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*Acceptance and Maintenance of*

**INSULATING OIL**

**IN EQUIPMENT**

IEEE Std 64-1969



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***An American National Standard***

***IEEE Guide for***  
**Acceptance and Maintenance of**  
**Insulating Oil in Equipment**

Sponsor

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# IEEE Guide for Acceptance and Maintenance of INSULATING OIL IN EQUIPMENT

## 1. INTRODUCTION

Insulating oil contained in equipment such as transformers, circuit-breaking devices, regulators, series and shunt reactors, as received from the manufacturer and as filled at the installation site but prior to service operation, should exhibit certain properties in order to insure satisfactory performance. It is expected that oil contained in equipment as received from the manufacturer when properly sampled from such equipment usually exhibits characteristics slightly different from those obtained from new oil, which has not been in contact with apparatus constructional materials.

Additionally, certain essential properties of insulating oil, used in transformers and circuit-breaking devices, must be retained in service if the oil is to perform its multiple role of electrical-insulating, arc-quenching, and heat-transferring agent reliably. It must have adequate dielectric strength to withstand the electric stresses imposed in service. It must retain a sufficiently low viscosity so that its ability to circulate and transfer heat is not impaired. It must pour readily at low temperatures and have high flash point and fire point for safety. Its dielectric losses should not become excessive. It should not be allowed to become so deteriorated or contaminated that it adversely affects other materials in the apparatus, nor should deterioration products sludge it sufficiently to impair its circulation through cooling ducts.

This Guide attempts to assist the power equipment operator in evaluating oil received in equipment and as filled at the installation site and to assist also in his efforts to maintain his oil in serviceable condition. It recommends and standardizes oil test and evaluation procedures, methods of reconditioning and reclaiming oil when necessary, and routines for restoring oxidation resistance by additions of inhibitors.

## 2. EVALUATION OF OIL RECEIVED IN NEW EQUIPMENT

Some users of power equipment find it desirable to make field screening tests while others find it more desirable to perform all tests on insulating oil in a laboratory. For those using field screening tests it is quite common to use such tests as dielectric breakdown voltage (most significant), neutralization number, color, and visual condition. Some operators with suitable equipment and trained personnel may wish to gain additional information by use of the interfacial tension test. If water-content or power-factor results are desired, such tests usually are performed in the laboratory.

In sampling oil contained in apparatus care must be

used in order to obtain a representative sample. ASTM Method D923\* should be followed.

Oil exhibiting the following characteristics is considered acceptable:

| <i>ASTM Methods</i>                           |                   |              |
|-----------------------------------------------|-------------------|--------------|
| Dielectric breakdown voltage                  | 26 kV             | D 877        |
| Neutralization number                         | 0.04 max          | D 664, D 974 |
| Color                                         | 1.0 max           | D 1500       |
| Condition—visual                              | clear             | D 1524       |
| Water content—parts per million               | 35 max            | D 1533       |
| Interfacial tension—dynes/cm (millinewtons/m) | 35 min (0.35 min) | D 971        |
| Power factor at 25°C                          | 0.001 (0.1%) max  | D 924        |
| 100°C                                         | 0.007 (0.7%) max  |              |

## 3. EVALUATION OF OIL FOR USE IN FILLING APPARATUS AT THE INSTALLATION SITE AND AFTER FILLING SUCH APPARATUS\*\*

- (a) Oil in drums, tank trucks, or railroad tank cars received at an installation site must meet certain minimum characteristics in order to be suitable for field processing into equipment. This is currently under study with particular attention being given to those factors resulting in contamination of the oil by the transport container and to the limits of contamination allowable.

For circuit breakers filled at the installation site, it would be expected that the dielectric breakdown voltage of the oil at the time of filling should be a minimum of 30 kilovolts.

- (b) The initial quality characteristics of oil in large apparatus filled at the installation site, particularly in the higher voltage classes, have not been firmly established as yet but are under study.

Oil taken from circuit breakers filled at the installation site should have a minimum dielectric breakdown voltage of 26 kilovolts.

## 4. CLASSIFICATION OF SERVICE-AGED INSULATING OIL

It is impossible to indicate the value of specific tests and recommended test limits for all possible existing applications of insulating oil in service. It should also be recognized that with the present state of knowledge,

\* ASTM methods referred to in this Guide are obtainable at headquarters of the American Society for Testing and Materials, 1916 Race Street, Philadelphia 3, Pa.

\*\* This is under study and material will be added here when study is complete.

no one test can be used as the sole criterion of the condition of oil in service. It is possible, however, to summarize the value and importance of the current tests and to suggest methods of treatment for the oil being examined, such methods being based on current industry experience. Oils in service may be placed in the following classifications based upon the composite evaluation of significant characteristics.

*Group I:* This group contains oils that are in satisfactory conditions for continued use.

*Group II:* This group contains oils that require only minor reconditioning for further service. (Reconditioning is the mechanical removal of moisture and insoluble contaminants. Typical means employed are filtering and centrifuging.)

*Group III:* This group contains oils in poor condition. They should be reclaimed or disposed of depending upon economic considerations. (Reclamation involves the use of methods and processes which result in a beneficial chemical change in the oil. Typical means employed are treatments with adsorption agents, acid refining, alkali treatment, etc.)

*Group IV:* This group contains those oils in such poor condition that it is technically advisable to dispose of them.

## 5. ECONOMIC FACTORS

A review of experience and cost data obtained from many operators and users of transformers reveals a wide variation of practices and cost data involved in the reconditioning and reclaiming of oil. These differences are mostly attributable to the type of system, field inspection operations, and available laboratory and shop facilities. For example, an operator having a large number of pole-type transformers installed over a large area may follow a different practice than one having large transformers in stations in a metropolitan area.

In determining whether or not reconditioning and/or reclaiming or insulating oil is economically justifiable, a number of factors must be considered. Some of these factors are as follows:

- 1) cost of materials,
- 2) disposition of service-aged materials,
- 3) total cost of process versus quality of end product,
- 4) equipment maintenance and amortization,
- 5) cost of collection and storage of oil,
- 6) labor and transportation costs,
- 7) laboratory costs,
- 8) cost of new oil versus cost of reprocessed oil,
- 9) loss of oil during reprocessing,
- 10) cost of inhibitors and blending process,
- 11) value of service-aged oil when used for some other purpose. (One user reports that they utilize certain amounts of this oil for fuel purposes with a value of between 7 and 10 cents per gallon.)

The economic justification of whether reconditioning and/or reclamation work is performed by company

personnel or contractors must be resolved on the basis of factors applicable in each particular case.

## 6. SAMPLING

Accurate sampling, whether of the complete contents or only parts thereof, is extremely important from the standpoint of evaluation of the quality of the product sampled. Obviously, careless sampling procedures or contamination in the sampling equipment will result in a sample that is not truly representative. This generally leads to erroneous conclusions concerning quality and incurs extra time, effort, and expense involved in securing, transporting, and testing the sample. It is very strongly recommended that all of the procedures and precautions outlined in the latest revision of ASTM D923 (Sampling Electrical Insulating Liquids) be followed.

## 7. OIL TESTS AND THEIR SIGNIFICANCE

There are many tests that can be applied to insulating oil for classification purposes. It is recommended that tests be the latest revisions accepted as standards or tentative standards by ASTM. These tests and their significance are as follows:

*ASTM Methods*

|                                                              |                |
|--------------------------------------------------------------|----------------|
| 1) Neutralization Number                                     | D 664, D 974   |
| Approximate Acidity Field Test                               | D 1534         |
| Approximate Acidity and Polar Contamination Spot Test        | D 1902         |
| 2) Dielectric Breakdown Voltage                              | D 877, D 1816  |
| 3) Interfacial Tension                                       | D 971          |
| Interfacial Tension Field Test                               | D 2285         |
| 4) Power Factor                                              | D 924          |
| 5) Color                                                     | D 1500, D 1524 |
| 6) Viscosity                                                 | D 88, D 445    |
|                                                              | D 2161         |
| 7) Flash Point                                               | D 92           |
| 8) Steam Emulsion                                            | D 1935         |
| 9) Specific Gravity (Relative Density)                       | D 1298         |
| 10) Pour Point                                               | D 97           |
| 11) Resistivity                                              | D 1169         |
| 12) Saponification Number                                    | D 94           |
| 13) Gas Content                                              | D 831, D 1827  |
| 14) Inorganic Chlorides and Sulfates                         | D 878          |
| 15) Corrosive Sulfur                                         | D 1275         |
| 16) Sludge                                                   | D 1313, D 1904 |
|                                                              | D 2112, D 2440 |
| 17) Water in Insulating Oil: Extraction Method               | D 1315         |
| Karl Fischer Method                                          | D 1533         |
| 18) DBPC Inhibitor in Electrical Insulating Oil              | D 1473         |
| 19) Visual Examination Field Test                            | D 1524         |
| 20) Sediment and Soluble Sludge in Service-Aged Oil          | D 1698         |
| 21) Refractive Index and Specific Optical Dispersion         | D 1807         |
| 1) Neutralization Number—D 664, D 974                        |                |
| Approximate Acidity Field Test—D 1534                        |                |
| Approximate Acidity and Polar Contamination Spot Test—D 1902 |                |

The neutralization number for service-aged oils is in general a measure of the acidic constituents of the oil and may be pertinent, if compared to the value for the new product, to detect contamination by substances with