertiary-Butyl Phenol in Insulating Liquids by Gas Chromatography.

ASTM D5837-99, Standard Test Method for Furanic Compounds in Electrical Insulating Liquids by High-Performance Liquid Chromatography (HPLC).

IEEE Std 62-1995, IEEE Guide for Diagnostic Field Testing of Electric Power Apparatus—Part 1: Oil Filled Power Transformers, Regulators, and Reactors.^{3, 4}

IEEE Std 637TM-1985 (R1992), IEEE Guide for the Reclamation of Insulating Oil and Criteria for its Use.

IEEE Std 980TM-1994 (R2001), IEEE Guide for Containment and Control of Oil Spills in Substations.

IEEE Std C37.010TM-1999, IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

IEEE Std C57.93TM-1995 (R2001), IEEE Guide for Installation of Liquid-Immersed Power Transformers.

IEEE Std C57.104-1991, IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

IEEE Std C57.121TM-1998, IEEE Guide for Acceptance and Maintenance of Less-Flammable Hydrocarbon Fluid in Transformers.

IEEE Std C57.131TM-1995, IEEE Standard Requirements for Load Tap Changers.

Title 40 Code of Federal Regulations Part 110, Discharge of Oil.⁵

Title 40 Code of Federal Regulations Part 112.7, Guidelines for the Preparation and Implementation of a Spill Prevention Control and Counter Measure Plan.

Title 40 Code of Federal Regulations Part 761, Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.

3. Definitions

The various tests conducted on the insulating oil are defined and described in Clause 5.

3.1 reclamation of oil: The restoration of usefulness by 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 such as Fuller's earth.

3.2 reconditioning of oil: The removal of insoluble contaminants, moisture, and dissolved gases from used, electrical insulating liquids by mechanical means, such as vacuum processing or filtering.

4. Evaluation of mineral insulating oil

4.1 General

This guide uses several different terms to identify insulating oil of a petroleum origin, for example, as defined in ASTM D3487-00. The terms *mineral insulating oil*, *liquid*, and *dielectric fluid* are all equivalent to *insulating oil* in the context of this guide.

³IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

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⁵Available from the U.S. Government Printing Office, Superintendent of Documents, Mail Stop SSOP, Washington, DC 20402.