SECTION SEVEN

ASKAREL TEST AND MAINTENANCE GUIDE

ASKAREL TEST
AND
MAINTENANCE GUIDE

GENERAL

This guide is intended to cover problems encountered with askarel-filled bushings, disconnect switches, and transformers and the askarel used therein, by operating and maintenance departments of utilities. No attempt has been made to cover other askarel-filled devices, e.g., cables, capacitors, etc., since the askarel used in these devices is usually somewhat different chemically, electrically and/or physically, and they present different test and maintenance problems.

The test and maintenance programs of askarel consumers vary from no tests or preventative maintenance, in the case of most small industrial plants having only one or two relatively inexpensive low-voltage, askarel-filled devices, to very complete acceptance and periodic tests and a comprehensive preventative maintenance program in the case of some large utilities. The majority of industrial plants and small utilities make only dielectric-strength tests on askarel samples. The extent of the askarel test and maintenance programs of any askarel consumer should be based on economics. A utility operating several askarel-filled bushings cannot justify the askarel test and maintenance programs of a utility having thousands of gallons of askarel in service in disconnect switches and transformers. Consideration of these facts, variables resulting from local conditions and the wide variation in the cost of various askarel-filled devices, illustrate the difficulty of attempting to recommend test and maintenance programs for askarel consumers.

To assist consumers in developing economical, practical askarel test and maintenance programs, the properties, application, and hazards of askarel are cited. Methods of handling, storing, sampling, and treating are described. The various askarel tests in general use are discussed and their significance, if known, is given.

PROPERTIES

The term "askarel" describes a broad class of non-flammable, synthetic, halogenated, hydrocarbon, insulating liquids processed by the Monsanto Chemical Company that have been used for over 30 years as an insulation and coolant in electrical apparatus and cables. This inert compound is chemical and heat-stable, fire-resistant, non-corrosive, and has high dielectric strength under normal operating conditions in electrical apparatus and cables. Numerous manufacturers of electrical apparatus and cables have their own trade name for the askarels they supply, e.g., Chlorextol, Dykanol, Inerteen, Noflamol, and Pyranol. In specifying a specific askarel, it is necessary to specify the designation and trade name, since some trade names cover a number of different types of askarel. The chemical, electrical, and physical properties of askarels vary widely as indicated by the following examples which are not all-inclusive:

PROPERTY	RANGE
Dielectric Constant	4.0 to 5.0 at 25°C
Electrical Resistivity	10^{11} ohms/CM^3 minimum at 100°C & 500 volts d-c
Pour Point	-44°C to +10°C
Physical	Resin-like, non-crystalline composition to thin, mobile liquids
Specific Gravity	1.50 to 1.58 (15.5/15.5°C)
Viscosity	43 to 100,000 seconds at 37.8°C (SUS)

Other properties of askarel are given under the heading "SPECIFICATIONS." At low temperatures, i.e., well below zero degrees C., the dielectric constant of askarel is approximately equal to the dielectric constant of insulating oil. At higher temperatures there is a region of anomalous dispersion in which the dielectric constant of askarel increases. From room-temperature to the maximum practical operating temperature, the dielectric constant of askarel is approximately twice the dielectric constant of insulating oil. It is advantageous, in the design of some electric devices, that the dielectric constants of askarel and cellulose insulation are approximately the same. Askarel is mixed with insulating oil to obtain a liquid insulation having the optimum dielectric constant for filling some types of bushings. Such mixtures are flammable.

Fortunately, there are only two types of askarels used in transformers, Pyranol-1470 and Inerteen-PPO. Askarels for transformers with other trade names will be identical with one of these askarels. The significant difference in these askarels are their pour points and the chloride "scavenger" compounds. However, these two types of askarels can be mixed in any proportion without any undesirable effects.

The solubility of water in new askarel is approximately 125 ppm at 25°C which is greater than in new insulating oil. As askarel ages, there is very little increase in the solubility of water in it; whereas the solubility of water in insulating oil increases rapidly as the oil ages and deteriorates. The solubility of water in askarel, as in insulating oil, increases rapidly with temperature. Askarel demulsifies more than twice as fast as oil and since it is much heavier than water, water rapidly rises to its surface. Askarel has a greater affinity than insulating oil for moisture. It will transmit more moisture to cellulose insulation than insulating oil will under the same conditions. The insulation in an askarel-filled transformer is more difficult to dry than insulation in an oil-filled transformer.

An outstanding advantage of askarel is that in addition to having excellent dielectric properties, it is non-flammable and will not evolve explosive gaseous mixtures when disintegrated either by extreme heat or by an electric arc. It is inherently stable, thus eliminating the oxidation and sludging experienced with insulating oil. Askarel is non-corrosive and will not deteriorate cellulose insulation. Insulating oil and other petroleum products are completely miscible with askarel. Small quantities affect its non-flammable properties. Contamination of askarel with any petroleum product should be carefully avoided, particularly since it is practically impossible to separate askarel from petroleum products. In the case of mixtures of askarel and insulating oil, contamination with any petroleum product may seriously alter the dielectric constant and result in an operating hazard. The addition of only two per cent insulating oil to askarel will decrease its fire resistance.

When askarel is subjected either to temperatures in excess of 200°C or to an electric arc it disintegrates and hydrogen-chloride gas is formed. Hydrogen-chloride gas dissolves in water and forms hydrochloric acid, the strength depending upon the ratio of hydrogen-chloride gas to water. Hydrochloric acid quickly attacks metallic parts and rapidly deteriorates cellulose insulation of electrical devices. This undesirable characteristic can be mitigated by the addition of a fraction of one per cent of a hydrogen-chloride "scavenger" which has no appreciable effect on the properties of askarel.

If askarel is exposed to an electric arc in a closed vessel, high pressures are created because the volume of the products of disintegration are greater than the volume of the askarel. Where the arcing is severe, the vessel will rupture unless it has a suitable pressure-relief device. In case of violent arcing that results in extremely rapid pressure buildup, vessels with pressure-relief devices may rupture.

DSW 357981

Askarel is an excellent solvent for many materials which perform satisfactorily in insulating oil, including paint, varnishes, gums, resins, some plastics, and many of the rubber and rubber-like materials. Such materials should neither be used in askarel-filled devices nor be allowed to contact askarel under any condition. Materials such as asphalts asphalt-base materials, moisture, and other foreign matter which contaminate insulating oil also contaminate askarel. It is, therefore, essential that askarel-filled devices be insulated with pure cellulose, untreated paper and cotton, porcelain, and other materials that neither affect nor are affected by askarel. Likewise, it is essential that cork gaskets or gaskets of other material that neither affect nor are affected by askarel be used in askarel-filled devices.

HAZARDS

It is not hazardous to handle askarel provided simple precautions are taken. Actually, it is handled practically the same as insulating oil. Unlike insulating oil, there is no fire hazard in handling askarel. Most people can handle askarel in the same manner as insulating oil without fear of toxic effects. Like insulating oil, some people are allergic to askarel and continued exposure will result in local skin irritation. Avoiding unnecessary contact with askarel and its vapor, particularly when it is hot, and cleanliness of workmen handling askarel, constitute adequate safeguards against such effects. Medicinal washes or detergents followed by an application of cold cream will eliminate any irritation resulting from askarel coming into contact with an open cut or skin abrasion. A drop of castor oil will neutralize any irritation caused by contact of askarel with the eyes. There is no evidence that ordinary exposure to askarel vapors results in any ill effects. However, like other volatile materials, exposure to concentrated askarel-vapors should be avoided, particularly in closed, unventilated rooms. The odor of askarel vapor should give sufficient warning of a hazardous concentration of askarel vapor. As with many volatile liquids, the vaporization of askarel increases rapidly with temperature. Therefore, ventilation, which is adequate for handling askarel at room temperatures, probably will not be adequate for handling askarel at elevated temperatures.

The gases produced when askarel is disintegrated by very high temperatures or an electric arc contain a high percentage of hydrogen chloride, a small percentage of carbon dioxide, carbon monoxide and oxygen and, in some cases, a small amount of phosgene. Very small concentrations of this combination of gases are very unpleasant and irritating, thus giving ample warning of their presence and preventing dangerous exposure of persons. The "all-purpose" gas-masks, available for use around oil-filled devices, offer ample protection from gases liberated from disintegrated askarel.

APPLICATION

Askarel-filled transformers should preferably be installed in well-ventilated enclosures. Where necessary, a pipe may be run from the pressure-relief device to the outside of the building to safely dispose of the gases resulting from askarel disintegration. This pipe should not be smaller than the pressure-relief device and should contain the minimum practical number of elbows. Where such piping or adequately-ventilated enclosures are impractical, gas absorbers may be used. Fireproof vaults are not required for askarel-filled transformers.

The temperature of the top askarel in transformers should not exceed 90°C. Askarel-filled transformers should be operated and loaded in accordance with the American Standards Association Designation C-57.

The effects of moisture on askarel-filled devices are even worse than on oil-filled devices. Water is more soluble in askarel than in insulating oil. The water solubility increases rapidly with temperature. In an askarel-filled device, water will float on the top of the askarel. In a transformer, water floats on top of the askarel where the temperature is high during operation, thus saturating the top askarel with water at a relatively high temperature. As askarel circulates in the transformer due to the temperature difference between the top and bottom of the radiator tubes, askarel saturated with water at high temperatures flows to cooler parts of the transformer tank where part of the water condenses out of the askarel. Some of the water will rise to the top of the askarel and some will be attracted into the cellulose insulation of the transformer by the electrostatic field. Since cellulose has a higher affinity for water than askarel, water can be removed from cellulose insulation in askarel only by very high winding temperatures. For these reasons, askarel-filled devices are generally sealed with a positive pressure of nitrogen maintained over the askarel. Sealing askarel-filled devices also insures against the loss of volatile fractions of askarel.

Hydrogen chloride detectors are available for mounting in the top of askarel-filled transformers. They will operate when a small amount of hydrogen chloride is evolved from askarel due to a very small arc. These detectors may be applied either to sound an alarm or to de-energize the transformer. They are affected only by hydrogen chloride. Pressure detectors are much slower than these detectors. The use of hydrogen-chloride detectors to de-energize askarel-filled transformers will insure the minimum deterioration of askarel due to an arc.

CONTAMINATION

Much greater care must be taken in applying, handling, storing, sampling, and testing askarel than is generally taken with insulating oil, since askarel is more susceptible to contamination and is more hygroscopic than insulating oil. Generally, askarel-filled devices and storage containers are sealed to insure against the entrance of moisture. The maintenance of a slight positive nitrogen-pressure over askarel will insure against breathing.

The contamination of askarel by many materials, i.e., asphalts, asphalt-base materials, varnishes, gums, resins, dirt, and other foreign matter, some plastics, rubber and some rubber-like materials, is usually apparent upon visual examination of a small sample. Such contamination, with the possible exception of dirt and some other foreign matter, can be readily detected with power-factor tests on small samples. As with insulating oil, the presence of suspended water and some foreign matter can be detected with dielectric-strength tests. Under some conditions, the Cloud-Point test is useful for detecting suspended and dissolved water in askarel.

Contamination of askarel by insulating oil and other petroleum products is usually determined by Fire-Point (D-92) or preferably by Volume of Oil in Oil-Contaminated Askarels (D-1808) tests, the latter being the most sensitive test for slight contamination. It has been reported that accurate measurements of the Refractive Index (D-1807) of a sample of askarel that is not contaminated and an identical sample contaminated with a slight amount of insulating oil or other petroleum product may be different.

Disconnect switches filled with askarel and transformer taps under askarel should not be operated while they are energized. Such operation will disintegrate the askarel; and if it does not contain a hydrogen-chloride "scavenger," rapid deterioration of insulation and severe corrosion of metallic parts will occur. If the askarel contains a hydrogen-chloride "scavenger," such operation will use up the "scavenger" which may be badly needed later.

STANDARD TEST METHODS

The American Society for Testing and Materials (1916 Race Street, Philadelphia Pennsylvania - 19103), Committee D-27 on Electrical Insulating Liquids and Gases, has developed numerous methods of tests for askarels which have been published. These test methods cover all tests on askarel that are generally used today by askarel consumers. Many of their test methods have been approved as American Standard by the American Standards Association. All ASTM test methods are periodically reviewed and are revised when advantageous. Additional test methods are developed as required. Since ASTM askarel test-methods are readily available at a nominal price, they will be frequently referred to but not duplicated herein. Either separate copies of any ASTM test method or standard or various compilations of test methods and standards may be purchased by anyone from the ASTM in any quantity.

It is recommended that all askarel tests be made in exact accordance with the applicable ASTM test methods. If ASTM methods are carefully followed, accurate results will be obtained. The use of ASTM methods will permit correlation of results of two or more laboratories which is advantageous when determining limits of test values. This may be impractical for some field tests. However, field tests are, in general, screening tests used only to determine whether askarel samples should be sent to a laboratory for more complete and more accurate tests.

It is essential that consumers use applicable ASTM test methods in making acceptance tests on askarel. These test methods are in general use in the industry and are invariably referred to in purchase specifications. The use of other test methods usually result either in a disagreement with the supplier or test results that are not indicative of the true properties of the askarel.

SPECIFICATIONS

The specifications shown on Table I are suitable for procuring either type of askarel for transformers. In specifying other types of askarel, it is probably the best practice to follow the recommendations of the electrical apparatus manufacturer.

TESTS UPON RECEIPT

Upon receipt, bushings filled with askarel or a mixture of askarel and insulating oil should be inspected and tested in the same manner as similar oil-filled bushings. Samples of askarel are rarely taken from bushings for tests unless there is some definite indication that such tests would be advantageous.

Askarel-filled transformers and disconnect switches should be inspected and tested upon receipt in the same manner as similar oil-filled devices. In addition, any device designed for operation with nitrogen over the askarel should be carefully tested for gas leaks. The most sensitive method of detecting nitrogen leaks is to add a small percentage of helium to the nitrogen and check the outside of the device for helium with a Mass Spectrometer. A less expensive method with good sensitivity is to add a small percentage of halogen gas, such as sulfur hexafluoride, and check the outside of the device with a Halogen Detector. Large leaks can, of course, be located by applying nitrogen pressure and soaping the exterior surface of the device. However, this method is useless for small leaks.

TABLE I

PROPERTIES	ASTM METHOD	PYRANOL 1470	INERTEEN PPO
Color, Max.	D-2129	150	150
Condition		Clear	Clear
Water Content, ppm, Max.	D-1533	30	30
Acidity, mg KOH/g, Max.	D-974	0.01	0.01
Dielectric Strength, 25°C, KV, Min.	D-877	35	35
Dielectric Constant, 100°C	D-924	3.8 to 4.3	3.7 to 4.0
Volume Resistivity, 100°C	D-1169	100	100
Hydrolyzable Chlorides, ppm, Max.	D-1820	1.0	1.0
Inorganic Chlorides, ppm, Max.	D-1821	0.10	0.10
Power Factor, 25°C, Per Cent, Max.	D-924	0.05	0.05
Refractive Index, 25°C	D-1807	1.6075 to 1.6085	1.6137 to 1.6147
Viscosity at 37.8°C, SUS	D-88	41 to 45	54 ± 2
Pour Point °C, Less Than	D-97	-44	-32
Specific Gravity 15.5/15.5°C	D-1810	1.563 to 1.571	1.560 to 1.568
Fire Point	D-92	None to Boiling	None to Boiling
Distillation range corrected for stem and barometric pressure	D-20	1st drop 210°C min. 35% 240 to 246 55% 290 to 330 65% 385 to 400 95% 395 to 415	1st drop 200°C min. 40% below 270°C 90% 395 to 415°C
Fixed Chlorine, Min		60.5 ± 5%	59.1%
Corrosion Test		After heating with aluminum for 6 hrs. at 200 to 220°C, the aluminum must not be corroded either on visual or weight inspection and the askarel should meet the following specifications:	
Color, Max.	D-2129	200	200
Acidity, mg KOH/g, Max.	D-974	0.01	0.01
Inorganic chlorides, ppm, Max.	D1821	5.0	2.0
Condition		Clear	Clear
Scavenger Content, Min.	D-1701	0.125% tin tetraphenyl	0.18 to 0.22% phenoxy propene oxide
Arc Formed Gases		Less than 1.0% of total combustible gases including carbon monoxide, hydrogen, and volatile hydrocarbons.	

When transformers are shipped without askarel, they are always filled with an inert gas such as nitrogen. The transformer should be checked to determine if it contains a positive pressure of nitrogen. The dew point of the nitrogen should be tested to detect the entrance of moisture. Before anyone enters the transformer tank, the gas should be completely displaced with air to insure against suffocation.

Under some temperature conditions askarel may condense on the surface of glass pressure-relief diaphragms and glass askarel-level gauges. Such condensation may appear to be water. Before condemning an askarel-filled device for being wet when such condensation is found, dielectric-strength and power-factor tests should be made on samples of askarel from the top of the device. If the results of these tests are satisfactory, the condensation is not water.

An askarel sample should be taken from the top and bottom of each askarel-filled transformer, disconnect switch, and container upon receipt. The samples should be visually examined and subjected to a dielectric-strength test. If the samples are not a clear, light-straw color, careful checks should be made to determine the source of contamination which should be quickly eliminated and the askarel should be treated in a manner that will remove the contaminant. If the dielectric strength should be less than 30-kv, the cause should be determined and remedied and the askarel should be treated to remove the moisture or other contaminant.

It is advantageous to make color and power-factor tests on new askarel. Power-factor tests are invaluable for detecting slight contamination of askarel. In the past, several manufacturers have inadvertently used askarel-soluble materials in askarel-filled devices. Where these materials were not found and eliminated prior to placing the devices in service, the devices have failed.

Where large quantities of askarel are purchased, it may be advantageous to subject several samples from the shipment to one or more of the following tests which are listed in the order of their apparent importance:

TEST	ASTM METHOD
Combustible Arc-Formed Gases or Fire Point	D-92
Hydrolyzable Chlorides	D-1820
Inorganic Chlorides	D-1821
Neutralization Number	D-974 or D-664
Pour Point	D-97
Scavenger Content	D-1701

Under some conditions the Refractive Index (D-1807) and Viscosity (D-88 or D-445) may be of interest.

It is suggested that all tests made periodically on askarel in service should also be made on each shipment of new askarel received whether required for the acceptance of new askarel or not. In making such tests, the same methods should be used that are used in making periodic tests. If periodic and acceptance test methods are different, tests using both methods should be made. Such test data is invaluable in detecting changes in askarel during its life.

DSW 357986

HANDLING AND STORAGE

Absolute cleanliness is even more essential in the handling and storage of askarel than in handling insulating oil, because askarel is more susceptible to contamination and is more hygroscopic than insulating oil. Askarel may be handled and stored in a manner similar to insulating oil, provided clean all-metal containers, piping, pumps, hose, fittings, etc., are used. During handling and storage it must not be allowed to contact nonmetallic material. It should preferably be handled in closed systems in a manner that will minimize aeration and the loss of volatile fractions of the askarel. Since askarel is very hygroscopic, it should not be exposed to humid air. It is recommended that complete separate facilities be provided for askarel and insulating oil to insure against contamination of askarel with insulating oil, as such contamination may result in a flammable, explosive mixture. It is possible, but rather impractical, to clean facilities normally used for handling and storing insulating oil sufficiently to insure against contamination of the askarel. If the facilities are used for storing and handling both insulating liquids, sooner or later someone will forget the essential cleaning job.

Where it is essential to clean handling and/or storage facilities used for insulating oil so that they can be used for handling and/or storing askarel, all oil should be carefully removed with a volatile solvent such as white gasoline, benzine, etc. Thorough cleaning will, no doubt, require several applications of the solvent. The solvent should be completely evaporated before using the facility for askarel to insure against contamination. Askarel-filled devices and askarel containers should not be opened unless the temperature of the askarel-filled device and container is higher than the ambient air temperature.

When necessary to store askarel-filled devices, they should be stored with askarel up to the normal operating level. They should be sealed and, if possible, there should be slight positive pressure of nitrogen over the askarel. It is essential to store askarel in sealed containers, preferably under dry nitrogen at a slight positive pressure. This insures against contamination by moisture, dirt and other foreign matter. It also prevents the loss of the volatile fractions of the askarel.

In order to minimize the aeration of askarel, containers and electrical devices should be filled from the bottom. It is preferable to flush air out of the device or container with dry nitrogen before filling with askarel, and maintain nitrogen over the askarel during the filling operation.

ROUTINE MAINTENANCE

The usual test, inspection and maintenance program for oil-filled bushings, disconnect switches and transformers should be followed for similar askarel-filled devices. The pressure of nitrogen over askarel should be checked each time an askarel-filled device is inspected or samples of askarel are taken from the device.

Askarel should be sampled and tested upon receipt of askarel-filled disconnect switches and transformers immediately before placing the device in service, after the device has been in service a week, and then semi-annually thereafter under normal operating conditions. Under abnormal conditions, more frequent sampling and testing may be advantageous.

DSW 357987

During routine inspections of askarel-filled devices, a careful check should be made for askarel on the outside of the device due either to spilling or leaking. In order to protect paint and insure against corrosion, askarel should be promptly removed from the exterior of askarel-filled devices with a suitable solvent, i.e., white gasoline, benzine, etc.

When it is necessary to replace gaskets on askarel-filled devices, care should be taken to insure against the use of gaskets or gasket-compounds that are affected by, or that may contaminate askarel. If it is not definitely known that the gasket or gasket-compounds are compatible with askarel, a test of compatibility should be made.

Askarel-filled transformers usually have pressure-relief devices. These devices should be included in the transformer inspection program.

It is advisable to add a hydrogen-chloride "scavenger" to askarel in disconnect switches and transformers that do not contain one, to reduce the danger of serious deterioration of insulation and rapid corrosion of metallic parts in case of an arc-over in the askarel. The power factor of askarel may be increased slightly by the addition of a "scavenger." The disadvantage of the increase in power factor is more than offset by the advantage of the "scavenger." A suitable "scavenger" can be obtained in sealed containers from suppliers of askarel-filled devices. The supplier's instructions for adding the "scavenger" to askarel should be carefully followed. It is desirable to notify the manufacturer when a hydrogen-chloride "scavenger" is added to askarel in an electrical device. The name-plate of the device should be marked to indicate this change.

Under some low temperature conditions, some "scavengers" will precipitate out of askarel. This is not harmful and will not change the electrical properties of the askarel. The "scavenger" will redissolve when the temperature rises.

SAMPLING

The sampling of askarel is similar to the sampling of insulating oil. It is recommended that the ASTM Method for Sampling Askarels (D-1809) be used for all sampling. Accurate sampling is extremely important from the standpoint of evaluating the quality of askarel. Particular care must be taken to prevent askarel touching any material which may contaminate it during sampling, handling or storage of the samples. Aeration of askarel during sampling should be held to the practical minimum. Since askarel is more hygroscopic than insulating oil, greater care must be taken to prevent exposure of askarel to moist air. Askarel should be sampled only on clear, dry days and when the askarel temperature is above the ambient air temperature. Top samples must be taken from the top surface, not just below the top surface. Many askarel-filled devices are equipped with sampling devices which facilitate obtaining samples from the top surface of the askarel. Before taking samples from an askarel-filled device or container that has been moved, it should be allowed to settle for at least 12 hours so that if there is any moisture, it will rise to the top.

PERIODIC TESTS

Since askarel is not subject to deterioration by oxidation as insulating oil is, it is only necessary to periodically test askarel for contamination and decomposition by an electric arc. It is not unusual to find askarel in electrical devices contaminated with bushing compound, pothead compound, varnish from transformer-winding insulation, matter dissolved out of gaskets of improper material and/or other foreign matter.

The probability of contamination of askarel with moisture depends on the design of the askarel-filled device, being greatest with free-breathing devices and least with sealed devices with nitrogen over the askarel. To insure against failure of askarel-filled electrical devices due to contamination or decomposition of askarel, periodic tests should be made on samples of askarel from all askarel-filled devices.

Periodic tests on askarels should include the following:

Color	- D-1702 or D-2129
Dielectric Strength	- D-877 or D-1816
Power Factor	- D-924
Visual Examination	- D-1702

If there is any possibility that the askarel is contaminated with insulating oil or any other petroleum product, Fire Point (D-92), or preferably Volume of Oil in Oil-Contaminated Askarels (D-1808) tests should be made. In the event that askarel may have been exposed to an electric arc, tests should be made for Hydrolyzable Chlorides (D-1820), Neutralization Number (D-664 or D-974), and Scavenger Content (D-1701). Under some conditions the Cloud Point Test (D-97) is a useful supplement to the Dielectric Strength and Power Factor Test for detecting moisture. The Pour Point (D-97) and Viscosity (D-88 or D-445) tests will indicate a change in askarel due to excessive evaporation of volatile fractions.

TEST METHODS

In addition to test methods included above, the following tests are also used for askarel for design purposes only:

TEST	
Coefficient of Thermal Expansion	- D-1903
Thermal Stability	- D-1936

During tests on askarel, particular care should be taken to avoid askarel contamination by askarel-soluble material, e.g., cells insulated with phenolic material should not be used for Dielectric-Strength, Power-Factor and Resistivity Tests. In making Dielectric-Strength tests, only one shot should be made for each filling of the cup.

Corrosion Tests and simple Fractional-Distillation Tests (D-20) are used by manufacturers of askarel-filled devices to determine the quality of askarel. Unfortunately, methods of making these tests have not been standardized.

The compatibility of askarel with gasket and other material can be tested as follows:

1. Measure the power factor of a sample of new askarel. (It should be 0.05% or less).
2. Place about 0.5% by weight of the material in question in the askarel. If the material is readily soluble, stir until dissolved and measure the power factor of the mixture.
3. If the material is not readily soluble, cover and let the mixture stand at room temperature.
4. After 48 hours, measure the power factor of the askarel.
   Note: Do not use a test cell or other vessel that may contaminate the askarel.

SCREENING TESTS

It has been found that under some conditions it is advantageous to make periodic screening tests on askarel samples in the field to determine when askarel samples should be sent to a laboratory for more accurate and complete tests. Experience indicates that if the results of field tests of askarel samples for Dielectric Strength (D-877), Power Factor (D-924), and Visual Examination (D-1702) are satisfactory, other tests are not necessary, unless there is a possibility that the askarel is contaminated with some petroleum product. If contamination is possible, tests should be made for Fire Point (D-92), or preferably for the Volume of Oil in Oil-Contaminated Askarels (D-1808).

The Doble-Type MH and Type MEU test sets have proven satisfactory and are recommended for determining the power factor of askarel in the field. The use of ASTM Method D-924 for the determination of the power factor of askarel in the field seems impractical, but can be performed conveniently in the laboratory by use of the Doble-Type M-O test set.

Each supplier of askarel or askarel-filled devices has an askarel testing service for consumers who do not have the necessary facilities. Many consumers find it advantageous to make screening tests in the field and utilize the manufacturer's service for the necessary laboratory tests.

TESTS RECORDS

To obtain the best results from an askarel test program, it is essential to keep complete askarel test records. These records should contain the results of each acceptance and periodic test, all special tests and the date each test was made. Without such test records, it is impossible to follow the change of the properties of askarel in service.

SIGNIFICANCE OF TESTS

GENERAL

The results of tests on askarel are significant only when made under definitely prescribed conditions. It is difficult and often impossible to compare results of tests made by different methods. The significance and limits of test values which follow are based on samples taken and tests made in exact accordance with all applicable ASTM Methods. Where the significance of askarel tests is the same as for oil tests in Section Three, it is not repeated in this Section.

ARC-FORMED GASES

An electrical arc in askarel will produce combustible gases if it is not properly compounded by the producer or if it is contaminated with petroleum. This test, which has not been standardized by ASTM, is normally used as a specification requirement for new askarel. For used askarel, the test for the Volume of Oil in Oil-Contaminated Askarel (D-1808) is preferred.

CHLORIDE COMPOUNDS, HYDROLYZABLE (D-1820)

This method provides a quantitative measure of the stability of the askarel to hydrolysis. Unstable compounds in excess of the acceptable limit may be deleterious to askarel-filled apparatus.

CHLORIDES, INORGANIC (D-1821)

In the presence of water, inorganic chlorides can ionize and result in corrosion of metals.

CLOUD POINT (D-97)

The cloud point of an askarel is the temperature at which matter begins to precipitate from askarel under prescribed test conditions. Cloud Point Tests have been used to supplement Dielectric Strength and Power Factor tests for detecting moisture. Care should be used in interpreting the results of this test, since some hydrogen-chloride "scavengers" give a rather high Cloud Point temperature.

COLOR (D-2129)

The color of an askarel is a useful indicator of contamination. A change in color of an askarel in service indicates contamination. Additional tests should be made on any askarel whose color has changed appreciably. A new askarel with a color appreciably darker than normal should be checked for contamination. Since askarel is normally a water-white liquid, ASTM Method D-2129 is far more sensitive than ASTM Method D-1500, used for insulating oils, to changes in color.

DIELECTRIC CONSTANT (D-924)

The dielectric constant of an askarel is the property which determines the electrostatic energy stored per unit of volume for unit potential gradient. The results of this test are used only for design purposes. If the dielectric constant of askarel or an oil-askarel mixture is changed due to contamination or the addition of insulating oil, it may result in an operating hazard.

DIELECTRIC STRENGTH (D-877)

The dielectric strength of an askarel is the minimum voltage at which electrical failure occurs under prescribed test conditions. It indicates the ability of an askarel to withstand electrical stress without failure. Low dielectric strength indicates contamination with water, solid-conducting particles, and/or other foreign matter. High dielectric strength is no indication that an askarel does not contain contaminants. The contaminants causing low dielectric strength can usually be removed with a filter press. Askarel with a dielectric strength of less than 30-kv is usually considered an operating hazard. This is the most popular acceptance and periodic test for askarel.

FIRE POINT (D-92)

The fire point of a liquid is the temperature at which the liquid supports combustion under prescribed test conditions. Since askarel has no fire point, this test is only of value for determining whether the askarel contains a large amount of combustible contaminant. The test for the Volume of Oil in Askarel (D-1808) is preferable for this purpose.

GAS CONTENT (D-831)

This test is used only for determining the gas content of askarel for cables and capacitors where de-gassed oil is essential. The use of ASTM Method D-1827 for determining the gas content of askarels has not been investigated by ASTM Committee D-27.

INTERFACIAL TENSION (D-971, D-1902, D-2285)

The interfacial tension of water against askarel is the force necessary to move a platinum ring through a water-askarel interface and is expressed in dynes per centimeter. Although this test has been widely used for oil, it is rarely used for askarel.

NEUTRALIZATION NUMBER (D-664, D-974)

The neutralization number of an acidic askarel is the number of milligrams of KOH required to react with 1 gram of askarel under prescribed test conditions. In case of a basic askarel, the neutralization number is the number of milligrams of KOH equivalent to the acid required to react with 1 gram of askarel under prescribed test conditions.

The neutralization number is of importance as a quality index of purity of new askarel. The neutralization number of new askarel should not exceed 0.010 mg KOH/gm. Since askarel is not subject to oxidation, a small change in neutralization number will indicate contamination. Decomposition of askarel may be indicated by a large change in neutralization number. A low neutralization number does not prove that there are no contaminants in the askarel.

POUR POINT (D-97)

The pour point of an askarel is the temperature at which it just flows under prescribed test conditions. A low pour point is important, particularly in cold climates, to insure that askarel will flow in cold weather and serve its purpose as an insulating and cooling medium. An increase in the pour point of an askarel is an indication of the loss of volatile fractions of the askarel.

POWER FACTOR (D924)

The power factor of an askarel is the cosine of the dielectric phase-angle between a sinusoidal alternating potential applied to an askarel and the resulting component of alternating current having the same period as the potential difference. Power factor indicates the dielectric loss in an askarel; thus the dielectric heating. Power factor is widely used acceptance and periodic test for askarel. The power factor of new askarel should not exceed 0.05 per cent at 25°C. High power factor of used askarel indicates contamination with moisture, carbon or other conducting matter, asphalt base material, varnish, glyptal, gasket materials and/or other foreign matter or deterioration products. It is well to investigate used askarel having a power factor in excess of 0.5%. When used askarel is found to have a power factor of 2.0% or more, the cause of the high power factor should be determined. If the high power factor is caused by water or other conducting matter, free chlorides or high neutralization number, the askarel is probably an operating hazard. If the high power factor is not due to these causes, it is probably not an operating hazard; except that when the power factor is quite high, it may result in excessive heating of the device in which it is used. High power factor due to askarel contamination may mask out other defects in askarel-filled devices.

REFRACTIVE INDEX (D-1807)

The refractive index of an askarel is the ratio of the velocity of light in a vacuum to its velocity in askarel. It is an indicator of the composition of an askarel and the nature and amount of contaminants in solution. Periodic refractive index measurements have been used as a check for contamination by petroleum products.

SLUDGE

Since askarel does not oxidize, this test is not used for askarel.

SPECIFIC GRAVITY (D-1810)

The specific gravity of an askarel is the ratio of the weights of equal volumes of askarel and water determined under specified conditions. The specific gravity of an askarel is used for converting the net weight of askarel to volume at 60°F. It has little value in determining askarel quality or the suitability of askarel for electrical applications. Periodic specific gravity tests are rarely made except for correcting interfacial tensiometer readings.

VISCOSITY (D-88)

Viscosity is the resistance of askarel to flow under specified conditions. The viscosity of an askarel used as a coolant in an electrical device is a principal factor in the dissipation of heat by convection in askarel. An increase increase in viscosity of an askarel indicates the loss of volatile fractions. This test is not generally made on used askarel.

TESTING ASKAREL-FILLED TRANSFORMERS

Power-factor tests are as valuable in determining the condition of insulation in an askarel-filled transformer as they are in determining the condition of insulation in an oil-filled transformer. The procedures and instruments required for determining insulation power factor of askarel-and oil-filled transformers are identical. Acceptable test values are of the same order of magnitude. Due to the limited data of tests on askarel-filled transformers, it is difficult to set exact test limits. It is practical to specify that the power factor of transformer-windings in askarel, with all bushings and the high-voltage switch in the circuit, shall not exceed three per cent when corrected to 20°C.

TREATMENT

The fact that the cost of askarel is approximately ten times the cost of insulating oil, and that the cost of reclaiming the two insulating liquids is about the same, insures that askarel can be economically reclaimed in relatively small quantities.

Moisture and large particles only can be removed from askarel with a filter press. A filter press, having deep frames charged with fuller's earth, is preferable. To charge a filter press having deep frames with fuller's earth, thoroughly mix 800/300 mesh fuller's earth with a few gallons of askarel and circulate the mixture through the filter press, adding fuller's earth as required until cakes of fuller's earth of suitable thickness are evenly deposited on the surface of the filter papers. It is advantageous to have a source of clean dry air available for blowing the remaining askarel out of the filter press upon completion of filtering.

A centrifuge is useless in treating askarel because of the high specific gravity of askarel.

Moisture, dirt and other foreign matter, asphalt and asphalt-base materials, paint, varnish, gums, resins, rubber and rubber-like materials can be removed from askarel with fuller's earth. It is impossible to remove insulating oil and petroleum products from askarel with fuller's earth.

DSW 357993

A number of devices are commercially available for treating askarel with fuller's earth. The three general types of fuller's-earth treating devices function as follows:

a. Fuller's earth is mixed with the askarel which is later removed with a filter press.

b. Askarel is pumped through a bed of fuller's earth, then through a filter press to insure that all fuller's earth is removed.

c. Askarel is pumped through fuller's earth bound into blocks with a suitable binder. If clean fuller's earth blocks are used, a filter press is not required.

Devices used for filtering oil and treating oil with fuller's earth should not be used for filtering and treating askarel, since it is practically impossible to clean them sufficiently to insure against contamination of askarel with insulating oil.

It is essential to use only thoroughly dried filter paper and fuller's earth in treating askarel. It should be remembered that dried filter paper and fuller's earth can reabsorb in less than ten minutes two thirds of the moisture that they will absorb from the air. Neither fuller's earth nor filter paper can be effectively dried after once being saturated with askarel. Treating temperatures should be as low as practical and, under no condition over 40°C due to the rapid increase in the solubility of water in askarel with increasing temperature. When askarel is circulated from a tank through a treating device and then back into the same tank, it should be taken from the top and returned to the bottom of the tank, since water floats on askarel. Treating devices and procedures should be designated to reduce aeration of askarel to the least practical amount.

Askarel can be removed from used filter paper and fuller's earth by placing them in a suitable container and just enough water to cover them. After standing overnight, the askarel can be drained from the bottom of the container and dried in the usual manner. This is due to the fact that filter paper and fuller's earth have a greater affinity for water than for askarel. It is impractical for a utility to attempt to remove insulating oil or other petroleum products from askarel.

Contaminated askarel may be returned to some manufacturers of askarel-filled devices for reclamation, provided the askarel is not contaminated with insulating oil and that the contaminant can be removed with fuller's earth. Askarel must be returned in sealed, clean, metal containers. The cost of such reclamation is usually about half the cost of new askarel. No appreciable quantity of the hydrogen-chloride "scavenger" will be removed by fuller's earth treatment of askarel unless excessive amounts of fuller's earth are used or the treatment is at an excessive temperature.

TREATMENT AFTER EXPOSURE TO AN ELECTRIC ARC

Immediately, not the day after an electrical arc-over in an askarel-filled transformer, dry nitrogen should be bubbled through the askarel for 4 to 6 hours using a 220 cubic-foot cylinder of nitrogen for each 100 gallons of askarel. The nitrogen should be fed into the transformer drain valve and allowed to escape through a suitable vent above the askarel level in the transformer. A metal standpipe from the drain valve to a point above the askarel level should be used to prevent askarel contacting non-metallic hose or the nitrogen regulator. This procedure is essential to minimize the destructive effect of hydrochloric acid on the insulation and metal parts of a transformer, even if the askarel contains a hydrogen-chloride "scavenger." If this procedure is followed, it may be practical to reclaim the askarel.

DSW 357994

Except while bubbling nitrogen through the askarel, the transformer should be kept sealed, with nitrogen over the askarel, from the time of failure until it is untanked.

The transformer tank-cover should not be removed until hydrogen-chloride has been removed from the askarel by bubbling nitrogen through it. If the core and coils are exposed to the atmosphere before the complete removal of hydrogen-chloride, the moisture in the air will dissolve the hydrogen-chloride, forming hydrochloride-acid, thus resulting in greater damage to the core and coils.

It is advisable to immediately advise the manufacturer of an electric arc-over in an askarel-filled transformer, giving him the transformer rating, serial number and all available data on the arc-over in order to obtain his recommendations as to the procedure to be followed in repairing any damage to the transformer and in reclaiming the askarel. The manufacturer will, no doubt, want samples of the askarel. It is recommended that no work except bubbling nitrogen through askarel should be done except upon the advice of the transformer manufacturer. Even when the manufacturer is contacted for recommendations on repairing a transformer after an arc-over in askarel, nitrogen should be promptly bubbled through the askarel. Bubbling nitrogen through askarel in a transformer is inexpensive; it can cause no damage and will minimize the necessary repairs and simplify the reclamation of the askarel.

Samples of the askarel should be promptly taken and tested for Color, Free Chlorides and Neutralization Number. A laboratory check on a relatively small quantity of the askarel will indicate whether it is practical to reclaim the askarel. In checking to see whether it is practical to reclaim askarel after an arc-over, particular attention should be paid to the carbon in the askarel, particles of which are usually much smaller than those found in insulating oil.

In case of a minor arc-over, the askarel can probably be reclaimed and also those parts of the core and coils not damaged by the arc-over may be salvaged. If severe arcing has occurred, it may be possible to reclaim the askarel; however, it is doubtful whether any part of the core and coils can be salvaged unless the askarel contained a hydrogen-chloride "getter." This can be determined only by tests on the askarel and careful inspection of the core and coils.

Upon completion of the nitrogen bubbling process, the core and coils should be removed from the transformer tank and carefully inspected. If the damage cannot be repaired immediately, all parts of the transformer should be washed with good askarel and they should then be retanked. The tank should be filled with good askarel and sealed with nitrogen over the askarel.

When all parts are available for repairing a transformer, transfer the askarel to a suitable metal container and remove the core and coils. Thoroughly clean the core, coils, and the inside of the tank and all other parts of the transformer with a solvent recommended by the transformer manufacturer. Carbon tetrachloride may be used on metallic parts but must not be allowed to contact the coils or insulation. This cleaning operation is necessary because askarel becomes quite tacky when exposed to the atmosphere. If metal parts are not immersed in askarel immediately after cleaning, a rust-preventative recommended by the transformer manufacturer should be applied to minimize corrosion.

Repairs should be made in the usual manner, the core and coils retanked and the transformer filled with askarel in the usual manner. The transformer should then be dried.

DRYING ASKAREL-FILLED TRANSFORMERS

It is advantageous to dry askarel-filled transformers completely assembled, filled with askarel and sealed, using the short-circuit method with continuous circulation of askarel through a filter press or, preferably, through a fuller's earth treating unit. In circulating askarel, it should be removed from the top of the device and returned at the bottom, since water will float on askarel. If the transformer is not sealed and the askarel circulation and treating system sealed, there will be a loss of volatile fractions of askarel due to evaporation. Drying will be slower than with an oil-filled transformer because of the greater difficulty in transferring water from cellulose insulation to askarel and in removing water from askarel.

In drying askarel-filled transformers by this method, 125 to 150 per cent of full-load current should be applied until the top askarel temperature reaches 60°C. Then the current should be reduced to the following maximum values:

Per Cent Full Load Current	Maximum Top Askarel Temperatures
80	75
75	80
50	85

If the above currents or temperatures are exceeded, the transformer insulation may be damaged by excessive temperature at hot-spots in the windings.

Under no condition should the top askarel temperature be allowed to exceed 90°C. The cover of the transformer should be lagged to prevent condensation. It is advisable to blanket the transformer tank during drying with a suitable insulating material to reduce temperature differences in the transformer, and thus minimize the condensation of moisture on the inner surfaces of the tank.

Under some conditions, it may be advantageous to operate the filter press or treating unit intermittently to reduce the temperature differences between the transformer winding and the top askarel.

CONCLUSIONS

Askarel is not hazardous to handle. Although more care is required, it may be handled, stored, sampled, tested and treated in a manner similar to insulating oil. Complete, separate facilities are advantageous for askarel.

Transformers filled with oil or askarel may be applied, operated, loaded, tested, and inspected in a similar manner. The principle difference is maintaining askarel-filled transformers is the procedure after an arc-over in askarel.

The disadvantages of askarel are compensated for by the elimination of fire and explosion hazards and its long trouble-free life in sealed electrical devices, under normal operating conditions.

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