

0249599.01

TOWOLDMON0028033
WATER_PCB-00012502

This information is provided as a service by Monsanto Chemical Company to help transformer users better understand the operating characteristics and maintenance procedures with askarel liquid insulation, and how these differ from mineral oil insulation.

The information given on the following pages is based on facts gathered by Monsanto during 30 years as producer of askarel. It represents knowledge gathered from the experience of transformer manufacturers and users over three decades.

Monsanto provides this information primarily as a guide on how to obtain maximum service with minimum reasonable maintenance of askarel dielectrics. All questions relating to the building and designing of transformers should be referred to regular transformer suppliers.

Monsanto gratefully acknowledges the assistance, guidance, and the contributions of certain data by the following:

Frank M. Clark	*General Electric*
Edward L. Raab	*General Electric*
James G. Ford	*Westinghouse Electric*
George Shombert, Jr.	*Allis Chalmers*

0249600

TOWOLDMON0028034
WATER_PCB-00012503

ASKAREL – HISTORY OF TRADE NAME TYPES

"Askarel" is the generic name for a special kind of liquid insulation that is completely different from ordinary transformer mineral oils. Askarel* liquid insulation — whatever the trademarked brand — is all made from Monsanto's Aroclor 1260 (hexachlorobiphenyl) . . . one of the world's best liquid insulations. This inert compound is chemically stable, fire-resistant, heat stable, non-corrosive, and has high dielectric strength under the operating conditions encountered in askarel-type transformers. Monsanto manufactures Aroclor 1260 and formulates askarel liquid insulation to the specification of the various transformer manufacturers.

Askarel liquid insulation is made by thinning Aroclor 1260 with trichlorobenzene or tri-, tetrachlorobenzene mix, and by the addition of a small amount of a chloride "scavenger" compound. The first transformer askarel was made in 1932, in accordance with General Electric Company's patents, and was trademarked Pyranol 1488. In '49, General Electric Company patented and began the use of 0.125% tin tetraphenyl scavenger additive, and this new askarel formulation was called Pyranol 1467. Westinghouse, too, offered an askarel insulation in 1933 under the company's trademark: Inerteen. The following table shows the composition and year of introduction of the two major types of askarel:

	Pyranol			Inerteen	
	1488	1467	1470	Inerteen	Inerteen PPO
Year Introduced	1932	1949	1952	1933	1949
Ingredients:					
Aroclor 1260	60	60	45	60	60
Trichlorobenzene	40	40		40	40
Tri-, tetrachlorobenzene mix			55		
Tin tetraphenyl		0.125	0.125		
Phenoxy propene oxide					0.20

Other Brand Names

Various manufacturers use other trademarked names, like Chlorextol (Allis Chalmers); Noflamol (Wagner Electric); Asbestol (Amertran Corp.); Saf-T-Kuhl (Kuhlman Electric). These askarel insulating liquids are either one type or the other. Some manufacturers, who designate their insulation by the generic name askarel, assign a number or code so that Monsanto, when filling a particular company's order, knows whether to furnish Pyranol 1470 or Inerteen PPO type askarel.

*Commonly used for transformers.

0249601

TOWOLDMON0028035
WATER_PCB-00012504

0249607

TOWOLDMON0028036
WATER_PCB-00012505

DIRECTIONS FOR HANDLING OF ASKAREL

In handling, storing, sampling, inspecting askarel — and in the operating of askarel transformers — take every precaution to guard the askarel insulation from exposure to high humidity and moisture contamination. Keep 5, 30, or 55 gallon drums of askarel dry; turn them over on their sides to keep water off the drum head (it can be sucked in by the drum "breathing").

Stability of Askarel Fluids

Askarel liquid insulation is a very carefully-manufactured, highly pure, chemically made fluid. It does not vary in composition like the range of mineral oils. And, askarel is heavier than water. If water gets into the askarel insulation, only a tiny amount (125 ppm) dissolves — the rest floats on top.

Askarel does not deteriorate when exposed to air, heat, hot metal; it does not break down over long use to form conducting or corrosive chemicals; it does not sludge or oxidize. Askarel will remain perfectly stable year after year unless broken down by exposure to severe arcing.

The only real "enemy" of askarel is contamination by water. Keeping askarel water-free will insure long-time service.

In emergency, the two general types of askarel insulation can be either mixed or interchanged and there will be no difference in the operation of the transformer. Do not, however, mix askarel type insulation with mineral oil.

0249603

TOWOLDMON0028037
WATER_PCB-00012506

The two different types of askarel fluid simply differ in pour point and in the tiny amount of "scavenger" additive. The Pyranol type has the lower pour point; it will still pour at 47° below (F.) zero. The Inerteen type will pour down to 26° below (F.) zero. The different scavenger additives are both effective for absorbing hydrogen chloride — which can be liberated from askarel if it is exposed to strong arcing.

However, the additive in Pyranol type askarel can "crystallize" out at 14° above (F.) zero and looks like a hazy cloud in the liquid. It does no harm; the crystals disappear after a while when the transformer warms up. This "haze" can be differentiated from water by a dielectric strength check.

Generally there is no need to mix or interchange; Monsanto supplies all types of askarel promptly — anywhere in the world.

Askarel should never be mixed with mineral oil

because the core binding materials and paint suitable for oil-filled units soften and deteriorate in askarel. And, over 2% mineral oil mixed into askarel begins to lower its fire resistance.

USE ORDINARY PERSONAL PRECAUTIONS

Transformer askarel has been made, handled, and used for over 30 years without causing toxic or other ill effects. It can be handled with only minor precautions. If accidentally spilled on hands, serious skin irritation will not occur. However, the liquid has a solvent action similar to paint thinner on the fats and oils of the skin and skin exposures may lead to drying and chapping.

Eye contact may result in painful temporary irritation but no permanent damage to tissues. If it gets in the eyes, flush with large amounts of water. As with all eye first-aid, refer to a physician. To relieve irritation, physicians have used a 1% Pontocaine solution as well as opthalmic cortisone acetate solution.

In case of contact, wash off the skin with soap and water; remove saturated clothing; clean up spills.

Infrequent exposure to askarel vapors will not cause any ill effects. However, prolonged exposure to high vapor concentrations should be avoided. If hot fluid must be handled in a closed or confined area, provide ordinary exhaust ventilation — or — wear an organic cartridge respirator approved by the U. S. Bureau of Mines.

0249604

TOWOLDMON0028038
WATER_PCB-00012507

CHECKPOINTS FOR INSPECTING
AND MAINTAINING ASKAREL

0249605

TOWOLDMON0028039
WATER_PCB-00012508

CHECKPOINTS ON MAINTAINING ASKAREL INSULATION

Take All Possible Precautions to Keep Transformer Askarel Dry

Whether askarel transformers are used indoors or outdoors — the major maintenance checkpoint to assure virtually trouble-free operation is to eliminate possible contamination of the inside of the shell by moisture. (This is also true for oil-type units.)

The following design information is provided as a guide for the frequency of inspection, for "modernizing" present units . . . and for ordering new equipment. (Your best source of specific design information is your transformer supplier.)

cover:

Welded. When the entire transformer cover is welded onto the body of the transformer, this avoids use of a gasket and eliminates "breathing" of humid air.

gasketing:

Use the proper gasketing for removable hand-hole openings. For maximum stability and fit, place the gasket in a recessed groove. Fine grain cork impregnated with nitrile rubber is suggested for gaskets. This type material is designated as NC757 by Armstrong Cork Co., Lancaster, Pa., and as M3150 by Wolverine Mfg. Co., Inkster, Mich. Suitable cement for this gasketing is dewaxed orange shellac, pigmented with iron oxide (available in pint size from Westinghouse, Sharon, Pa., Style No. 1150419).

Nitrile rubber is sometimes used to seal the hand-hole. Because it is slowly attacked by askarel, this gasket must be recessed to allow minimum contact. Teflon, DuPont's Viton and most silicone "rubbers," while relatively expensive, warrant consideration for long term use requirements, at least for the smaller size gaskets.

fins:

Weld all fin connections.

0249606

TOWOLDMON0028040
WATER_PCB-00012509

connections:

Weld all major instrument or pipe connections. For incidental taps or nipples — above liquid — wrap the thread with Teflon tape: below liquid, seal threads with askarel-resistant cement, such as Westinghouse 6707-3 (a shellac base with special rubber filler).

bushing connections:

The most satisfactory bushings will be the type with rolled-on flanges with two ring seals rolled into a depression in the porcelain and sealed with silicone rubber rings held under compression. Metal-to-glass or metal-to-porcelain sealed bushings are also satisfactory.

Bushings on smaller size transformers (around 100 KVA) can be sealed with cork-nitrile rubber composition.

nitrogen blanket:

Blanket the "air space" above the askarel with dry nitrogen. If the transformer has so many leaks that pressure will not hold — then bleed in a small amount of nitrogen steadily. Otherwise, "modernize" by welding.

Another approach to "designing out" moisture contamination: call for a "conservator" attachment so that the transformer shell is completely filled with the askarel. This eliminates the breathing of the air space. The liquid askarel level in the "conservator" is higher than the transformer cover; any water that would "seep" into the shell floats to the surface of the askarel in the conservator!

drying breathers:

Transformers not hermetically sealed, and designed to allow breathing, should be fitted with a drying breather containing silica gel or anhydrous alumina.

A detailed description of this drying arrangement for mineral oil units is contained in the booklet "Activated Alumina Maintenance Program" (1955, Aluminum Company of America, Pittsburgh, Pa). This approach is also suitable for askarel transformers.

0249607

TOWOLDMON0028041
WATER_PCB-00012510

If desired — although these factors are unimportant — to keep power factor as low as possible and resistivity as high as possible, hang a container of anhydrous alumina in the circulating system of the transformer (askarel as well as mineral oil units).

Expected Service Life and Importance of Moisture Protection

Properly designed and installed askarel transformers will give trouble-free service for a minimum of 30 years. Since their introduction in 1932, the manufacturers report finding the over-all failure rate to be less than 0.5% for all units under test and service conditions. The Edison Electric Institute's report (1956-1958) on their member utilities publishes the failure rate for askarel transformers as 0.13 per hundred banks per year! Even the rare reports of failure are invariably found to be due to improper sealing that allows moisture to enter.

The dielectric strength of askarel is highly sensitive to excess moisture; not sensitive to ordinary dissolved contaminants. While the dielectric strength can also be lowered by severe arcing, askarel turns noticeably black or has particles of sooty carbon floating in it if arcing has occurred. Unless severe arcing (internal electrical failure) has occurred, the dielectric strength is also the "moisture indicator."

New askarel has a minimum dielectric strength of 35 KV at 25°C.; a maximum moisture content of 30 ppm. If the dielectric strength is checked periodically and decreases significantly — this indicates moisture pick-up, arcing, or both. When the dielectric strength has dropped to 22 KV or less, an analysis for water is necessary. If water is found in excess of 100 ppm, its source should be located and corrections made.

When the moisture content approaches 125 ppm (saturation level), the dielectric strength of askarel drops below the value required for efficient insulating. The moisture content should not be allowed to rise over 70 ppm; it should be held as near as possible to 30 ppm. Maintaining a low moisture level will assure high dielectric strength and top operating efficiency.

Relation of "Breakdown Strength" To Amount of Dissolved Water In Askarel and Mineral Oil

	Breakdown Voltage (ASTM)	
Water Content (PPM)	Askarel	Mineral Oil
0	70 KV	50 KV
20	55	39
40	47	30
60	40	26
80	38	22

0249608

TOWOLDMON0028042
WATER_PCB-00012511

Transformer Askarel
Shipping Specifications

Properties	Pyranol 1467	Pyranol 1470	Inerteen PPO
Color, APHA	150 max.	150 max.	150 max.
Condition	Clear	Clear	Clear
Water content, ppm (ASTM D1533-60)	30 max.	30 max.	30 max.
Acidity, mg. KOH/g. (ASTM D974-55)	0.01 max.	0.01 max.	0.01 max.
Dielectric Strength, 25°C., 0.1 inch gap (ASTM D877-49)	35 KV, min.	35 KV, min.	35 KV, min.
Dielectric Constant, 100°C., 1 KC (ASTM D924-49)	3.7 to 4.0	3.8 to 4.3	3.7 to 4.0
Volume Resistivity, 100°C., 500 volts DC 0.1 inch gap, 10^9 ohm-cm.	100	100	100
Inorganic chlorides, ppm.	0.10 max.	0.10 max.	0.10 max.
Refractive index, 25°C. (ASTM D901-56)	1.6137 to 1.6147	1.6075 to 1.6085	1.6137 to 1.6147
Viscosity at 37.8°C. (ASTM D88-56) Saybolt Universal Seconds	54 ±2	41 to 45	54 ±2
Pour point °C. (ASTM D-97-57)	−32 or lower	−44 or lower	−32 or lower
Specific gravity 15.5/15.5°C. (ASTM D287)	1.560 to 1.568	1.563 to 1.571	1.560 to 1.568
Burn point (ASTM D92)	None to boiling	None to boiling	None to boiling
Distillation range (ASTM D20-56) corrected for stem and barometric pressure	1st drop 200°C. min. 40% below 270°C. 90% 395 to 415°C.	1st drop 210°C. min. 35% 240 to 256 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	59.1% min.	60.5 ±5%	59.1% min.
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, APHA	200 max.	200 max.	200 max.
Acidity, mg. KOH/g.	0.01 max.	0.01 max.	0.01 max.
Inorganic chlorides ppm.	5.0 max.	5.0 max.	2.0 max.
Condition	Clear	Clear	Clear
Scavenger content	0.125% tin tetraphenyl	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.		

0249609

TOWOLDMON0028043
WATER_PCB-00012512

CHECKPOINTS FOR INSPECTING ASKAREL INSULATION

Periodic Inspection

On a regular schedule — at six, nine, or twelve month intervals make a simple visual inspection of your askarel insulation and run a dielectric strength check. If dielectric strength has decreased significantly from last inspection, or if it has gradually decreased to the 22-20 KV range (@ 25°C.) — RUN A CHECK FOR MOISTURE. Use ASTM D901, D877. (Karl Fischer Method)

> ***WHAT CHECKPOINTS MEAN: Dielectric Strength***
>
> *The dielectric strength of askarel is the major indicator to the operating efficiency of your liquid insulation and of the askarel transformer itself. Besides the "visual" inspection tests — the dielectric strength is the only test necessary to run on a routine basis. Well-sealed askarel transformers have service records of 25 to 30 years on the original askarel. New askarel has a minimum dielectric strength of 35 KV at 25°C.; a maximum moisture content of 30 ppm.*

Visual Inspection: Color

New askarel is a clear, faint-yellow liquid. After long-term use, this color may gradually intensify to light brown.

Color Change

Any color change such as taking on a green, red, or blue cast indicates extraction. When distinct color pick-up is noted, the complete range of electrical characteristics should be checked to learn if extracted color is the tell-tale for contamination. Notwithstanding, color change alone is not a danger signal. When checking out a color change, the dielectric strength is by far the most important of the electrical characteristics; not the Power Factor or Volume Resistivity.

> ***Contamination***
>
> *High power factor and low volume resistivity in transformer mineral oils are commonly regarded as "danger signals" that the oil has deteriorated and broken down chemically.*
>
> This is NOT TRUE of askarel liquid insulation.

0249610

TOWOLDMON0028044
WATER_PCB-00012513

New, unused askarel shows these electrical values:

Power Factor: 0.05-0.2% @ 60 cycles/20°C.
(about 1-2.0% @ 60 cycles/100°C.)

Volume Resistivity: 100-1000 × 10^9 ohm-cm.
(@ 100°C., 500 V., DC., 0.1" gap)

Used askarel from SATISFACTORILY OPERATING TRANSFORMERS normally (and frequently) shows these values:

Power Factor: 20 to 80% @ 60 cycles/100°C.

Volume Resistivity: about 25 × 10^9 ohm-cm.
(@ 100°C., 500 V., DC., 0.1" gap)

This relatively high power factor and the relatively low volume resistivity of askarel sampled from normal operating transformers ARE TO BE EXPECTED. Even at these levels, the askarel's dielectric strength is EXCELLENT, STILL in the 30-35 KV range.

The reason is simple: askarel, unlike mineral oil, is a relatively polar liquid. With double the capacitance of mineral oil, askarel has greater dielectric strength. And this property is the important factor for transformer insulation. Thus, the volume resistivity of askarel is more sensitive to traces of conductive contaminants than oil. However, even in the presence of large amounts of contaminants, the volume resistivity does not seem to fall below 5 x 10^9 (ohm-cm). Yet the dielectric strength remains high, because intrinsically askarel remains a non-conductor.

Approximate Relationship Between Power Factor, Volume Resistivity, and Dielectric Strength of Transformer Askarel

Power Factor (60 cycles)		Volume Resistivity x 10^9 ohm-cm. (@ 100° C., 500 Volts DC., 0.1" gap)	Dielectric Strength 25°C., 0.1" gap
100°C.	25°C.		
2%	0.05%	1500	>35 KV
5%	0.1%	500	>35 KV
15%	0.7%	100	>35 KV
20-25%	2.0%	60-70	>35 KV
40-50%	—	25	>35 KV

Clarity

Inspect to make sure askarel remains clear in service. Development of turbidity or cloudiness indicates contamination from water, insulation particles, metallic dust, or dirt. Cloudiness or turbidity calls for complete analysis (unless the askarel is Pyranol 1470, sampled after extreme cold that has temporarily precipitated the "scavenger"). Heating to 150-200°F. and agitating for a few hours will make this type of turbidity disappear; a dielectric strength (high result) check test will prove this white cloudiness is not water.

0249611

TOWOLDMON0028045
WATER_PCB-00012514

Turbidity

. . . may be the visual sign of water, or may indicate contamination from core materials, dirt, or deteriorating construction materials.

Approximate Solubility of Water in Transformer Askarel and Mineral Oil

Temperature		Amount of Water (PPM) Dissolved	
°C.	°F.	Askarel	Mineral Oil
−30	−22	8	8
−20	− 4	16	10
−10	14	28	13
0	32	41	20
10	50	65	33
20	68	94	58
30	86	128	85
40	104	170	130

Effect of Common Insulation Materials on Power Factor and Dielectric Strength (Heat Aged 96 hrs. in Askarel @ 100° C.)

	Askarel After Exposure	
Material Immersed	Power Factor, Percent @ 60 cyc., 100°C.	Dielectric Strength 25°C.
None (control)	1.0	35 KV
Black varnished cloth	85.0	42 KV
Copper	1.5	40 KV
Pressboard	2.0	37 KV
Manila paper	1.5	39 KV
Bakelite	1.6	41 KV
Shellac	6.0	36 KV
Iron	5.0	39 KV
Synthetic rubber	70.0	39 KV

Effect of Common Insulation Materials on Volume Resistivity of Askarel

Sample	Volume Resistivity x 10^9 ohm-cm (@ 100°C., 500 Volts DC., 0.1" gap)
1. New askarel before heat aging	2,000
2. New askarel after heat aging 96 hrs @ 100°C.	1,900
3. After heat aging with 1 sq. inch specimens of:	
a. Phenolic resin tap changer material	1,200
b. Paper	750
c. Grade A press board (tan)	500
d. Grade A press board (gray)	500
e. Grade A press board, laminated strip	400
f. Cotton wrapping	300
g. Glyptal 1276 cement, cured 48 hrs. @ 110°C.	100

High dielectric strength will quickly indicate that any turbidity present is not moisture; that the insulating efficiency of the askarel is still excellent. While relatively high power factor and low volume resistivity are to be expected, when turbidity or a foreign color occurs these electrical values may confirm the askarel may be in contact with deteriorating construction materials.

0249612

TOWOLDMON0028046
WATER_PCB-00012515

Black Color and Carbon Particles . . .

show that askarel has "arced," especially if in the blackened liquid small particles of carbon can be seen. Askarel that has been exposed to arcing cannot be "refined" and should be discarded. To check the visual appearance chemically, dip moist blue litmus paper in sample. If paper turns red, the askarel has been arced beyond ability of the scavenger to capture the hydrogen chloride.

Askarel Stability

Askarel insulation is one of the most inert, chemically-stable, heat resistant, non-corrosive liquids known. It will not break down, oxidize or sludge when exposed to air and high temperatures, 150°C. or even somewhat higher. Arcing, however, will break down the compound, to liberate some hydrogen chloride and small amounts of carbon.

Approximate Composition
Arc Formed Gas From Transformer Askarel

Gas	Amount
carbon monoxide	0.3 per cent
carbon dioxide	0.3 per cent
oxygen	0.6 per cent
inert gases	1.5 per cent
hydrogen chloride	97.3 per cent

It has been calculated and theorized that one kilowatt of arc energy can produce about 135 cc. of gas of decomposition from askarel; compared with about 85 cc. of gas from mineral oil.

Moisture

If the inspection sample of askarel shows 35-30 KV dielectric strength by the ASTM method, there is no need to check the moisture content. However, if dielectric strength has gone down to the 22-20 KV range, check for moisture using the Karl Fisher Method, ASTM D-1533.

Dielectric Strength Is Moisture Indicator

The moisture content of new askarel is 30 parts per million maximum. The moisture saturation level is about 125 ppm at ordinary temperatures. When the moisture content approaches 125 ppm (saturation level), the dielectric strength goes down. The moisture content of askarel should not be allowed to rise over 70 ppm; it should be held as near as possible to 30 ppm. Askarel's dielectric strength can be restored to the 35-30 KV range by simple refinement to take out the dissolved moisture. When the dielectric strength indicates it is time to refine the askarel, it is also time to inspect and get rid of any water accumulation in the transformer shell.

TOWOLDMON0028047
WATER_PCB-00012516

INTERPRETATION OF ASKAREL INSPECTION FINDINGS

Judge the condition of your askarel insulation and the transformer on the basis of your visual inspection, the dielectric strength, and (when dielectric strength is found low), by the amount of the usually confirming high moisture content.

Do NOT judge the conditions on the basis of the askarel's power factor or volume resistivity.

High Power Factor and Low Volume Resistivity

. . . in used askarel is to be expected; these values are not an indication of chemical or electrical breakdown . . . even though such values often indicate mineral oil's breakdown. Askarel and oil are two different chemical substances. Askarel is (compared to oil) a relatively polar liquid . . . highly sensitive to traces of ionizable impurities. The dielectric constant of new askarel is about 4, nearly twice as high as mineral oil. Infinitesimal amounts of impurities from insulation, dirt, coatings can markedly increase the power factor. (The same amount might not affect oil at all.) And further, unless critical care for cleanliness is taken in making the power factor test on askarel — the result can be erroneously still higher! With a power factor so sensitive and a test procedure so strict — it is to be expected that when askarel is put into a new transformer, the power factor will go up immediately on contact with the materials of construction. Authorities agree: the power factor of askarel in use will be high, as much as 20-80% at 100°C. and 60 cyc. (about a tenth of this at 20°C.). In service, the power factor of askarel "goes up" to a greater extent than mineral oil, but this — in the absence of other "signals" — has no significance.

High power factor alone is not a danger sign with askarel insulation IN A PROPERLY CONSTRUCTED TRANSFORMER. However, high power factor in the absence of moisture in the shell, coupled with "turbidity" and/or distinct foreign color, can indicate improper construction.

Volume resistivity, too, may be expected to decline fairly rapidly even in a normally operating transformer. It should not drop below about 25 x 10^9 ohm-cm. and experience shows it will not drop below 5-10 x 10^9 even in the presence of heavy contamination, other than water.

0249614

TOWOLDMON0028048
WATER_PCB-00012517

INSPECTION INTERPRETATION

*If askarel is clear, even though darkened to brown; has no sediment or turbidity; has dielectric strength over 25 KV . . . give it the inspection "OK".

*If askarel is clear; has foreign color of blue, green, red . . . it is "extracting color" from internal materials. This is not, of itself, an operating hazard when the dielectric strength stays over 20 KV and moisture remains low. However, this rare occurrence calls for checking into condition of the interior construction and consulting the transformer maker.

*If askarel is clear; but dielectric strength drops to 22-20 KV, and moisture rises over 70 ppm . . . the askarel is ready for simple "refining".

*If dielectric strength has dropped to 22-20 KV or lower range; and if moisture is 115-125 ppm . . . the askarel is ready for refining. A thorough inspection should be made for water droplets in the transformer shell, and even for "globules" of water floating on the askarel surface. If found, mechanical means should be devised to protect the transformer from "breathing" moist air to prevent recurrence.

*If askarel is dark brown to black; if black particles of carbon are seen; and dielectric strength is low . . . the askarel has been broken down by arcing. It cannot be refined and should be discarded.

If any of these five simple inspection tests appear out of the ordinary or the relationship between appearance and test values is abnormal — contact your transformer supplier for a complete analysis.

Whenever a sample is to be shipped to the transformer manufacturer (or to Monsanto) for complete analysis, the container must be a 4 to 5-pint amber glass bottle. For your convenience, various transformer manufacturers and Monsanto will send you the sample bottle filled with new askarel. You simply empty out the new askarel and re-fill the bottle with your sample. Follow the directions shown under: "Sampling."

TOWOLDMON0028049
WATER_PCB-00012518

WHAT TO DO . . .

To minimize inspection and maintenance

These simple tests will show you the condition of your askarel insulation, but only indirectly the condition of your transformer. They can be relied upon when your inspection sample is carefully taken (so as not to "miss" moisture on the surface). If you have taken mechanical precautions against moisture entry into your askarel transformer — and can "keep it dry" — these tests will be your assurance that, between checks, you can forget about maintenance.

Check out: Is your transformer completely and hermetically sealed or does it have gasketed areas? (Even the tightest gaskets can "breath".) Do you have a high fluctuating load? (Hot-to-cold temperature cycling makes the breathing faster and harder.) Is the air around your transformer cold and dry or hot and moist?

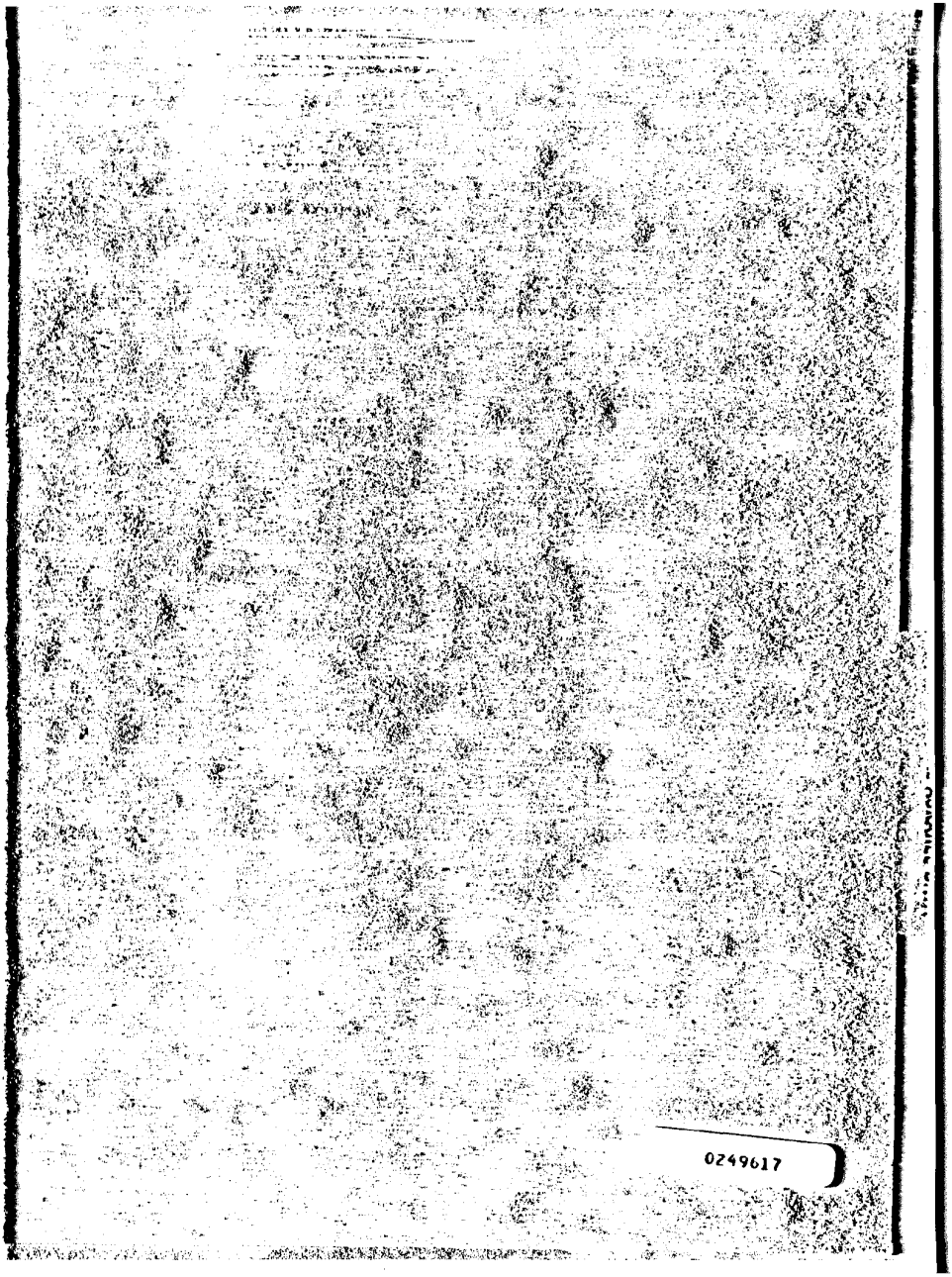
When you have condensation from "breathing" and high humidity — you can guard against trouble by fitting the transformer with a drying device (all transformer makers offer these).

Or you can bleed dry nitrogen or dry air through the "air space" above the askarel. The important thing to remember is that any mechanical steps you take to stop inside condensation will be double protection for trouble-free operation.

When buying equipment, specify whether transformers are intended for outdoor installation or will be used in a high moisture area. If so, it's wise to pay the only slightly increased cost for "designed-in" moisture protection; this will more than pay for itself because askarel units, properly protected from moisture entry, will give trouble-free operation indefinitely.

0249616

TOWOLDMON0028050
WATER_PCB-00012519



TOWOLDMON0028051
WATER_PCB-00012520

Sampling Askarel

Take a sample as close to the top of the liquid surface as possible. (Many large askarel transformers have a built-in sampling tube near the surface for convenient sampling.) Then to make sure that your SAMPLE truly represents your askarel insulation, take another sample from the bottom. If additional sampling tube connections are contrived on the valves for easier sampling, make the tubes of clean glass, stainless steel, aluminum or tin for rigid types; and silicone or Teflon tubing for flexible types.

Use NEW containers for the askarel sample. A new and previously unused small mouth pint glass bottle fitted with a Bakelite screw cap fitted with an aluminum or tin bottle cap liner is recommended. Be sure that the new bottle does not stand open to collect dust or moisture. Rinse the sample bottle and cap lining two or three times with askarel from the transformer; then fill it. If the sample will be tested promptly, a clear glass bottle can be used. If sample is to be stored indefinitely, use an amber glass bottle or wrap clear glass with aluminum foil.

1. **Select a dry day. Do not sample insulation on a warm, moist day when humidity exceeds 75%, and . . .**

2. **Make sure that the askarel is at least as warm as the surrounding air. (Cold liquids can condense moisture from humid air.)**

Water floats on askarel

If there is any water in your transformer, it may collect in little puddles ON TOP of the askarel. And therefore, more water will probably be dissolved in the askarel near the top, where it contacts any collected condensation.

If you find low dielectric strength and high moisture in the askarel, you will probably want to thoroughly dry out the core and coil structure and consult the manufacturer for instructions.

When you take your askarel sample for testing, take the same precautions (but no more) that you would take when sampling mineral oil.

0249618

TOWOLDMON0028052
WATER_PCB-00012521

Refining Askarel for Re-Use

Most operators prefer a portable refining apparatus, such as a plate press, fitted with a dolly, (available from Sparkler, Mundelein, Ill.); or the earthen cartridge filter type, (available from Industrial Filter Corp., Lebanon, Ind.). Filter paper liners for the plate press are available from Carl Schleicher & Schuell Co., Keane, N. H.

If you use a filter press, before refining it is advisable to oven-dry the filter paper at 110°C. for 3 to 4 hours in an air circulating oven to remove all moisture. If the askarel to be refined contains excessive moisture, circulate it hot (55-60°C.) through the filter fitted with the paper liners only. After filtration the dielectric strength should be 35 KV., minimum.

Precautions

Any flexible hoses and gaskets on the refining equipment should be lined with or made of materials that will not be softened by contact with askarel fluid. (Silicone or Teflon-lined, or flexible metal materials are suitable.)

Guide to Rate of Dissolved Water Removal by Filtering Askarel Through A Paper Press

Passes Through Paper Press	Water in Askarel PPM
0	115
1	35
2	22
3	18
4	12
5	10
6	10

TOWOLDMON0028053
WATER_PCB-00012522

Treatment for Maximum Improvement of Power Factor and Volume Resistivity

Use Attapulgus clay or Fuller's earth, dried and activated by heating for 12 hours at 250°F. immediately prior to use, as a coating on the filter surface. The amount of earth used should be 0.1 to 0.2 per cent by weight of the askarel (askarel weighs about 13 pounds per gallon).

To deposit the earth evenly, stir one-third of the earth with a small portion of askarel in a clean container. Pump the mixture through the filter and follow with two more one-third portions. Then circulate askarel taken from near the top of the transformer, pass it hot (55-60°C.) through the filter and feed back through the bottom transformer outlet. Continue circulation until the fluid is clear and shows the electrical properties are fully restored.

Checking Transformer After Refining Askarel Fluid

After refining the askarel, the over-all insulation resistances of the transformer should approximate the values for a new transformer filled with fresh askarel. If the transformer insulation resistance is judged unsatisfactory, the manufacturer should be contacted for complete inspection and analysis of the equipment.

Effect of Earth Refinement on Removal of Scavengers

Only slight and insignificant loss (by selective adsorption) of tintetraphenyl and phenoxy propene oxide occurs when askarel is refined by treatment with 0.1 to 0.2 per cent by weight of earth. To remove significant amounts of the scavengers requires repetitious treatment with much larger amounts of earth.

Amount of Tin-Tetraphenyl Depletion From Pyranol 1470 By Repetitious Treatment With One Per Cent by Weight of Earth

		Tin-Tetraphenyl Content	
Sample	Original	After 4 treatments at 90°C.	After 7 treatments at 90°C.
No. 1	0.119%	0.018%	0.006%
		After 4 treatments at 60°C.	After 6 treatments at 60°C.
No. 2	0.107%	0.021%	0.003%

TOWOLDMON0028054
WATER_PCB-00012523

TYPICAL VALUES FOUND IN ASKAREL INSULATION UNDER VARIOUS CONDITIONS OF USE

	A	B	C	D	E	F
	New askarel	Askarel in properly* built new or rebuilt units prior to use.	After normal operation; a survey of 50 units, most 2-5 yrs. old; some 10.	Non-arced but slightly contaminated askarel in improperly* built units, new or slightly used.	Same askarel as in Column D — after refining.	Heavily arced askarel due to neglect and internal electrical malfunction.
Inspection Check Points						
Color	Light straw	Light straw	Light straw	Can have foreign shades, blue, green, red cast.	Foreign shades remain showing extraction of oil soluble color.	Black
Clarity	Clear, free from particles	Clear, practically free from particles	Clear, trace of particles	Clear, slight amount of particles	Clear, free from particles	Contains carbon particles
Moisture 25°C.	30 ppm	30 ppm	10-70 ppm all dissolved water	20-100 ppm all dissolved water	30 ppm	Near 125ppm saturation level — plus possible undissolved water
Dielectric Strength 25°C., 0.1″ gap	35 KV minimum	35-48 KV	35-45 KV	30-42 KV	40-45 KV	5-15 KV
Volume Resistivity 100°C., 500 Volts, DC., 0.1″ gap	100×10^9 ohm-cm. minimum usually 500-1,500	20×10^9 ohm-cm. minimum usually at least 100×10^9	$15\text{-}400 \times 10^9$ ohm-cm.	about 5×10^9 ohm-cm.	at least $1{,}500 \times 10^9$ ohm-cm.	about 3×10^9 ohm-cm.
Power Factor:						
100°C. 60 cycles	2-5%	10-25%	10 to near 80%	30 to 100%	2-5%	100%
25°C. 60 cycles	0.05-0.1%	0.5-2%	0.5 to near 10%	about 7 to over 15%	0.1-0.2%	at least 25%

**A properly built transformer is defined as one in which the materials of construction are chemically and electrically compatible with askarel.*

0249621

TOWOLDMON0028055
WATER_PCB-00012524

CLEANING ARCED TRANSFORMERS

If a unit has arced so that the askarel is no longer fit for use, a thorough cleaning of the unit is necessary before re-filling with new askarel insulation and returning it to service. Follow this procedure:

1. **Drain out all dark, carbon-contaminated askarel. (Discard by dumping or burying where it will not contaminate a water supply.)**

2. **Wire brush carbon deposits from internal parts and insulation.**

3. **Flush thoroughly using new askarel (not an oil, not a cleaning solvent).**

4. **Wipe internal parts dry of askarel with lint free rags.**

5. **Flush a second time with fresh askarel; drain; then fill to the proper level with new askarel.**

6. **Energize transformer to warm the fluid for 24 to 48 hours; then circulate the askarel through a filter, returning it to the unit filtered and ready for use.**

TOWOLDMON0028056
WATER_PCB-00012525

Thermal Conductivity

The thermal conductivity values of Pyranol 1470 at 27°C. and 58°C. are 26.2 and 25.8 x 10^{-5} calories centimeters^{-1}, degrees centigrade^{-1}, second^{-1}, respectively. Or, approximately 0.06 BTU per (hr.) (sq. ft.) (°F.) per foot.

Heat Capacity

Over the temperature range of 25° to 125°C. the specific heat of transformer askarel is close to 0.30 calories per gram per degree.

Coefficient of Expansion

The average coefficient of expansion of transformer askarel over the temperature range 20 to 100°C. is 0.0007 cc/cc./°C. One gallon would increase to 1.056 gallons on heating from 20 to 100°C.

Fire Resistance

To use the generic name askarel the fluids must be approved by the Underwriters' Laboratories as possessing adequate fire resistance and freedom from forming explosive gases when arced. These liquids do not have a burn point (ASTM D92-33) (Cleveland open cup method) up to about 205°C., at which temperatures they begin to boil. The significance of this is that they do not burn or support combustion under conditions encountered in transformer operation. Thus the danger of secondary explosion (or fire) is eliminated.

Effect of Temperature on Dielectric Strength of Askarel

Temperature °C.	Dielectric Strength
−60	67 KV
−40	63 KV
−20	57 KV
0	55 KV
20	50 KV
40	50 KV
60	48 KV
80	45 KV

0249623

TOWOLDMON0028057
WATER_PCB-00012526

Vapor Pressure of Pyranol 1467 and Inerteen PPO

Temperature °C.	Vapor Pressure mm. Hg.
40	1
60	4.9
80	9
100	35
120	60
140	90

The Viscosity and Density of Pyranol 1467 and Inerteen PPO Type Askarel

Temperature °C.	Viscosity		Density gm/cc.
	Centistokes	Saybolt Universal Seconds	
−20	600	2,800	—
0	42	195	1.574
20	17	85	1.552
40	7.5	50	1.529
60	4.5	40	1.507
80	2.9	36	1.485
100	2.0	33	—

Solubility of Air and Nitrogen in Transformer Askarel

	Percent of Gas By Volume Corrected to			
	25°C. 760 mm		0°C. 760 mm	
	25°C.	100°C.	25°C.	100°C.
Air	6.3	5.5	5.8	5.0
Nitrogen	6.0	4.8	5.5	4.4

(When a container of askarel is heated rapidly from 25 to 100°C., no appreciable gassing is observed.)

Approximate Vapor Pressure vs. Temperature For Transformer Askarel

Temperature °C.	Pyranol 1467 and Inerteen PPO	Pyranol 1470
40	1 mm Hg.	0.9 mm Hg.
60	5 mm Hg.	3.5 mm Hg.
80	9 mm Hg.	8.3 mm Hg.
100	30 mm Hg.	18 mm Hg.
120	60 mm Hg.	32 mm Hg.
140	90 mm Hg.	53 mm Hg.

0249624

TOWOLDMON0028058
WATER_PCB-00012527

Analytical Services on Transformer Askarel Available from Monsanto

Transformer users not wishing to make their own fluid analysis can obtain these services from Monsanto. Simply contact Monsanto and specify what analyses are wanted. You will be sent the proper-sized sample container filled with fresh askarel. When you receive this, empty it and carefully take your sample (follow procedure for sampling in this guide) and send the container to Monsanto's laboratory. Charges listed include sample container, shipping, handling and laboratory costs.

TYPES OF ANALYSES AVAILABLE

ANALYSIS 1)

ROUTINE MAINTENANCE CHECK
Total Charge: $20.00

To determine the general condition of the fluid and find whether futher analysis is necessary. (one-quart sample required)

Properties Tested
Color and Condition
Dielectric Strength
Moisture

You will be notified of the results of this test. If further testing is indicated, and you want a complete analysis, you will be sent a five-pint sample container. This sample will be used for the following series of tests:

ANALYSIS 2)

COMPLETE ANALYSIS
Total Charge: $50.00

(a) To determine the extent of fluid contamination, (b) earth refinement to determine what degree of restoration of electrical and insulating properties is possible, (c) check test to see how the fluid responded to earth treatment.

a) Complete Analysis: to determine the extent of contamination

Properties Tested
Color and Condition
Specific Gravity
Refractive Index
Water
Free Chlorides
Acidity
Dielectric Strength
Power Factor, Dielectric Constant, and Resistivity

b) Earth Refinement

Consists of treatment for 2.5 hours at 50-60°C. with 0.1 to 0.2 percent by weight of properly conditioned Attapulgus clay and then filtration through dry filter paper.

c) Analysis After Laboratory Earth Refinement:

Properties Tested
Refractive Index
Water
Free Chlorides
Acidity
Dielectric Strength
Power Factor, Dielectric Constant, and Resistivity

You will be notified of the results of this test series on your sample. Then, after refining your entire transformer fluid fill you can check on the results by requesting the following analysis:

ANALYSIS 3)

ANALYSIS AFTER EARTH REFINEMENT Total Charge: $30.00
(This charge will not apply when analyses 1 and 2 have already been made.)

To determine whether the entire lot of askarel fill responded to the same extent as the laboratory sample. (five-pint sample required)

Properties Tested
Color and Condition
Refractive Index
Water
Free Chlorides
Acidity
Dielectric Strength
Power Factor, Dielectric Constant, and Resistivity

To arrange for the tests described above write to the following address:

Paul G. Benignus
Monsanto Chemical Company
800 North Lindbergh Blvd.
St. Louis 66, Missouri

Samples to be tested should be clearly marked for identification and sent directly to:

Monsanto Chemical Company
W. G. Krummrich Laboratory
Monsanto, Illinois
Attention: R. Kuster

0249625

AVAILABLE

TOWOLDMON0028059
WATER_PCB-00012528

Monsanto



MONSANTO CHEMICAL COMPANY
ORGANIC CHEMICALS DIVISION
ST. LOUIS 66, MISSOURI

The information herein regarding obtaining optimum results from askarel fluids in your transformer has been accumulated by Monsanto for over 30 years from the experience of makers and users of askarel transformers and it is believed will be helpful.

Nothing herein shall be construed as applying to other than askarel insulation. Data and maintenance suggestions herein do not apply to the other components of the transformer. All operating and maintenance suggestions recommended by the manufacturer of the transformer should also be carefully followed.

Because these maintenance directions apply only to the askarel insulation, Monsanto disclaims any liability for damage to property or injury to persons arising from transformer operation.

0249626

2-976-0862 Litho in U.S.A.

TOWOLDMON0028060
WATER_PCB-00012529

0249627