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IEEE Guide for Acceptance and Maintenance of Transformer Askarel in Equipment

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Foreword

(This foreword is not a part of IEEE Std 76-1974, IEEE Guide for Acceptance and Maintenance of Transformer Askarel in Equipment.)

Originally published in 1958 as a trial-use guide for maintenance of transformer askarel, this standards document has been revised, updated, and approved as a full-status IEEE Guide. The new edition not only reflects current practice, it also takes into consideration recent environmental concerns about materials containing polychlorinated biphenyls. The standard was developed and approved by the Insulating Fluids Subcommittee of the IEEE Transformers Committee. At the time it approved this document, its membership was:

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IEEE Guide for Acceptance and Maintenance of Transformer Askarel in Equipment

1. Scope and Introduction

The term askarel generally describes a widely used broad class of nonflammable synthetic halogenated hydrocarbon insulating liquids. In this guide, it applies solely to askarel in transformers, reactors, and accessory equipment operated at power frequencies.

Transformer askarels contain PCB's (polychlorinated biphenyls), which have been used in the United States and elsewhere over the past 40 years for many industrial and consumer applications. Recently, evidence has accumulated to indicate that PCB's are widely dispersed throughout the environment and that they can have adverse ecological and toxicological effects.

The Federal Interdepartmental Task Force report COM-72-10419, "Polychlorinated Biphenyls and the Environment," dated May 1972, has recommended restricting PCB's to use in transformers and capacitors.

Methods for handling and disposal of askarels and askarel-impregnated materials are given in Draft American National Standard, Guidelines for Handling and Disposal of Capacitor and Transformer-Grade Askarels Containing Polychlorinated Biphenyls, C107.1.

This guide assists the power equipment operator in evaluating askarel as received in transformers, reactors, and accessory equipment operated at power frequencies and in his efforts to maintain askarel in serviceable condition. It recommends standardized tests and evaluation procedures. Methods are outlined for reconditioning and reclaiming askarel whenever necessary.

2. General Characteristics of Askarel

Askarels of various compositional types are used. Under arcing conditions the gases produced, while consisting of predominantly noncombustible hydrogen chloride, can yield varying amounts of combustible gases depending upon the askarel type.

Insulation systems incorporating these askarels and cellulosic or other organic materials may, when arced, produce gaseous mixtures which are moderately flammable. As a precaution, such gases should be removed from the askarel by bubbling dry nitrogen through the askarel and flushing the gas space with dry nitrogen before any work is performed on the apparatus.

Askarel contained in apparatus as received from the manufacturer but prior to service operation should exhibit certain properties in order to insure satisfactory performance. It should be expected that askarel properly sampled from such equipment usually exhibits characteristics somewhat different from those obtained on new askarel which has not been in contact with apparatus constructional materials. Experience has indicated that variation of some characteristics of the askarel will not impair the service life of the equipment.

However, certain essential properties must be retained if askarel is to perform reliably its dual role of electrical insulation and heat transfer agent. It must have adequate dryness and a dielectric strength sufficient 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 should not be allowed to become so deteriorated or contaminated that it adversely affects the operation of the apparatus.

In comparison to mineral insulating oil, askarel is a relatively polar material; that is, its molecules are dipoles, free to rotate around their axes and responsive to orientation by electrical forces. Askarel also exhibits a much higher dielectric constant and capacitance than insulating oil, and these differences must

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be kept in mind when interpreting electrical test data.

Because it is relatively polar and possesses high solvency power, askarel is much more electrically sensitive to trace contaminants than insulating oil, and consequently the choice of constructional materials destined for use in askarel is very critical. This sensitivity is reflected in the power factor and resistivity (specific resistance) of the askarel.

It is important to note that, with the exception of water, the dielectric breakdown voltage of askarel is not generally adversely affected by many of the contaminants to which its power factor and resistivity (specific resistance) are so sensitive. In fact, the dielectric breakdown voltage of askarel is somewhat greater than that of insulating oil. Therefore, the values assigned these dielectric fluids in newly supplied transformers are 30 kV minimum and 26 kV minimum, respectively.

As with insulating oil, askarel must be kept dry. It can pick up moisture from exposure to humid atmosphere. Under similar conditions of exposure, askarel can pick up nearly twice as much moisture when measured on a parts per million weight basis.

A final obvious difference is that askarel is about one and one half times as heavy as water, whereas mineral oil is lighter than water. This means that any free water present will float on askarel, whereas free water in oil will be at the bottom.

3. Evaluation of Askarel Received in New Equipment

Some users of askarel equipment find it desirable to make "as received tests" on all equipment. It is quite common to use the dielectric breakdown voltage test and visual appearance as the most significant tests. If suitable equipment and trained personnel are available, additional information may be obtained from the power factor, color, and moisture content tests.

In sampling askarel contained in apparatus, extreme care must be exercised in order to obtain a representative sample. ASTM Standard D 923-70 (ANSI C59.21-1973), Sampling Electrical Insulating Liquids,[1] should be followed.

New equipment with askarel exhibiting the characteristics given in Table 1 is considered acceptable.

The significance of the foregoing and other tests listed in this guide are discussed in Section 7.

4. Classification of Service-Aged Askarel

It is extremely difficult, if not impossible, to indicate the value of specific tests and recommended test limits for all possible existing applications of askarel. It should also be recognized that with the present state of knowledge no one test can be used as the sole criterion of condition of askarel. It is possible, however, to summarize the value and importance of current tests and to suggest methods of treatment for the askarel being examined, such methods being based on current industry experience. Askarel may be placed in the following classifications based upon composite evaluation of significant characteristics and on field and laboratory screening tests.

Group I. This group contains askarel which is in satisfactory condition for continued use.

Group II. This group contains askarel which requires only minor reconditioning for further service. (Reconditioning is the removal of moisture and insoluble contaminants. The usual method employed is filtration.)

Group III. This group contains askarel in poor condition. It should be reclaimed or discarded depending upon economic considerations. (Reclamation involves the use of methods and processes which result in a purification of the askarel. Treatment with an absorbing agent such as fuller's earth is most widely used.)

Group IV. This group contains askarel in such poor condition and requiring such dras-

[1] ASTM Standards referred to in this guide are obtainable from Headquarters, American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa, and from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

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Table 1
Acceptable Characteristics of Askarel in New Equipment

Characteristics		ASTM Standards
Dielectric breakdown voltage	30 kV minimum	D 877-67 (1971) (ANSI C59.19-1968) (R1973)
Color	300 maximum (straw color)	D 2129-64 (1969) (*ANSI C59.114-1970*)
Visual condition	clear	D 1702-66 (1971) (ANSI C59.104-1970)
Water content	35 parts per million max	D 1533-61 (1969) (ANSI C59.53-1963 (R1969))
Power factor at 25°C	*	D 924-65 (1969) (*ANSI C59.22-1967*) (*R1973*) D 150-70

*The power factor of askarel taken from new transformers, reactors, and accessory equipment can reflect the presence of moisture, dissolved polar compounds, or other contaminants and may vary with the type of equipment from which the sample was taken due to the different ratios of liquid-to-solid insulation and to the high solvency power of the askarel. Given an acceptable water content and dielectric breakdown voltage of the askarel as indicated above, a high power factor seldom impairs the serviceability of the askarel within rather broad limits and is indicative of the degree of contamination present.

Recognizing the possibility of a wide range of power factors being recorded for askarel in new equipment, it is difficult to establish a single limit which would be acceptable to both suppliers and users for all applications. However, as a broad guide, power factors up to about 10 percent at 25°C and 60 Hz do not in general indicate any abnormal contamination providing that the other criteria (water content, dielectric breakdown voltage, etc) are met. Much higher power factors may indicate excessive contamination or the misapplication of the solid materials used in manufacture in contact with the askarel and should be investigated.

tic treatment that it is not feasible either technically or economically to attempt reclamation. Examples of such a condition would be a severely arced or excessively oil contaminated askarel.

5. Economic Factors

In this section of the guide, askarel is classified on the basis of significant characteristics. Many of the undesirable characteristics of used askarel can be corrected by reconditioning or reclaiming, if economic conditions justify it. The alternate choice is to replace with new askarel.

A review of the experiences of many users of electric equipment reveals a wide variation in the actual cost data involved in the reconditioning or reclaiming of askarel. This variation can be attributed to the amount and condition of askarel involved, laboratory and shop facilities, whether the work is performed at one central or several distant locations, and the availability of qualified personnel.

Askarel that contains water and insoluble contaminants can be reconditioned by mechanical means using various filter devices. If soluble or colloidal contaminants, or both, are present in the askarel, reclaiming can be done with special filtering devices or a special filter press using a material such as fuller's earth.

To determine if reconditioning or reclaiming of askarel is economically justifiable, a number of factors must be considered. Some of these factors are as follows:

(1) Value of askarel being considered for processing

(2) Cost of processing materials

(3) Total cost of process versus quality of end product

(4) Equipment maintenance and amortization

(5) Cost of collection and storage

(6) Labor and transportation costs

(7) Laboratory cost

(8) Loss of askarel during processing

(9) Cost of scavengers and makeup of chemicals if addition is necessary and desirable

(10) Cost of disposing of processing material and scrap askarel

(11) Cost of new askarel delivered at job site

6. Sampling

Representative samples, whether of the complete contents or only parts thereof, are extremely important from the standpoint of evaluation of the quality of the product sampled. Obviously careless sampling procedure or contamination in the sampling equipment will result in a sample that is not truly repre-

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sentative. This generally leads to erroneous conclusions concerning quality and incurs loss of time, effort, and expense involved in securing, transporting, and testing the sample. It is strongly recommended that all of the procedures and precautions outlined in ASTM D 923-70 (ANSI C59.21-1973) or in the latest revision thereof approved by the American National Standards Institute be followed.

Because of the high specific gravity (relative density) of askarel (greater than 1), water and some other impurities are most likely to be found at or near the surface. The top sample, therefore, is considered to represent the worst condition.

7. Askarel Tests and Their Significance

There are a number of tests that can be applied to askarels as a basis for their classification as indicated in the foregoing. These tests and their significance are given in Table 2.

(1) Color. The color of askarel is represented by a numerical value based on comparison with a series of numbered color standards with transmitted light under prescribed conditions. Color is chiefly significant as an indicator of contamination in askarel. Frequently this contamination is the result of solvent action between the askarel and other materials in the apparatus involved. No definite relationship can be established between color and the physical and electrical characteristics of the liquid.

(2) Dielectric Breakdown Voltage. The dielectric breakdown voltage of askarel may be defined as the voltage at which electrical breakdown of the material occurs under prescribed conditions. The dielectric breakdown voltage of askarel is of importance as a measure of its ability to withstand electrical stress without failure. It may also indicate the presence of contaminating materials, such as water, conducting particles, dissolved contaminants, or the decomposition products resulting from an electric arc. A high dielectric breakdown voltage, however, is not a certain indication of the absence of all contaminants.

(3) Flash and Fire Point. The flash point of askarel is the temperature to which askarel must be heated in order to give off sufficient vapor to form a flammable mixture with air under the conditions of the test. Askarels have a flash point which is not indicative of a hazardous condition unless followed by a fire point.

The fire point of a material that emits combustible vapor may be defined as the temperature to which the material must be heated in order to support continuous combusion when exposed to the atmosphere under prescribed conditions. Askarels have no fire point. The test is only of value, therefore, in showing whether the material has the nonflammable characteristics required of an askarel, or has a large amount of combustible contaminant.

(4) Inorganic Chlorides. In the presence of water, chlorides can ionize. Their corrosive action can then be detrimental to the life of the apparatus in which the askarel is used. The presence of ionizable chlorides may be indicative of arc decomposition of the askarel.

(5) Neutralization Number. In the inspection of new askarels, the neutralization value is of importance as a quality index of purity.

Since askarel is not subject to deterioration by oxidation, small changes in the neutralization value of service-aged askarels may indicate the solution of basic or acidic materials from the various solid materials in contact with the askarel or the deterioration of such soluble materials to form basic or acidic materials. A large change in acidity may indicate decomposition of the askarel by an electric arc.

(6) Pour Point. The pour point of askarel may be defined as the temperature to which the liquid just flows under prescribed conditions of test. The pour point has little significance as far as contamination or deterioration is concerned but may be used for type identification.

(7) Power Factor. Power factor is the ratio of the power dissipated in the askarel in watts to the product of the effective voltage and current in volt-amperes, when tested with a sinusoidal field under prescribed conditions. Since askarel is not subject to oxidation, an increase of power factor value of the askarel in service may be attributed to the presence of moisture, dissolved polar compounds, or other contaminants. Depending upon the type of ap-

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Table 2
Askarel Tests to Determine Classification

Tests	ASTM Standards
(1) Color	D 2129-64 (1969)(ANSI C59.114-1970)
(2) Dielectric breakdown voltage	D 877-67 (1971)(ANSI C59.19-1968 (R1973))
(3) Flash and fire point	D 92-72
(4) Inorganic chlorides	D 1821-63 (1969)(ANSI C59.55-1963 (R1969))
(5) Neutralization number	D 974-64 (1968)(ANSI Z11.131-1964 (R1971)) D 664-58 (1968)(ANSI Z11.59-1958 (R1971))
(6) Pour point	D 97-66 (1971)(ANSI Z11.5-1966 (R1972))
(7) Power factor	D 924-65 (1969)(ANSI C59.22-1967 (R1973)) D 150-70
(8) Refractive index	D 1807-64 (1969)(ANSI C59.105-1970)
(9) Resistivity (specific resistance)	D 1169-64 (1969)(ANSI C59.51-1965 (R1969))
(10) Scavenger content	D 1701-69
(11) Specific gravity (relative density)	D 1810-63 (1970) (ANSI C59.68-1965 (R1969))
(12) Viscosity	D 88-56 (1968)(ANSI Z11.2-1956 (R1971)) D 445-72 (ANSI Z11.107-1973)
(13) Visual examination of service-aged askarels in the field	D 1702-66 (1971)(ANSI C59.104-1970)
(14) Volume of oil in oil-contaminated askarel	D 1808-63 (1969)(ANSI C59.67-1965 (R1969))
(15) Water content	D 1533-61 (1969)(ANSI C59.33-1963 (R1969))

paratus and application, high power factor due to contamination other than moisture seldom impairs the serviceability of the askarel. However, the high power factor may influence the transformer winding power factor.

(8) Refractive Index. Refractive index is defined as the ratio of the velocity of light in air to its velocity in the substance under prescribed conditions. The refractive index of askarel varies with its composition and with the nature and amount of contaminants held in solution. Changes of refractive index of askarel in service may be useful in estimating compositional change and degree of soluble contamination.

(9) Resistivity (Specific Resistance). Volume resistivity (specific resistance), in ohm-centimeters, of askarel is the ratio of the dc potential gradient in volts per centimeter paralleling the current flow within the sample to the current density in amperes per square centimeter at a given instant of time and under prescribed conditions. The resistivity of askarel is a measure of its electrical insulating properties. High resistivity normally reflects low content of free ions and ion-forming particles and indicates a low concentration of conductive contaminants.

(10) Scavenger Content. Askarels are decomposed by an electric arc with the evolution of hydrogen chloride gas. A scavenger, which reacts chemically with dissolved hydrogen chloride gas to form a nonvolatile reaction product, may be added to an askarel and serves a useful function in improved preservation of the submerged portion of the apparatus should an arc occur. Measurement of scavenger content indicates the amount of protection available against dissolved arc-formed gases and permits estimation of the amount of makeup additive required.

(11) Specific Gravity (Relative Density). The specific gravity (relative density) of an askarel is the ratio of the weights of equal volumes of askarel and water at 15.56° C. Specific gravity (relative density) may be useful for type identification or to determine marked compositional changes.

(12) Viscosity. The viscosity of an askarel is its resistance to uniformly continuous flow, without turbulence, inertia, or other forces, and is usually determined by measuring the time of flow of a given quantity of liquid under controlled conditions. Viscosity of askarels varies with temperature, and for that reason is always designated at a specified temperature.

Viscosity is a controlling factor in the dissipation of heat by convection in insulating and cooling liquids. This is particularly important in transformers and other apparatus where heat generated in windings and cores must be largely removed by transmission through the liquid to a heat exchanger or the containing case. It is also a factor in the rate of impregnation of certain apparatus.

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(13) Visual Examination of Service-Aged Askarels in the Field. This method provides for field examination of service-aged askarels, sampled from equipment in service, chiefly for the purpose of determining whether laboratory tests are required. This method may be of significance in visually detecting cloudiness which is an indication of the presence of moisture, carbon particles, which may show an arcing condition, or color which is chiefly significant as an indicator of contamination in askarels. No definite relationship has been established between color and the physical and electrical characteristics of the liquid. By the use of this method it may be possible to extend the period between routine laboratory tests.

(14) Volume of Oil in Oil-Contaminated Askarel. The quantitative determination of the volume of oil in oil-contaminated askarel is important as a check on the degree of contamination and as a means of ascertaining when the nonflammable property of this fluid has been impaired to such an extent that it can no longer be classified as a nonflammable liquid.

(15) Water Content. The water content is that amount of water, expressed in parts per million by weight, which is present in the liquid. The test is significant in that it will show the presence of water which may not be evident from electrical tests. Changes in water content of askarel in service may be indicative of undesirable operating conditions requiring correction.

8. Testing Procedures

The testing of askarels is best accomplished in adequately equipped laboratories. However, some find it advantageous to make field screening tests.

8.1 Field Screening. Field screening tests are usually made to determine which samples of askarel may require laboratory investigation. Since most tests of askarel can be done best with laboratory equipment and trained personnel, field tests are usually limited to visual inspection and dielectric breakdown voltage.

No standardized procedure is available at the present time for performing field tests on service-aged askarel or for classification. Portable dielectric test sets have been available for some time and have proved satisfactory. In addition to the preceding tests, some operators with suitable field equipment and trained personnel may wish to gain additional information by use of a power factor test. In interpreting results of these tests, consideration must be given to other characteristics of the askarel.

8.2 Laboratory Screening. Askarel requiring laboratory evaluation will vary widely in condition, depending upon the degree of contamination. There are many tests of a research nature which could be applied, but the general use of such tests would be impractical. The following tests, therefore, are believed to be adequate for classifying service-aged askarel:

(1) Dielectric breakdown voltage
(2) Inorganic chlorides
(3) Neutralization number
(4) Power factor or resistivity (specific resistance)
(5) Specific gravity (relative density)
(6) Visual condition and color
(7) Water content

9. Reconditioning and Reclaiming Service-Aged Askarel

9.1 General. Askarel does not oxidize, sludge, or decompose in normal transformer use. It will break down when subjected to an electrical arc. If the arc exposure has been of long duration, it is usually best to discard the fluid.

However, when arc exposure has been relatively mild or if the askarel is merely contaminated with moisture and other conducting impurities, restoration is practical. An exception is the lack of a practical method for removing mineral oil from askarel. Askarel contaminated with over 2 percent by volume of transformer mineral oil may no longer be classified as a nonflammable liquid.

9.2 Treatment After Exposure to an Arc. When askarel is exposed to arcing, hydrogen chloride gas is liberated. Some hydrogen chloride will remain dissolved in the askarel and must be removed as quickly as possible.

This is done by bubbling about 220 ft^3 (6.23 m^3) (1 cylinder) of dry nitrogen through each 100 gal (3.785 m^3) of askarel. The nitrogen

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should be admitted at the bottom of the tank or container vented sufficiently to allow the nitrogen to escape, while preventing entrance of moisture. This procedure for removing hydrogen chloride is recommended even though the askarel contains a hydrogen chloride scavenger.

9.3 Filtering Through Dry Blotter Paper to Remove Moisture and Extraneous Particles. Since undissolved moisture will be at the surface of the askarel, any simple means should be used to drain or siphon off excess water.

The final drying is done by circulating the askarel through dry blotter paper. The askarel temperature should not exceed 60°C. Several passes through multiple layers of freshly dried paper may be required. Filtering should not be done when the relative humidity exceeds 75 percent.

The filter paper must be dried immediately before use. For best results, the paper is spread for maximum surface exposure in a hot air circulating oven and heated for 4 to 6 h at 110°C.

After filtration the dielectric breakdown voltage of the askarel should be at least 35 kV.

9.4 Fuller's Earth Treatment for Maximum Improvement of Power Factor and Volume Resistivity. The askarel should be relatively dry prior to final refinement with conditioned fuller's earth.

Most operators prefer a portable fuller's earth refining apparatus such as a plate press or an earthen cartridge type filter. As this apparatus involves recirculation, the askarel should be removed from the top of the tank and returned at the bottom, because free moisture and most of the other undissolved contaminants will be found near the surface of the askarel. Since these recirculating procedures can introduce air into the askarel, sufficient time (at least 4 h and preferably over night) should be allowed for the air to escape before re-energizing the apparatus.

When a filter press is used, the plates are fitted with dry filter paper. This is coated with 0.1 to 0.2 percent by weight of dried fuller's earth based on the weight of askarel to be treated. (Askarel weighs nearly 13 pounds per U. S. gallon, 1556 kg/m^3.) The finely divided clay should be activated and dried to not over 1 percent of moisture by heating for 12 h in shallow trays at about 200° C, immediately prior to use.

To deposit the fuller's earth evenly, about one-third of the total quantity is stirred into a small portion of the askarel in a clean container. This mixture is pumped through the filter, then followed with two more one-third portions. Then the askarel is pumped from the top level of the tank, through the filter, and returned to the tank at the bottom. It is desirable that the askarel temperature not exceed 60°C during the filtering operation.

Circulation is continued until the fluid is clear and tests show that the electrical properties are fully restored.

9.5 Addition of Scavengers. Only slight loss (by selective absorption) of the hydrogen chloride scavengers occurs when askarel is refined by treatment with 0.2 percent by weight of fuller's earth at a temperature not above 60°C. Significant removal of the additives can result from treatment with much larger amounts of fuller's earth.

Initially 0.1 to 0.2 percent by weight of scavenger, usually an epoxide, is incorporated in modern transformer askarel. Inquiries about replenishing the additive should be directed to the transformer manufacturer, or to the supplier of the fluid.

10. Handling Materials

All common metals are satisfactory for use with askarel in dry environments. To avoid rust, it is preferable to use stainless steel or aluminum for filter presses or equipment used intermittently or in the presence of moisture.

Because stainless-steel piping may be difficult to fabricate, the use of aluminum or galvanized steel is more common.

Pipe connections should be welded wherever possible. Flanged connections are very good when fitted with a sufficient number of bolts to hold the gasket seal securely.

Where readily removable connections are needed, deep pipe threads should be cut and wrapped with tetrafluoroethylene tape[1] to make the seal.

[1]Such as *Teflon*.

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In addition to tetrafluoroethylene, other materials completely compatible with askarel and suitable for gaskets are certain elastomers[3] and stainless-steel rings with an acceptable elastomer[4] between the steel laminations. Silicone elastomer does not have good abrasive resistance and it is not suitable for use with mineral oil. Fluoroelastomers[5] have relatively good abrasion resistance and are resistant to both askarel and mineral oil.

If a fine-grain cork-nitrile rubber-composition gasket is used, it is desirable to coat the exterior of the seal with room-temperature curing epoxy cement or RTV silicone cement.

Well-cured or dried adhesive cements of dewaxed orange shellac, dextrine glue, polyvinyl alcohol acetate,[6] phenolic or epoxy, are relatively noncontaminating to askarel.

Suitable hoses are those of the flexible metal type, or those in which only tetrafluoroethylene[4] or silicone polymers are in contact with the askarel.

The preferred valves are those in which only stainless steel is in contact with the askarel. Where required, the stainless-steel valve may be seated with tetrafluoroethylene.[4] Also brass valves are acceptable.

Asbestos graphite packing[7] is suitable valve stem packing.

Centrifugal pumps suitable for handling hot oil are the recommended type. Gear type pumps are not desirable. All wetted surfaces of the pump should be of stainless steel. The shaft seal should be the external mechanical (carbon ring) type to eliminate packing material and its exposure to askarel. All askarel handling equipment should be reserved solely for use with askarel, and should not be used interchangeably with mineral oil.

11. Askarel Used Under Mild Arcing Conditions

Askarel is used, to some extent, in apparatus where it is subjected to light, intermittent arcing, such as in self-contained induction regulators, where operating switches are continually producing slight arcs, in transformer de-energizing switches, etc. Under normal operating conditions, deterioration of the askarel is very slight. However, improperly adjusted or defective switches in this type of apparatus can produce excessive and prolonged arcing and accelerated deterioration of the askarel. It is recommended that when askarel is used under these conditions, checks of the liquid, especially for moisture and dielectric strength, be made more frequently than when it is used only as a cooling and insulating fluid. Deterioration of this type is indicated by a blackening of the liquid. It can usually be reconditioned as previously described. Special attention should be given to maintaining the scavenger at the appropriate concentration.

12. Askarel Under Excessive Temperature or Fault Conditions

Chlorobenzenes used in transformer askarels begin to boil at temperatures of about 205°C under atmospheric conditions. If the material is heated to such high temperature in a sealed system, pressure develops. Pressure will also develop in the system if the askarel is arced sufficiently to generate copious hydrogen chloride gas.

Therefore, it is recommended that wherever possible, sealed askarel-filled equipment be provided with pressure relief devices. These devices must be large enough to provide immediate relief at a definite pressure, and to prevent further buildup of pressure if decomposition continues. It must be remembered that the presence of devices of this sort does not necessarily preclude the rupturing of containing vessels, since pressure buildup can be extremely rapid under violent arcing conditions.

13. Recommended Handling Precautions

It is generally accepted that the exposure to askarel is not hazardous, provided simple precautions are taken. Most people can handle askarel in the same manner as insulating oil without fear of adverse effects. Some people

[3] Such as Viton and Silastic.
[4] Such as Viton, Teflon, or silicone.
[5] Such as Viton.
[6] Such as Elvanol.
[7] Such as number 117 braided Garlock type, or Raybestos Manhattan type 365-C.

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are allergic to askarel, and continued exposure may result in skin irritation. Therefore, direct contact with askarel and its vapors, particularly when hot, should be avoided. This, combined with personal cleanliness, should constitute an adequate safeguard against harmful effects. Eye protection (glasses, shields, etc) are required. The use of any type glove should be avoided. Medicinal washes or detergents followed by an application of cold cream or silicone-bearing hand lotions[a] have been successfully used to eliminate irritation resulting from askarel coming into contact with an open cut or skin abrasion. A drop of castor oil has been found to neutralize, in most cases, irritation caused by contact of askarel with the eyes.

Exposure to concentrated askarel vapors should be avoided, particularly in closed unventilated rooms. As with many volatile liquids, the vaporization of askarel increases rapidly with temperature. Therefore, ventilation which is adequate for handling askarel at room temperature may not be adequate for handling askarel at elevated temperatures. The gases produced when askarel is decomposed by very high temperatures or an electric arc in the presence of air or organic insulating materials contain a high percentage of hydrogen chloride and small percentages of carbon dioxide, carbon monoxide, and oxygen. Very small concentrations of this combination of gases are very unpleasant and irritating, thus giving ample warning of their presence. The all-purpose canister-type gas masks are suitable for protection from gases liberated from decomposed askarel.

14. Storage, Handling, and Disposal

Transformer askarel can be handled in about the same manner as transformer mineral oil.

14.1 Drums. The askarel drum is made of steel lined with a specially selected material properly cured. Galvanized drums may also be used.

Askarel must be kept dry. It can pick up moisture from contact with humid air. Drums of askarel should not be stored outdoors in an upright position, as water can collect in the dish of the drum head and can be drawn into the drum under certain conditions. Drums should be stored on their sides with the bungs downward and under cover. It is preferable to store drums indoors.

Askarel should not be transferred into drums that have previously contained other materials.

14.2 Tank Cars. Tank cars are solid aluminum, or steel lined with aluminum, or a zinc-tin coating.

It is desirable to provide canopies for unloading askarel cars. The car should not be opened in the rain or snow. It is desirable to not open the car if the relative humidity exceeds 75 percent. Precautions must always be taken to exclude dirt.

14.3 Sampling. See Section 6 for a discussion of sampling.

14.4 Effect of Light Exposure. Prolonged exposure to ultraviolet light (sunlight, some fluorescent lights) should be avoided. Askarel can decompose under such conditions. Sample bottles are preferably of the amber glass type.

14.5 Disposal. Methods for disposal are given in Draft American National Standard, Guidelines for Handling and Disposal of Capacitor and Transformer-Grade Askarels Containing Polychlorinated Biphenyls, C107.1.

15. Underwriters' Laboratories Reports

The Underwriters' Laboratories have exhaustively examined, at the electrical manufacturers' requests, the miscellaneous hazards involved in the use of askarel and askarel-filled apparatus. Reports have been issued to the respective manufacturers covering the trade-named askarels being considered. It is suggested that interested users of transformer askarel contact the manufacturers for this information.

[a] Such as Silicare.

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Appendix

Results of Survey of United States and Canadian Users of Transformer Askarel

(This appendix is not a part of IEEE Std 76-1974, IEEE Guide for Acceptance and Maintenance of Transformer Askarel in Equipment.)

A1. General

This survey of the United States and Canadian users of askarels was made in 1966 in order to show the practices followed in testing, reconditioning, and reclaiming of askarels. Of the 96 inquiries sent out, 50 replies were received with usable information, which is a 52 percent return. All of the following data are shown as a percentage of those returning the questionnaires and it should be pointed out that this includes information from both manufacturers as well as users and no attempt has been made to classify them according to the size of the systems involved.

Of the users of askarels who returned the questionnaire, 32 percent make only field tests; 32 percent make only laboratory tests; 24 percent make both field and laboratory tests; and 12 percent make no tests at all on askarels. Most all make tests at a fixed time interval and the largest group follow a yearly schedule. Of those users returning the questionnaire, 67 percent recondition askarel, which is below acceptable limits, and the most popular method employs the combination fuller's earth and blotter press.

This survey was made purposely to determine the types of tests being made by askarel users and to give an indication of acceptable limits. The following data are the overall results of the questionnaire.

A1.1 Field Tests for Askarel. Of askarel users, 66 percent do some type of field testing. Of these, 93 percent make a test for dielectric breakdown voltage.

At least two field tests are made by 57 percent as follows:

(1) Dielectric breakdown voltage
(2) Visual examination and color

Other tests used in decreasing order of frequency are power factor, neutralization number, and moisture.

A1.2 Laboratory Testing for Askarel. Of askarel users, 56 percent make an average of four tests in their laboratories on samples. Of these, 93 percent determine the dielectric breakdown voltage.

At least four tests are made by 64 percent as follows:

(1) Dielectric breakdown voltage
(2) Color and condition
(3) Neutralization number
(4) Moisture content
(5) Power factor

Other tests used in decreasing order of frequency are inorganic chlorides, resistivity (specific resistance), and specific gravity (relative density).

A1.3 Askarel in New Equipment. Of the users, 80 percent test the dielectric breakdown voltage of askarel in new equipment. Also tested by 22 percent are the following:

(1) Power factor
(2) Moisture

Other tests used in decreasing order of frequency are neutralization number, inorganic chlorides, and resistivity (specific resistance).

A2. Testing

Most reporting companies test used askarels and approximately

(1) 32 percent use only field tests
(2) 32 percent use only laboratory tests
(3) 24 percent use both field and laboratory tests
(4) 12 percent do not test

The relative importance of the field tests are as follows:

(1) 93 percent dielectric breakdown voltage
(2) 40 percent color and visual examination
(3) 14 percent power factor
(4) 11 percent neutralization number

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The average limits on service-aged samples are as follows:

(1) Dielectric breakdown voltage: average 27 kV, range 20 to 35 kV

(2) Power factor: average 10 percent, range 2 to 40 percent

(3) Neutralization number: average 0.12, range 0.05 to 0.5.

(4) Inorganic chlorides: average 0.5, range 0.01 to 2.0

(5) Moisture: average 45 parts per million, range 40 to 55 parts per million

The average limits on askarel in new equipment are as follows:

(1) Dielectric breakdown voltage: average 30 kV, range 22.5 to 35 kV

(2) Power factor: average 3 percent, range 0.05 to 5 percent.

(3) Moisture: average 32.5 parts per million, range 20 to 50 parts per million

A3. Reconditioning

Of the users of askarel returning the questionnaire, 67 percent recondition askarel from transformers:

(1) 73.5 percent prefer the combination fuller's earth-blotter press

(2) 17.5 percent use only the blotter press

(3) 9 percent use only fuller's earth

The average limits on reconditioned askarels, are as follows:

(1) Dielectric breakdown voltage: average 29 kV, range 23 to 35 kV

(2) Power factor: average 3.5 percent, range 2 to 15 percent

(3) Neutralization number: average 0.10, range 0.01 to 0.5

(4) Moisture: average 35 parts per million, range 30 to 50 parts per million

A4. Frequency of Testing

The frequency of testing practiced by askarel users is as follows:

(1) 53 percent test every year

(2) 17.5 percent test every 5 years

(3) 17.5 percent test when there is a reason for testing

(4) 9 percent test every 2 years

(5) 3 percent test every 6 months

Most users test all askarel units at the same interval regardless of rating.

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The average limits on service-aged samples are as follows:

(1) Dielectric breakdown voltage: average 27 kV, range 20 to 35 kV

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