IS ASKAREL PHASING OUT?

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WHAT IS IT?

The term "askerel" as defined by IEEE, ASTM, and the National Electrical Code generally describes a broad class of fire-resistant synthetic chlorinated hydrocarbon insulating liquids. By controlling the composition of these mixtures, a manufacturer can obtain desired combinations of thermal, chemical, and dielectric properties that result in insulating liquids which have greater resistance to oxidation and fire resistance than mineral oils.

The Monsanto Chemical Company is the sole supplier of polychlorinated biphenyls (commonly referred to as PCB). ~~Under~~ Their trade name is "Aroclor"(R), they also mix this dielectric fluid with chlorobenzenes to produce Pyranol and Inerteen, the trade names of askarels used by the General Electric and Westinghouse companies respectively.

CHARACTERISTICS AND USES

Askarel~~s~~ ~~are~~ is one of the best liquid insulations developed by science and this accounts for its popularity since ~~they were~~ it was introduced 45 years ago.

Askarel is chemically stable, fire-resistant, heat stable, non-corrosive, non-conducting, and has a high dielectric strength under operating conditions.

Because of these characteristics, ~~they have~~ it has been used for many industrial and consumer applications. Askarel also gives electrical equipment the critical advantages of reliability, long life, compactness, and low cost.

Because of its fire-resistance, askarel equipment has been permitted by the National Electrical Code and insurance companies to be located inside of buildings with its installation savings as well as the safety aspects.

Arcing in askarel, however, will breakdown askarel and liberate mostly hydrogen chloride and small amounts of carbon. This arc-formed gas from

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transformer askarel is non-flammable and non-combustible. The carbon will discolor the liquid and reduce its dielectric strength. Askarel-filled interrupter switches were used years ago in industry, but have been superseded by the air type.

The following use categories or applications are important to know because of the environmental and ecology story:

1. Open, e.g. paints, printing inks, paper coatings, plastics, carbonless duplicating paper, calking compounds, ashesives, nonflammable oils and others

2. Nominally closed application systems, e.g. hydraulic, heat transfer, and lubricating fluids.

3. Closed applications, e.g. sealed transformers and capacitors.

In the past this accounted for about 60 percent of the use, but now is 100 percent of domestic askarel output.

ENVIRONMENTAL AND ECOLOGY CONSIDERATIONS

Although askarels have been in use for 45 years, it was only recently that there was evidence to indicate that PCBs were rather widely dispersed in the environment, including terrestrial and aquatic environment, although the largest amount is present in landfills and dumps.

Askarels are chemically stable--incredibly stable, which is part of the environmental problem, i.e. they do not readily degrade. It persists, and if discarded in the environment in sufficient quantities, it could result in a gradual accumulation in certain ecological systems. This was the reason PCB was put on the Environmental Protection Agency (EPA) Toxic Pollutant List. Many industrial materials more dangerous to handle and more immediately harmful are not on that list.

About 1971, widespread newspaper headlines were generated when large

quantities of fowl in Minnesota and in North Carolina and large numbers of eggs in several locations were destroyed after they were found to be contaminated with high concentrations of PCB. In each case, the source of contamination was traced to a Class 2 (nominally closed system), leaking heat exchanger cooling system in a fish meal processor's plant which apparently went unnoticed for some time. Unfortunately, this fish meal was used as an ingredient in a commercial poultry feed product.

PCBs were first identified as potential food contaminants in 1966. These were in residues of fresh water fish attributable from various sources, from carbonless paper (Category #1), and food packaging materials, some of which migrated into packaged food.

It is unfortunate that the scientific area did not have sensitive and meaningful diagnostic evaluations in the earlier years. It was a Dr. Jensen of Sweden (1966) who first referred to PCB as a new pollutant in our environment (36 years since the commercial use of askarels).

In 1971, representatives of several government agencies established an interdepartmental task force to coordinate the scientific efforts of the government aimed at understanding the family of PCB chemical compounds. Their report (1) represents and reflects the position of the agencies of the Federal Government.

That task force reviewed all of the available scientific information on various aspects of the PCB problem and found much data that it regarded as inadequate and many questions that remained unanswered. But on the basis of available information, the task force concurs on the following findings, conclusions, and recommendations: (They list nine items but only a few are listed here.)

1. "PCBs should be restricted to essential or non-replaceable uses which involve minimal direct human exposure since they can have adverse effects on human health. There currently are no toxicological or ecological data available to indicate that the levels of PCBs currently known to be in the environment constitute a threat to human health, but additional experiments are underway to evaluate the impact of low level, long-term exposure to PCBs."

5." Housekeeping is particularly important in the manufacture, use, and disposal of PCBs."

Note especially their following recommendation:

6. "The use of PCBs should not be banned entirely. Their continued use for transformers and capacitors in the near future is considered necessary because of the significantly increased risk of fire and explosion and the disruption of electrical service which would result from a ban on PCB use. Also, continued use of PCBs in transformers and capacitors presents a minimal risk of environmental contamination - - -."

9." More scientific information about PCBs is needed, and several Government agencies are seeking it through research. The task force recognizes that the scientific basis of much of our knowledge must be strengthened through research. The total exposure of a human being to a given substance from all sources--air, water, and food--must be considered, and interactions of PCBs and other substances within and outside the body must be evaluated. Similar consideration must be given to the other body organisms."

And, the report goes on to state that the current scientific knowledge gained from laboratory animal experiments if often inadequate to allow

reliable interpretation of the data in terms of possible effects on man. Also, the scientific basis for interpreting such tests must be improved because of the sparsity of knowledge about PCBs in the environment.

It is not surprising that based on the above government report as well as other information that industry does not agree with many of the FDA proposed rules, regulations, or standards; they are not practical and are not based on ecological facts, e.g. available data do not support categorizing PCBs as a "highly toxic" material, nor setting standards on the basis of an arbitrary hazard rating; and the maximum recommended concentration of PCBs in fresh water is a meaningless number that is not supported by convincing ecological data.

When questions about the effect of PCBs on the environment first surfaced, the Monsanto Company--the sole United States manufacturer of PCB--reviewed its product line and their applications. They then took steps to reduce the entry of PCB into the environment.

Monsanto ~~immediately~~ stopped the sale of PCB to applications in the first two categories, i.e. open and nominally closed applications. This, in itself, decreased their PCB output by ~~catastrophic~~ one-half. And those were the applications which caused the catastrophic incidents. (4)

Today, the PCB manufactured by Monsanto is sold only to the electrical industry where it is used in closed systems as a dielectric fluid in transformers and capacitors--applications where there are no known acceptable substitutes.

Housekeeping is particularly important in the manufacture, use, and disposal of PCBs. References (2,3,4) & 5 are directed to this area, and are guidelines for handling and disposal of these dielectric fluids.

Thus, the situation today is drastically different from conditions which existed only four years ago: First, the amount of PCB used is only about half due to eliminating the open and nominally closed applications; and, second, is carefully used in the United States by less than 50 companies in their use in sealed electrical equipment. Prior to 1971, there were thousands of users.

What is needed is a broader educational program directed to users of PCBs to assure proper handling and disposal.

WHAT ARE THE ALTERNATIVES TO ASKAREL?

Many companies are working on substitute fluids which will have the attractive characteristics of askarels but without their environmental problem.

Much work has already been done for capacitor fluids; Monstanto has in service a new liquid--1016--which retains a high dielectric constant and yet is partially biodegradable. General Electric has a liquid for small capacitors known as Econol, and Dow Chemical has an alkylated chlorodiphenyl oxide fluid which ~~is~~ also is not a PCB; both of these are in the market development stage. ~~It has~~ these have been in use for several years but that is hardly long enough ~~time~~ for adequate testing. Monsanto has developed MCS 1238, a blend of synthetic hydrocarbons with a high dielectric constant modified to give equivalent dielectric properties to Arbor. Use of such a fluid would minimize capacitor design changes.

Silicone fluids.

One of the attractive liquid chemicals that may replace askarel for transformers is a silicone fluid--dimethyl siloxane, a silicone oil. These are manufactured by at least four United States companies with Dow Corning and General Electric the two major sources.

Silicone fluids have many of the desirable electrical characteristics

of askarel and yet are not toxic. The excellent dielectric properties of silicone fluids are a consequence of their unique chemical structure. Basically, there is nothing in the silicone structure that can provide anything but good electrical properties, except gross contamination or water.

Silicone fluids are available in a wide range of viscosities and for MANY applications. Companies have zeroed-in for a viscosity around 50cs which is a compromise in terms of flash point about 550°F and with a fire point higher. (Askarel has no flash point.)

Silicone fluids have low toxicity and physiological inertness; for example, their use is permitted by the Food & Drug Administration (FDA) and are currently being used in a wide variety of medical and pharmaceutical applications ([redacted]).

The silicone fluids are used where their general inertness is an essential property. They are compatible with most of the materials used in existing askarel transformers with the exception of silicone rubber which is sometimes used in gasketing. (The silicone fluid acts as a plasticizer for the silicone rubber causing it to swell.)

Silicone fluids will burn under the right conditions, so they cannot be classed as "nonflammable" like askarel. They will burn only if the flame or source of heat is continuous; if that is removed, the silicone will cease to burn. Therefore, they might be classed as <u>self-extinguishing</u>.

UL does not approve or reject liquids for use in electrical test equipment, nor do they test or list any liquid-filled electrical equipment. However, they do provide a classification service of flammability rating. A comparison of a few fluids is included here:

Fluid	Flammability Rating
Ether	100
Mineral oil (Transformer)	10-20
Silicone oils (Transformer) (50cs)	4-5
Askarels	2-3

Thus, ~~the~~ transformer silicone oil is close to askarel in this important rating.

Also, silicone oil has ~~an~~ a unique characteristic which may have a special significance for transformers. Since most transformer faults start as turn-to-turn faults, the arc breaks down the fluid forming gases and semi-solid residues which remain in suspension and are relatively conductive reducing the dielectric strength and snuffing out the arc.

While there is a considerable amount of data available relating to the performance of silicone fluids under dielectric stress, there are many voids in the information which must be filled in order to develop confidence in the use of the fluid for an acceptable normal life of liquid-filled transformers; specifically, considerably more in-service installations in various industrial and utility environmental locations.

Dow Corning has had several of their load-center type transformers retrofitted with silicone oil (50cs) the last few years to gain experience. Their future plant transformers will use silicone oil. Thus, this will help fulfill the experience gap. In most cases, there should be only a few parts to be replaced during retrofitting, but check with the transformer manufacturer. The change in the transformer kVA rating should also be checked; it may be about 10 percent less due to the difference in heat conductivity and viscosity of silicone oil.

The Japanese National Railway has used silicone oil-filled transformers on their electric coaches for about five years with good results, but these required several design modifications. MONS 071122

At the present time insurance companies have not formulated a policy on the use of silicone oil; however, they have approved its use in a limited number of individual cases.

The silicone fluids have been used for many years in specialty uses, primarily for radar, but that service experience, while helpful, will not qualify the fluid for larger ratings for industrial service (OSHA)

One very important area is the UL, Code, and insurance companies' acceptability of silicone oil-filled transformers for indoor and other locations presently approved by these groups for askarels. That will involve testing and on-site experience. As a suggestion, these groups should consider the tentative approval of silicone fluid applications in specified physical and environmental locations to obtain the experience. The author further suggests an investigative and experience program by manufacturers, users, UL, and insurance companies to obtain information useful in determining if such transformers can replace askarel units--either for all or only specific locations.

One disadvantage of silicone fluids is its cost--about twice that of an askarel fluid; e.g. on a typical 1000-kVA indoor load-center type transformer, the additional cost is 8 to 10 percent for the liquid only. There may be additional costs--or savings--but that can only be determined on design ←——basis.

Of course dry-type transformers are and can be used to replace askarel-filled transformers; practically all of these are the so-called "load-center" units for the construction, industrial, and some utility applications--usually with primary voltages up to 15 kV and low-voltage utilization below 600 volts. Here are some comparisons of these various types of transformers.

GENERAL COMPARISONS OF

VARIOUS TYPES OF TRANSFORMERS

(1000 kVA)

	Oil	Askeral	Dry Open	Type Scaled C_4F_8 Gas
Price - relative	1.0	1.25	1.25	2.0
Wt. (lb) 5/15 kV	5400	6300	4000/5400	8300/9000
OL Capacity				
750-2000 kVA	15%	15%	33 1/3%	None
2500 kVA	25%	25%	33 1/3%	None
BIL 5/15 kV	60/95	60/95	25/50	60/95
Sound level, dB				
w/o fans running	60	60	65	64
with fans running	67	67	67	-

EXPLOSIONS

In the last year or so "explosion" tests were conducted in Japan and by one [redacted] transformer manufacturer in the United States comparing transformer mineral oil, askarel, and silicone oil fluids. The fluids were tested in small tanks with a loose cover and "shot" with 4000-5000 amperes at 4800V.

Not surprisingly, the covers blew off. (Such performance was known many years ago.) Such tests are not representative of actual operation. Such explosions do occur occasionally on exposed utility power systems, but they are rare on industrial service.

Transformer failures are usually associated with turn-to-turn failures and limited fault current and not the catastrophic magnitudes of the above tests. Manufacturers offer various sensors and devices to detect incipient faults as well as severe faults. The author knows of only one such catastrophic occurrence--in that case, lightning hit an askarel transformer on the roof of a building--but there was no fire damage. A check with a major insurance company confirmed the scarcity of such accidents.

IS A NEW LIQUID DIELECTRIC THE ANSWER?

Much emphasis is currently being directed to the use of silicone oil in place of askarel. But, is that the right or only solution?

It may be that a new non-liquid transformer will emerge. Several European manufacturers and at least one U. S. manufacturer offer such a transformer in some of the lower load-center kVA ratings in an epoxy cast-coil design. Currently, such designs are difficult to manufacture except in small ratings in the 100-500 kVA range. ([redacted]

[redacted]) Thus, [redacted]

More manufacturing development work is needed.

Another alternative is a modification of existing open dry-type transformers for more universal applications. (The sealed-dry gas type is too large, too heavy, and too expensive for general use.)

CONCLUSION

Unless the EPA suddenly prohibits the use of askarel, it is the author's opinion that this fluid will continue to be used in transformers and capacitors until new liquid(s) become available and have been sufficiently tested for safety to obtain approval of the necessary bodies.

Askarel units have given excellent service over the past 45 years. And, with the present restriction to sealed equipments only for transformers and capacitors and carefully controlled by the equipment manufacturers along with the much better housekeeping in handling the liquids, there should be a minimum chance of loss to the environment.

One factor which may affect the use of askarel-filled transformers is a new policy of indemnification by the buyer to the seller. The wording of the indemnification contract may vary, but essentially it applies to any and all liabilities and expenses, including actions, suits, proceedings, investigations, instituted or issued by any governmental agency or body. This includes the handling, possession, use, or disposition of askarels which may contaminate the environment.

The government should restrict the import of askarels for use in closed systems only as is true domestically.