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PYRANOL*

Characteristics of Transformer, Regulator, and Capacitor Pyranol

Pyranol is the trade-mark of the General Electric Company for cooling and insulating materials which generically are known as askarels. In addition to the desirable characteristics of mineral oil, askarel has the distinctive property of being non-flammable. The development and application of these materials are fully covered by U. S. Letters Patent.

The development of these materials has been actively carried on since 1928 and Pyranol was first used commercially in capacitors in 1931. Today Pyranol capacitors are recognized as the standard means of improving power factor. Practically all power-factor-capacitor manufacturers have asked for and received license to manufacture and sell capacitors impregnated with Pyranol. Over 20,000,000 kvar of 60-cycle power-factor units, using Pyranol, are in service today in addition to over 6,000,000 kvar of high-frequency Pyranol capacitors. More than 60,000,000 small specialty capacitors are in service for applications such as power factor correction of ballasts, capacitor-motors, radio transmitters, luminous-tube transformers and radar. The above figures are given as industry figures.

Pyranol was first used commercially in transformers in 1932. Since then, more than 35,000 Pyranol transformers, ranging in size from 1½ to 27,000 kva and totalling more than 10,000,000 kva, have established an excellent operating record. Many of these installations include Pyranol current transformers and Pyranol potential transformers. The above figures apply to General Electric alone.

The first Pyranol induction voltage regulators were built in 1938, and there are now more than 1250 units in service, totalling more than 110,000 kva.

The Laboratories of the National Board of Fire Underwriters have investigated transformer, regulator, and capacitor Pyranols, and their series of reports No. 2581 definitely substantiates all the claims made for Pyranol.

The following statements, prepared by our research, engineering, and laboratory organizations, summarize the answers to questions that are asked by users and prospective users of Pyranol equipment.

HISTORY OF PYRANOL

Pyranol was developed to meet a specific need—the elimination of the fire and explosive hazard inherent in the use of mineral insulating oil as a dielectric and cooling medium in capacitors, regulators, and transformers. Like most scientific developments, Pyranol is the result of careful study and analysis of the problems involved. Its successful development and commercial application meant the solution of a number of problems which were apparently insolvable. Could a non-flammable liquid be obtained which was not inherently chemically unstable and corrosive? What type of organic hydrocarbon molecule was best adapted to meet the requirements of resistance to sludge and oxidation? How do hydrocarbons decompose under the electric arc? How can the high degree of liquidity so necessary for the proper cooling of transformers be obtained with a non-flammable substance normally solid or plastic-like? These and other problems of equal difficulty and importance were attacked, and their successful solution has been the firm foundation on which the commercial application of Pyranol to transformers, regulators, and capacitors has been built.

PHYSICAL CHARACTERISTICS

Pyranols for different applications have different physical characteristics, ranging from a resin-like, noncrystalline composition to a thin, mobile liquid.

The two Pyranols now in greatest commercial use are: (1) The transformer and induction-voltage regulator type (No. 1470), and (2) the capacitor type (No. 1476). Both types have the distinctive Pyranol characteristics of high dielectric strength and non-flammability.

The characteristics of these two Pyranols serve to demonstrate the wide range of physical properties possessed by the liquid materials.

	Transformer Pyranol No. 1470	Capacitor Pyranol No. 1476
Color	straw-yellow	straw-yellow
Burning point	none	none
Viscosity at 37.8 C (Saybolt)	42 sec	2400 sec
Flow point (A.S.T.M.)	lower than −44 C	+10 C
Dielectric constant (specific inductive capacity)	4.5	4.5

CHEMICAL STABILITY

The Pyranols are all chemically stable and are not affected by reaction with other materials used in Pyranol filled equipment. Experience gained from transformers in service and from factory tests proves that they are nonoxidizing, and that the Pyranols show no development of corrosive acidity or insoluble sludge over long periods at high temperatures, even up to 150 C.

PHYSIOLOGICAL EFFECTS

Normal Liquid Condition

Liquid Pyranols, like mineral oils, can be handled at room temperature without fear of toxic effects. With some individuals, continued exposure to liquid Pyranols may, as with mineral oils, produce skin irritations. Cleanliness among workmen handling Pyranol is an adequate safeguard against such effects. Ordinary detergents or medicinal washes will remove any irritation caused by bringing Pyranol in contact with an open cut or skin abrasion. A drop or two of castor oil will neutralize any irritation caused by contact of liquid Pyranol with the eyes.

Evaporation from Liquid Pyranol

As with most volatile materials, exposure to concentrated Pyranol vapors in unventilated rooms should be avoided. During the 23 years' experience of the General Electric Company in manufacturing Pyranol, there is no record of any workman requiring first aid or medical assistance because of Pyranol vapors.

Products of Decomposition

Air-saturated Pyranol at 25 C, when decomposed by an electric arc, evolves finely divided carbon and gases in the following approximate proportions:

	Transformer Pyranol, No. 1470	Capacitor Pyranol, No. 1476
Hydrogen chloride	97.50%	99.00%
Oxygen	0.60	0.10
Unsaturated hydrocarbons	.00	.40
Carbon dioxide	.28	.00
Carbon monoxide	.28	.00
Phosgene	.00	.00
Saturated hydrocarbons	.00	.00
Hydrogen	.00	.00
Chlorine	.00	.00
Inert (gases)	1.34	.50

With the exception of the hydrogen chloride, these products of decomposition, which are formed only on failure of the apparatus, are present in such minute

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proportions as to render it unnecessary even to consider them. Hydrogen-chloride gas is an irritant and gives full warning of its presence, even in small quantities, by its immediately noticeable odor and irritant action on the nasal membranes. All requirements for protection against gases which may be liberated under arc decomposition where Pyranol filled transformers are installed in restricted locations are met by the "all-purpose" gas masks available for use around dry-type and oil-filled transformer installations.

DIELECTRIC STRENGTH

The dielectric strength of mineral oil, when new, meets the requirements of capacitor, regulator, and transformer use. Unfortunately, however, mineral oil oxidizes, and among the products formed as a result of this oxidation are some of high conductivity and low dielectric strength, such as the organic acids and water. Pyranol is not subject to oxidation. Its dielectric strength is independent of its exposure, even to severe oxidizing conditions during use.

The dielectric strength of Pyranol is normally of high order. Commercial values higher than 30 kv are customarily expected.

Like mineral oil, however, Pyranol follows the usual gas-solubility laws. Exposed to wet air, it will absorb some water, and an equilibrium will be set up between the water in the Pyranol and that in the air with which it may come in contact. In contact with water, Pyranol will dissolve the water until a state of saturation is reached. In this respect, Pyranol greatly resembles new mineral oil; but, unlike mineral oil, its ability to absorb or dissolve water does not change materially with use.

Because of the nonoxidizing characteristics of Pyranol, filtration of this liquid will normally be less frequently required than with mineral oil. If it should become necessary to dry transformer Pyranol, it can be done in a manner similar to that used in the drying of mineral oil; that is, by the use of a filter press or a specially arranged centrifuge.

DIELECTRIC CONSTANT

The dielectric constant of transformer, regulator, and capacitor Pyranols is 4.5 at 25 C. This is practically the same as the dielectric constant of the solid insulations used in transformer, regulator, and capacitor designs, and a more nearly equal distribution of dielectric stress throughout the insulation structure is obtained than with mineral oil.

RESISTIVITY AND POWER FACTOR

Laboratory tests and careful observation throughout many temperature cycles, and over long periods of time, have shown that the resistivity and power-factor values of capacitor Pyranols are of the same order of magnitude as those of any good mineral oil adapted for use with these products. Tests on samples of transformer and regulator Pyranol returned from the field, and other tests in the laboratory, indicate that the power factor will be higher and the resistivity will be lower than those of mineral oil.

EFFECT OF PYRANOL ON OTHER MATERIAL

Pyranols are stable and chemically inert. Pyranol and its vapors have no effect on the metals and insulations used in Pyranol filled equipment, but are, in general, powerful solvents of most of the gums, binders, paints, etc., customarily used in oil-filled equipment. For this reason, such materials have been eliminated from Pyranol filled equipment, and only paper, pressboard, porcelain, and other carefully selected materials which have proved to be unaffected by Pyranol are used. It has been found that the aging of these materials under Pyranol will be approximately the same as that under oil. No materials should be used in contact with Pyranol, except those specifically approved by the General Electric Company. When Pyranol is decomposed by an arc, hydrogenchloride gas is produced. The new No. 1470 Pyranol, and No. 1467 which it has superseded, unlike the No. 1488 Pyranol previously used, chemically neutralizes any of this gas which may have been absorbed in the liquid. Consequently, the gas can cause no damage to the organic insulation.

This new No. 1470 Pyranol (and the older No. 1467) enables Pyranol filled apparatus, in the rare case of failure, to be opened, inspected, and repaired as readily as oil-insulated apparatus. Pyranol in which arcing has occurred can usually be returned to a satisfactory condition by filtration through a fuller's earth press.

MIXTURE WITH OIL

Mineral oil is completely miscible with Pyranol, and it is extremely difficult to separate the two materials once they have been mixed. It is important, therefore, to avoid contamination of Pyranol with mineral oil or other petroleum oils, the presence of which definitely influences the vital characteristics of the nonflammability of Pyranol.

PRESSURE CAUSED BY ARCING

If an arc occurs under the surface of any liquid, the liquid evolves gases. The type of liquid determines the characteristics of the gases formed. The amount of energy in the arc and the duration of the arc determine the quantity of the gas produced. In general, protective gear or circuit-interrupting devices are installed to prevent the evolution of a sufficient amount of gas to rupture the enclosing tank. If the protective gear does not interrupt the arc in time, and no means of release is provided, the gases will be vented by rupture of gasketed joints or, in extreme cases, by rupture of the container itself. Because gases produced by an arc in Pyranol are nonflammable and nonexplosive, it is feasible to relieve the gas pressure in the tank by means of a frangible diaphragm. For indoor installations of oil-filled equipment, this method would be undesirable, as the flammable gases released might result in a secondary explosion.

All Pyranol transformers and regulators above 25 kva which are to be installed in buildings in accordance with the National Electrical Code are provided with such a frangible diaphragm.

The frangible diaphragms for indoor Pyranol distribution transformers or Pyranol regulators are so arranged that: (1) a pipe can be attached thereto, through which the gases that are products of decomposition can be vented to the outside air; or (2) a gas absorber can be attached thereto containing active materials that will absorb the hydrogen chloride which constitutes the major portion of the evolved gases.

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