

INSTRUCTIONS

GEI-28007

DRYING PYRANOL TRANSFORMERS

INTRODUCTION

Transformers shipped filled with Pyranol* require drying if the Pyranol tests 25 kv or less or if there is evidence of moisture. The dryness of transformers that have been disassembled or out of Pyranol depends on the care taken to keep all parts dry while exposed. Unless proper care has been taken and it is certain that no moisture has been allowed to enter, dry the transformer as subsequently instructed.

INITIAL DRYING WITH FILTER PRESS

A transformer contaminated with moisture will not only have moisture in the windings and insulation but also suspended in the Pyranol. By using a filter press the water held in suspension will be removed. In order to drive the moisture out of the windings and insulation the filter-press operation must be followed by a short-circuit drying heat run.

Any free water in the transformer will rise to the top of the Pyranol and float. It must be removed before drying is begun and should be drained through the upper filter-press valve.

The most efficient filtration occurs when the Pyranol temperature is between 20 C and 40 C. At the higher coil temperatures maintained during the short-circuit heat run the filter press loses its ability to remove any appreciable amount of moisture from the Pyranol. Usually drying will progress satisfactorily with no further filtering if thorough ventilation is provided.

SHORT CIRCUIT METHOD

This method consists of heating the winding and Pyranol up to a specified temperature for a limited time by short-circuiting one winding and applying a suitable reduced voltage to the other. (Note:—Always load the full total windings.) Knowledge of the transformer impedance is of assistance in determining the voltage required to circulate the desired cur-

rent in the windings. If the impedance is not indicated on the nameplate, it may be obtained from the nearest Apparatus Sales Office of the General Electric Company upon request. The rating and serial number of the transformer should accompany such a request.

If it is necessary to obtain drying voltage over a long transmission line, thorough protection against all kinds of overvoltages on the line should be installed so that the transformer being dried will not be damaged.

BLANKETING

Before applying voltage, blanket the transformer, beginning at the bottom of the corrugations, tubes, or radiators and wrap the tank with heavy paper, cloth, or building felt until sufficient surface has been covered. The amount of blanketing must be ascertained by trial. To prevent condensation thoroughly lag the cover. Ventilate the cover by raising the manhole covers etc. six inches. Protect the openings from weather inclemencies if the transformer is out-of-doors. If the drying is carried on indoors, good ventilation, or other means should be provided to exhaust the vapors from the room.

If the tank is equipped with radiators or tubes an effective means of preventing radiation from them is to lower the Pyranol below the top inlets; however, make sure all high-voltage parts are under Pyranol.

The Pyranol level may be above the upper radiator openings when the radiator flanges are equipped with valves. Close the upper valves, LEAVING THE BOTTOM VALVES OPEN; this will prevent circulating and cooling of Pyranol by the radiators. Pyranol expansion in radiators with both valves closed will generate excessive pressure and damage the valve disks, gaskets or welds.

When radiators are isolated by closing the valves (or leaving the Pyranol below the top inlets when no valves are furnished) suffi-

*Registered trade-mark for G-E askarel

Instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the General Electric Company.

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Dec 3, 1941

cient heat can be obtained by blanketing the tank surfaces and not the radiators. Some regulation of temperature may be obtained by manipulating the radiator valves.

Very little heat is radiated by the tank of an artificially cooled transformer; therefore, it may be unnecessary to blanket the tank, but be sure the cover and cover accessories are heavily lagged. The Pyranol temperature can be held to the desired value by allowing a small flow of the cooling medium.

TEMPERATURES

Table 1 gives the maximum Pyranol temperatures which apply to the self-cooled rating of type OA (self-cooled) as well as OW (water-cooled with internal cooling coil) transformers. The latter may not need blanketing of the tank although the cover should be lagged.

Before drying three-winding transformers or forced-liquid-cooled types, obtain advice from the nearest Apparatus Sales Office of the General Electric Company.

TABLE 1

Maximum-allowable Short-circuit Amperes in per cent of Full Load, Based on Self-Cooled Rating	Maximum-allowable Top Pyranol Temperatures
50%	100 C
75%	90 C

Do not allow the top-Pyranol temperature to exceed the specified value for the given percent load, because the windings are at a higher temperature than the Pyranol, and damage to the insulation may result.

It is desirable to maintain top-Pyranol temperatures up to the limit with load continuously applied. See that the thermometers used are in good condition and that the top-Pyranol temperatures are accurately observed. Use only spirit thermometers of the immersion type in the Pyranol when checking the reading of dial thermometers.

PYRANOL TESTING

Continue the drying until tests of seven consecutive samples of top Pyranol taken every four hours show a dielectric strength of 30 kv or higher. Allow the Pyranol samples to cool to room temperature (not more than 30 C) before testing.

ADDING ADDITIONAL PYRANOL

After completion of the drying run, add clean, dry Pyranol of high dielectric strength to fill the tank to the proper level. The hot Pyranol is free of air bubbles so it is preferable to complete the filling of the transformer from the top of the tank rather than through the drain valve, as, in the latter case, air bubbles may be trapped in the winding.

MEGGER READINGS

Megger readings cannot be relied upon to indicate the progress of drying liquid-filled transformers, since, in this case, the resistance of the liquid is measured in parallel with that of the solid insulation and they cannot be segregated.

While the insulation resistance of a transformer without Pyranol, as determined by megger readings cannot be relied upon as a sure indication of its condition at any one time, the general trend of the readings, as a drying run proceeds, is a fairly accurate indication of the progress of drying. Continue drying until the readings become approximately constant at a value considerably above those taken at the beginning of the drying. Variation in temperature causes wide variation in resistance, the values varying inversely with each other.

If the megger shows a short circuit, that is, an insulation resistance too low to be read, it is very likely due to an excessive amount of moisture. Low readings also sometimes indicate the presence of moist spots in the insulation. Widely different megger readings may be obtained on different transformers but the average readings should be approximately alike for transformers of the same capacity and design.

TRANSFORMER & ALLIED PRODUCT DIVISIONS

GENERAL  ELECTRIC

PITTSFIELD, MASS.

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Lithe in U.S.A.



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 nonflammable.

The development of these materials has been actively carried on since 1928 and Pyranol was first used commercially in capacitors in 1931. It was first used commercially in transformers in 1932 and in induction-voltage regulators in 1938.

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 nonflammable 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 nonflammable 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 Pyranols now in greatest commercial use are: (1) the transformer and induction-voltage regulator type (No. 1470), (2) the capacitor type (No. 1476), and (3) the capacitor type (No. 1499). All types have the distinctive Pyranol characteristics of high dielectric strength and nonflammability.

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

	Transformer Pyranol No. 1470	Capacitor Pyranol No. 1476	Capacitor Pyranol No. 1499
Color	Straw- Yellow	Straw- Yellow	Straw- Yellow
Burning point	None	None	None
Viscosity at 37.8 C (Say- bolt)	42 Sec	2400 Sec	87 Sec
Flow point (A.S.T.M.) ..	Lower than -44 C	+10 C	-14 C
Dielectric constant (specific inductive capacity)	4.5	4.25	4.8
Specific gravity at 25/ 15.5 C	1.58	1.505	1.586

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 30 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 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

*eg. trade-mark of General Electric Co.

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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 No. 1470 Pyranol is 4.5 at 25 C, of No. 1476 Pyranol is 4.25 at 25 C and of No. 1499 Pyranol is 4.8 at 25 C. These values are 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.

The high power factor does not indicate degradation of the Pyranol but rather the solution of trace amounts of transformer materials in the liquid. This effect of increased power factor is not harmful unless dielectric strength is affected adversely.

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, hydrogen-chloride 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, if there has been no contact with free water or high humidity, this gas can cause little damage to the organic insulation except in the immediate vicinity of the failure.

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 practically impossible 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 non-flammability 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 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.

For further information, contact your nearest G-E Apparatus Sales Office, Agent, or Distributor

GENERAL  ELECTRIC

SCHENECTADY, N. Y.

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Pyranol® Insulating Liquid

For Transformers and Regulators

INTRODUCTION

Pyranol is the trademark 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 nonflammable. Transformer Pyranol is compounded to General Electric specifications and is available in several different forms. The type used in any particular transformer can be determined from the nameplate. Types 1488, 1467 and 1470 are obsolete. Currently used types are A13B3B and A50P524. All replacement or make-up orders should be for Type A13B3B.

REQUISITIONS

The Monsanto Chemical Company, St. Louis, Mo., is in a position to supply quantities of A13B3B Pyranol liquid direct to users. All orders for quantities in excess of 100 gallons should be sent directly to the nearest Monsanto Chemical Company office or their St. Louis headquarters.

Emergency requirements and small orders of 100 gallons or less can be obtained in 5-gallon cans or 30-gallon drums from Rome, Georgia. Send requisitions to Renewal Parts Specialist, General Electric Company, Medium Transformer Department, Redmond Circle, Rome, Georgia 30161.

PRICES

MEDIUM TRANSFORMER-R (086)

Net price f.o.b. Rome, Georgia with transportation charges "collect" for A13B3B Pyranol liquid, including non-returnable containers:

5 gallons, including can. . . . *\$50.00
30 gallons, including drum. . . *\$150.00

CONTAINERS

When A13B3B Pyranol liquid is sold at the prices authorized on this page, the containers become the property of the purchaser, and drums as well as cans are nonreturnable.

SHIPPING WEIGHT

5-gallon can and
Pyranol liquid. 75 lbs
30-gallon drum and
Pyranol Liquid. 425 lbs

PYRANOL INSULATIONS FOR CAPACITORS

Requests for information on, or quantities of, capacitor Pyranol insulation should be referred to the Manager of Marketing, Capacitor Department, Hudson Falls, New York 12839.

Transformer Pyranol should not be used in capacitors.

PYRANOL INSULATING LIQUID FOR OTHER USES

When a request for information or an order is received for Pyranol liquid to be used in equipment other than GE transformers or GE induction regulators, it is necessary for the factory to have certain information before any action can be taken.

If proposed use is an electrical one, it will probably be necessary to negotiate for a license under GE patents. The inquirer should write to the Patent Attorney, Power Transmission Division, 6901 Elmwood Ave., Philadelphia; Pennsylvania, giving proposed use, expected yearly requirements and other general information on the product to be manufactured, so to determine if General Electric Pyranol liquid is suitable.

If proposed use is not electrical, then a license is probably not required and information should be obtained direct from the Monsanto Chemical Company.

PYRANOL TESTING SERVICE

The General Electric Company will, on request, test samples of the liquid from Pyranol transformers and feeder voltage regulators. Two types of test are available — Normal Routine Maintenance Tests and Comprehensive Diagnostic Tests.

Place requisition on Pittsfield Works (Massachusetts) or Rome Works (Georgia) to cover the preparation of each quart sample and the analysis report of tests results of each sample of the liquid from customer apparatus.

Test reports will include:

(A) Routine Maintenance Tests
Dielectric Strength
Refractive Index
Color
Water Content
Acidity
Comments on condition of sample

The net price for routine maintenance tests for each Pyranol quart sample be.....

(B) Comprehensive Tests

Dielectric Strength
Specific Gravity
Color
Acidity
Water Content
Refractive Index
Percent Scavenger
Free Chlorides

Comments on Condition of Sample

The net price for comprehensive tests for each Pyranol sample will be.....

New, clean, one-quart bottles filled with Pyranol liquid will be shipped with receipt of requisition at Pittsfield, Mass. or Rome, Ga. Sampling instruction on the bottle and in GEI-65080. It will be issued when the original sample are shipped from Pittsfield, Mass. or Rome, Ga., and this charge will be the purchaser to obtain the test results of the liquid returned to us for analysis.

If because of emergency reasons samples are in other than GE sample bottles, effort should be made to use brown glass bottles preferably new from drug store. Fruit jars are not to be used. Aluminum foil should be used to line caps. Each bottle should be thoroughly rinsed with Pyranol liquid from the prior to sampling, plainly marked with the serial number of the apparatus in which the sample was taken, and where taken from top or bottom. The temperature of the liquid at the time of sampling and all other pertinent data should be given on a tag attached to each sample bottle and repeated on the requisition placed to cover the testing service. It will be at the same prices as given in preceding paragraphs.

REQUISITION SERVICE

Send requisition and direct any correspondence about it to:

Supervisor, Stock Replacement
General Electric Company
Building 34, Room 346
100 Woodlawn Avenue
Pittsfield, Massachusetts 01201

or
Renewal Parts Specialist
General Electric Company
Redmond Circle
Rome, Georgia 30161

*Changed since Jan. 23, 1971 issue.

NY 700, 701, 702, 711-713, 721-723, 731-737

Prices and data subject to change without notice

GENERAL ELECTRIC

772539

Pyranol

Feb. 8, 1971

Pyranol® Insulating Liquid

For Transformers and Regulators

RETURN OF SAMPLES

Samples to be tested should be sent to:

Materials Laboratory
General Electric Company
Building 11-312
100 Woodlawn Avenue
Pittsfield, Massachusetts 01201

or

Advance Development Engineering
General Electric Company
Redmond Circle
Rome, Georgia 30161

FILTERING

If test results indicate that moisture or other contaminants are present, they can usually be removed by passing the insulating liquid through a Pyranol purifier. This device may be used either as a paper filter press for drying or with fuller's earth and paper for purifying. For details of the filtering procedure, refer to instructions GEH-1031, copies of which are available upon request. For information on drying and filtering equipment, contact the nearest General Electric Sales Office.

HANDLING AND STORAGE

Pyranol contains polychlorinated biphenyls which some studies have shown may be an environmental contaminant. Extreme care should be taken to prevent any entry into the environment through spills, leakage, use, disposal, vaporization or otherwise.

For detailed instructions on the handling and storage of Pyranol, refer to GEI-65080.

ADDITION OF SCAVENGER TO PYRANOL LIQUIDS

The advantage of the modern Pyranol materials A13B3B and A50P524 is inclusion of a diepoxide scavenger, D5D70A. This hydrogen chloride scavenger can be added to any of the older Pyranol liquids to improve their ability to neutralize the dissolved hydrogen chloride gas which might result from an internal fault.

Scavenger addition to reclaimed Pyranol liquid may be necessary since both the older scavenger, tetraphenyl tin, and the new diepoxide scavenger suffer some depletion during refining, particularly when activated earth is used. The diepoxide scavenger, D5D70A, will be used

to replenish scavenger deficiencies which occur in any of the Pyranol liquids.

The following suggested additions are based on 100 gallons of Pyranol liquid. For quantities other than those shown, either of Pyranol liquid or scavenger, the required value can be obtained by interpolation.

Scavenger Concentration by Analysis (% by Weight)	Pounds of D5D70A Required
0.0	1.90
0.02	1.65
0.04	1.40
0.06	.90
0.08	.40
0.10	.40

PRICES

MEDIUM TRANSFORMER-2 (086)

Net price f.o.b. Rome for Compound D5D70A, including container and boxing:
1 quart can (2 pounds)\$5.00
1 gallon can (8 pounds)16.00
NOTE: Minimum Order25.00

Cans should not be opened until the compound is to be put into the Pyranol liquid. Size of can should, therefore, be selected to total the required quantity.

PERFORMANCE OF PYRANOL LIQUID WITH OTHER MATERIALS

Pyranol liquid is stable and chemically inert. It has no effect on the metals and insulation used in Pyranol filled equipment but is, in general, a powerful solvent for 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 carefully selected materials which have proved to be unaffected by the Pyranol liquid are used. It has been found that the ageing of these materials under Pyranol liquid will be approximately the same as under oil.

There will be, however, a leaching effect of trace amounts of Pyranol soluble polar compounds from the materials of construction. These trace compounds have an exaggerated effect on

certain electrical measurements commonly used to judge the condition of mineral insulating oil. Tests on samples of transformer and regulator Pyranol materials 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.

MIXTURE WITH OIL

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

PRESSURE CAUSED BY ARCING

All Pyranol insulated transformers above 25 KVA which are to be installed in buildings in accordance with the National Electrical Code are provided with a mechanical, self-resetting relief device.

The pressure reliefs for indoor Pyranol transformers or Pyranol regulators are so arranged that:

- (1) A pipe can be attached thereto through which the gases which are products of arcing can be vented to the outside air;
- (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.

PHYSIOLOGICAL EFFECTS

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

Pyranol[®] Insulating Liquid

For Transformers and Regulators

PROPERTIES OF PYRANOL LIQUIDS

Property	Pyranol A13538	Pyranol A50P524	ASTM Test Method
Acidity, max, mg KOH/g	0.014	0.014	D 974, D 664
Color, APHA, max	150	150	D 2129
Condition	Clear	Clear	(Visual)
Chlorides, inorganic, max, ppm	0.1	0.1	D 1821
Dielectric constant at 100 C and 1 kv	3.8 to 4.3	4.4 to 4.9	D 924
Dielectric strength, min, kv	35	35	D 877
Fire point	none to boiling	none to boiling	D 92
Pour point, max, deg. C	-44	-30	D 97
Refractive index	1.4075 to 1.4085	1.4146 to 1.4166	D 1807
Scavenger content, percent D5D70A	0.115 to 0.135	0.115 to 0.135	
Specific gravity	1.560 to 1.571	1.412 to 1.425	D 1810
Coefficient of thermal expansion, cm ³ /cm ³ deg. C	0.007	0.007	D 1903
Viscosity, Saybolt Universal, sec at 37.8 C	41 to 45	50 to 55	D 88
Water content, max, ppm	30	30	D 1533

GENP 004582

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PYRANOL*

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Specific gravity at 25/ 15.5 C	1.38	1.505	1.384

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 30 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 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 No. 1470 Pyranol is 4.5 at 25 C, of No. 1476 Pyranol is 4.25 at 25 C and of No. 1499 Pyranol is 4.8 at 25 C. These values are 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.

The high power factor does not indicate degradation of the Pyranol but rather the solution of trace amounts of transformer materials in the liquid. This effect of increased power factor is not harmful unless dielectric strength is affected adversely.

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, hydrogen-chloride 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, if there has been no contact with free water or high humidity, this gas can cause little damage to the organic insulation except in the immediate vicinity of the failure.

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 practically impossible 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 non-flammability 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 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.

For further information, contact your nearest G-E Apparatus Sales Office, Agent, or Distributor

GENERAL  ELECTRIC

SCHENECTADY, N. Y.

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GENP 004584

Pyranol® Insulating Liquid For Transformers and Regulators

INTRODUCTION

Pyranol is the trademark 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 nonflammable. Transformer Pyranol is compounded to General Electric specifications and is available in several different forms. The type used in any particular transformer can be determined from the nameplate. Types 1488, 1467 and 1470 are obsolete. Currently used types are A13B3B and A50P524. All replacement or make-up orders should be for Type A13B3B.

REQUISITIONS

The Monsanto Chemical Company, St. Louis, Mo., is in a position to supply quantities of A13B3B Pyranol liquid direct to users. All orders for quantities in excess of 100 gallons should be sent directly to the nearest Monsanto Chemical Company office or their St. Louis headquarters.

Emergency requirements and small orders of 100 gallons or less can be obtained in 5-gallon cans or 30-gallon drums from Rome, Georgia. Send requisitions to Renewal Parts Specialist, General Electric Company, Medium Transformer Department, Redmond Circle, Rome, Georgia 30161.

PRICES

MEDIUM TRANSFORMER-R (086)

Net price f.o.b. Rome, Georgia with transportation charges "collect" for A13B3B Pyranol liquid, including non-returnable containers:

5 gallons, including can. *\$50.00
30 gallons, including drum... *\$150.00

CONTAINERS

When A13B3B Pyranol liquid is sold at the prices authorized on this page, the containers become the property of the purchaser, and drums as well as cans are nonreturnable.

SHIPPING WEIGHT

5-gallon can and
Pyranol liquid..... 75 lbs
30-gallon drum and
Pyranol liquid..... 425 lbs

PYRANOL INSULATIONS FOR CAPACITORS

Requests for information on, or quantities of, capacitor Pyranol insulation should be referred to the Manager of Marketing, Capacitor Department, Hudson Falls, New York 12839.

Transformer Pyranol should not be used in capacitors.

PYRANOL INSULATING LIQUID FOR OTHER USES

When a request for information or an order is received for Pyranol liquid to be used in equipment other than GE transformers or GE induction regulators, it is necessary for the factory to have certain information before any action can be taken.

If proposed use is an electrical one, it will probably be necessary to negotiate for a license under GE patents. The inquirer should write to the Patent Attorney, Power Transmission Division, 6901 Elmwood Ave., Philadelphia, Pennsylvania, giving proposed use, expected yearly requirements and other general information on the product to be manufactured, so to determine if General Electric Pyranol liquid is suitable.

If proposed use is not electrical, then a license is probably not required and information should be obtained direct from the Monsanto Chemical Company.

PYRANOL TESTING SERVICE

The General Electric Company will, on request, test samples of the liquid from Pyranol transformers and feeder voltage regulators. Two types of test are available—Normal Routine Maintenance Tests and Comprehensive Diagnostic Tests.

Place requisition on Pittsfield Works (Massachusetts) or Rome Works (Georgia) to cover the preparation of each quart sample and the analysis report of tests results of each sample of the liquid from customer apparatus.

Test reports will include:

(A) Routine Maintenance Tests

Dielectric Strength
Refractive Index
Color
Water Content
Acidity
Comments on condition of sample

The net price for routine maintenance tests for each Pyranol quart sample be.....

(B) Comprehensive Tests

Dielectric Strength
Specific Gravity
Color
Acidity
Water Content
Refractive Index
Percent Scavenger
Free Chlorides
Comments on Condition of Sample

The net price for comprehensive tests for each Pyranol sample will be.....

New, clean, one-quart bottles filled with Pyranol liquid will be shipped with receipt of requisition at Pittsfield, Mass. or Rome, Ga. Sampling instructions on the bottle and in GEI-65080. Inv will be issued when the original samples are shipped from Pittsfield, Mass., Rome, Ga., and this charge will entitle the purchaser to obtain the test result the liquid returned to us for analysis.

If because of emergency reasons samples are in other than GE sample bottles, effort should be made to obtain brown glass bottles preferably new from drug store. Fruit jars are not to be used. Aluminum foil should be used to line caps. Each bottle should be thoroughly rinsed with Pyranol liquid from the unit prior to sampling, plainly marked with the serial number of the apparatus from which the sample was taken, and when taken from top or bottom. The temperature of the liquid at the time of sampling and all other pertinent data should be given on a tag attached to each sample bottle and repeated on the requisition placed to cover the testing service. Bill will be at the same prices as given in the preceding paragraphs.

REQUISITION SERVICE

Send requisition and direct any correspondence about it to:

Supervisor, Stock Replacement
General Electric Company
Building 34, Room 346
100 Woodlawn Avenue
Pittsfield, Massachusetts 01201

or

Renewal Parts Specialist
General Electric Company
Redmond Circle
Rome, Georgia 30161

Feb. 8, 1971

Pyranol® Insulating Liquid

For Transformers and Regulators

RETURN OF SAMPLES

Samples to be tested should be sent to:

Materials Laboratory
General Electric Company
Building 11-312
100 Woodlawn Avenue
Pittsfield, Massachusetts 01201

or

Advance Development Engineering
General Electric Company
Redmond Circle
Rome, Georgia 30161

FILTERING

If test results indicate that moisture or other contaminants are present, they can usually be removed by passing the insulating liquid through a Pyranol purifier. This device may be used either as a paper filter press for drying or with fuller's earth and paper for purifying. For details of the filtering procedure, refer to instructions GEH-1031, copies of which are available upon request. For information on drying and filtering equipment, contact the nearest General Electric Sales Office.

HANDLING AND STORAGE

Pyranol contains polychlorinated biphenyls which some studies have shown may be an environmental contaminant. Extreme care should be taken to prevent any entry into the environment through spills, leakage, use, disposal, vaporization or otherwise.

For detailed instructions on the handling and storage of Pyranol, refer to GEI-65080.

ADDITION OF SCAVENGER TO PYRANOL LIQUIDS

The advantage of the modern Pyranol materials A13B3B and A50P524 is inclusion of a diepoxide scavenger, D5D70A. This hydrogen chloride scavenger can be added to any of the older Pyranol liquids to improve their ability to neutralize the dissolved hydrogen chloride gas which might result from an internal fault.

Scavenger addition to reclaimed Pyranol liquid may be necessary since both the older scavenger, tetraphenyl tin, and the new diepoxide scavenger suffer some depletion during refining, particularly when activated earth is used. The diepoxide scavenger, D5D70A, will be used

to replenish scavenger deficiencies which occur in any of the Pyranol liquids.

The following suggested additions are based on 100 gallons of Pyranol liquid. For quantities other than those shown, either of Pyranol liquid or scavenger, the required value can be obtained by interpolation.

Scavenger Concentration by Analysis (% by Weight)	Pounds of D5D70A Required
0.0	1.90
0.02	1.45
0.04	1.40
0.06	.90
0.08	.60
0.10	.40

PRICES

MEDIUM TRANSFORMER-R (086)

Net price f.o.b. Rome for Compound D5D70A, including container and boxing:

1 quart can (2 pounds)\$5.00

1 gallon can (8 pounds)16.00

NOTE: Minimum Order25.00

Cans should not be opened until the compound is to be put into the Pyranol liquid. Size of can should, therefore, be selected to total the required quantity.

PERFORMANCE OF PYRANOL LIQUID WITH OTHER MATERIALS

Pyranol liquid is stable and chemically inert. It has no effect on the metals and insulation used in Pyranol filled equipment but is, in general, a powerful solvent for 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 carefully selected materials which have proved to be unaffected by the Pyranol liquid are used. It has been found that the ageing of these materials under Pyranol liquid will be approximately the same as under oil.

There will be, however, a leaching effect of trace amounts of Pyranol soluble polar compounds from the materials of construction. These trace compounds have an exaggerated effect on

certain electrical measurements commonly used to judge the condition of mineral insulating oil. Tests on samples of transformer and regulator Pyranol materials 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.

MIXTURE WITH OIL

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

PRESSURE CAUSED BY ARCING

All Pyranol insulated transformers above 25 KVA which are to be installed in buildings in accordance with the National Electrical Code are provided with a mechanical, self-resetting relief device.

The pressure reliefs for indoor Pyranol transformers or Pyranol regulators are so arranged that:

- (1) A pipe can be attached thereto through which the gases which are products of arcing can be vented to the outside air;
- (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.

PHYSIOLOGICAL EFFECTS

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

Pyranol[®] Insulating Liquid For Transformers and Regulators

PROPERTIES OF PYRANOL LIQUIDS

Property	Pyranol A13838	Pyranol A50P524	ASTM Test Method
Addity, max, mg KOH/g	0.014	0.014	D 974, D 664
Color, APHA, max	150	150	D 2129
Condition	Clear	Clear	(Visual)
Chlorides, inorganic, max, ppm	0.1	0.1	D 1821
Dielectric constant at 100 C and 1 kv	3.8 to 4.3	4.4 to 4.9	D 924
Dielectric strength, min, kv	35	35	D 877
Fire point	none to boiling	none to boiling	D 92
Four point, max, deg C	-44	-30	D 97
Refractive index	1.6075 to 1.6085	1.6146 to 1.6166	D 1807
Scavenger content, percent DSD70A	0.115 to 0.135	0.115 to 0.135	
Specific gravity	1.560 to 1.571	1.412 to 1.425	D 1810
Coefficient of thermal expansion, cm ³ /cm ³ deg C	0.007	0.007	D 1903
Viscosity, Saybolt Universal, sec at 37.8 C	41 to 45	50 to 55	D 88
Water content, max, ppm	30	30	D 1533

GENP 004587

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Pyranol® Insulating Liquid

INTRODUCTION

Pyranol insulating liquid is an askarel which has been compounded to General Electric Company specifications and contains polychlorinated biphenyls (PCB's). Care should be taken to prevent any entry of this material into the environment through spills, leakage, use, disposal, vaporization or otherwise.

Materials that are unaffected by Pyranol have been selected for use in constructing Pyranol transformers and no substitutes should be made for these materials without the approval of the General Electric Company.

These instructions contain certain excerpts from NEMA Publication No. TR-P6-1973 and/or ANSI standards C107.1 concerning techniques for handling and disposing of askarels and askarel-contaminated materials. For further information on this subject the user is referred to the latest revisions of these publications.

SAFETY PRECAUTIONS

Based on a long period of safe industrial usage, it is generally thought that exposure to Pyranol is relatively harmless to humans. However, it is still recommended that exposure be held to a minimum.

VAPORS

Breathing of concentrated vapors in poorly ventilated areas or of fumes from heated Pyranol should be avoided. High concentrations of vapors can cause irritation of the eyes, nose, throat and upper respiratory tract.

CAUTION - Hydrogen chloride gas is formed when Pyranol is decomposed by an electrical arc. Although a scavenger is added to chemically neutralize any of this gas dissolved in the liquid, some free gas may be present. This gas is an irritant and the inhalation of large quantities can be dangerous and harmful to personnel. The

presence of hydrogen chloride gas even in small quantities is readily detectable by its strong odor and irritant action on the nasal membranes. Should anyone be exposed to a quantity of this gas, immediately escort him to fresh air.

If exposure to high concentrations of Pyranol or its arced products is necessary under emergency conditions, an approved gas mask of the organic canister-type or self-contained breathing apparatus must be worn. Such exposure should be under the surveillance of other personnel capable of rescue in case of accident. If the odor of Pyranol or its arced products is detected by the person wearing protective equipment, he should immediately go into fresh air. All gas masks, respirators and replacement parts should have Bureau of Mines approval and be maintained on a regular schedule in accordance with the manufacturer's recommendation.

LIQUID

Unlike mineral insulating oil, there is no fire hazard in handling Pyranol. A limited solvent action (similar to that for paint thinner) on the fats and oils of the skin with prolonged contact may lead to drying and chapping of the skin. As with insulating oil, some people are allergic to Pyranol and continued exposure may result in skin irritation. Both the liquid and vapor are moderately irritating to eye tissue.

Operating procedures should require avoidance of contact with Pyranol. The use of porous gloves which can absorb and retain Pyranol is to be avoided. Resistant gloves and aprons of the neoprene, polyethylene, viton type should be used if contact is unavoidable. In case of spillage on the clothing, the clothing should be removed as soon as practical, the skin washed and the clothing laundered.

Medicinal washes or mild detergents followed by the application of cold cream will reduce the irritation resulting when Pyranol comes in contact with an open cut or abrasion.

Safety glasses with side shields or a face shield should be worn when handling Pyranol. Eyes which have been exposed to the liquid should be irrigated immediately with large quantities of running water for 15 minutes and then examined by a physician if the irritation persists. (A drop of castor oil has been found to reduce irritation.)

Persons developing a skin irritation or respiratory tract irritation while working with Pyranol should be placed under supervision of a physician.

Ingestion or swallowing of Pyranol is not generally regarded as a problem of the industry. Should accidental ingestion occur, a physician should be consulted. Hands should be washed with warm water and soap before eating, drinking, smoking or using toilet facilities.

RECEIVING, HANDLING AND STORING

RECEIVING

Immediately upon receipt of a Pyranol-filled transformer or shipping drums containing Pyranol an examination should be made for leaks. If leakage is evident either at this time or at any time thereafter, the cause should be corrected and the spillage soaked up with absorbent materials such as sawdust or fuller's earth, followed by a clean-up of the affected area with rags soaked with kerosene or other approved solvent such as perchloroethylene or trichloroethylene. All materials used should be collected for proper disposition as described under "Disposal".

HANDLING

On those infrequent occasions when the Pyranol is removed for shipment, the transformer will be shipped gas filled and is to be liquid filled at installation. (Refer to separate installation instructions for filling procedures.) If the transformer is located outdoors, adequate precautions must be taken to insure that no dirt or moisture enters

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

the Pyranol during the filling operation. Before opening a container of Pyranol allow it to stand until the liquid is at least as warm as the surrounding air.

Before placing the Pyranol in the transformer take a sample from each container and make dielectric test as outlined under "Sampling" and "Testing". If the tests are unsatisfactory, restore the dielectric strength before placing the Pyranol in the transformer. When transferring from containers to the transformer it is recommended that the liquid be passed through a filter press to remove any undetected moisture or sediment which may be present.

Pyranol must be handled in containers, pipes, all-metal hoses, etc., which are free from oil, grease, pitch, or other foreign materials, since these contaminate the liquid and decrease its nonflammable properties. All apparatus used in sampling, filtering, storing, or transporting Pyranol must be maintained for exclusive use with Pyranol, since it is extremely difficult to remove all traces of oil or other Pyranol contaminants from equipment of this type. Also, mineral oil is completely miscible in Pyranol, and it is practically impossible to separate the two liquids after they have been mixed.

All-metal hose must be used in handling Pyranol since rubber and rubber-lined hoses are dissolved by Pyranol. This is also true of synthetic rubber hose.

Use kerosene or other approved solvent to remove all traces of Pyranol on the outside of the transformer tank. This precaution should be taken since Pyranol has a tendency to soften the paint. Examine the external surfaces of the transformer at intervals to see that the paint is unharmed. If places are found where the paint has been attacked, thoroughly clean the surface and repaint with a good grade of durable paint recommended by the General Electric Company. All Pyranol-contaminated materials are to be collected for proper disposition as outlined under "Disposal".

Shipping Notice

Whenever any Pyranol-filled transformer or shipping drum is placed in transit it should be identified with a prominent label containing the following warning or words to this effect:

NOTICE TO CARRIER

**CAUTION - YOU ARE HANDLING
A TRANSFORMER (OR DRUMS)**

FILLED WITH PYRANOL INSULATING LIQUID. THIS PRODUCT CONTAINS POLYCHLORINATED BIPHENYLS (PCB'S). CARE SHOULD BE TAKEN TO PREVENT ITS ENTRY INTO THE ENVIRONMENT. IF A SPILL OR LEAK DOES OCCUR NOTIFY THE PROPER FEDERAL AND STATE AGENCIES IMMEDIATELY.

STORAGE

Shipping drums should be stored indoors in an area especially selected for this purpose. A curb should enclose the area to provide a basin for containing the Pyranol from one or more drums should they become damaged. The area must not have a drain which is connected to a sanitary or storm sewer.

If necessary to store drums or cans containing Pyranol outdoors, protect the containers from the weather and direct contact with water. Regardless of location, all drums should be stored in a position which results in the bungs being under a positive pressure. Do not open a drum or can until the Pyranol is actually needed. Any change in temperature while the containers are open will cause an exchange of air with the possibility of moisture entering the Pyranol. Partially emptied drums must be tightly resealed and stored in the same manner as above.

PERIODIC INSPECTION

The insulating liquid must be maintained at the proper level (see nameplate) and for the longest possible service life of the transformer, the dielectric strength of the Pyranol should be maintained at a high value. It is recommended, therefore, that the liquid be sampled and tested after the first few days of operation, again after six months, and yearly thereafter. Keep accurate records of the tests and filter or replace the liquid as indicated.

The entire transformer should also be thoroughly checked for leaks at these same intervals.

SAMPLING

Pyranol samples should be taken in a manner to avoid any contamination of the environment. All rinsings and contaminated materials should be collected in suitable containers for disposition as outlined under "Disposal".

The accuracy of test data can be seriously affected by improper sampling. In order to obtain consistent results it is recommended that the methods outlined in the following paragraphs be observed.

Strict attention should be given to the cleaning and drying of sampling and testing receptacles. Samples should be taken when the insulating liquid is at least as warm as the surrounding air to avoid the possibility of moisture condensation. If the transformer or drum is outdoors, the sample should be taken on a clear day with precautions being taken to guard against contamination by windblown dust, etc. Observe the following procedure to obtain consistent results from samples taken either for field or factory tests.

SAMPLING FROM TRANSFORMERS

1. Impurities which tend to affect the dielectric strength of Pyranol will generally be found at the top and therefore the sampling valve is located on the side of the tank about one inch below the 25C liquid level.

2. Samples should be collected in one quart, small neck, brown glass bottles with foil lined screw caps. If desired, glass sampling bottles may be obtained from the General Electric Company as explained under "Testing Service."

3. To clean the bottles, rinse with non-leaded, oil-free gasoline. Then wash with strong soapsuds, rinse thoroughly with distilled water, and dry in an oven at 105C to 110C for at least 8 hours. After drying, the bottles must be tightly sealed. Store them in a dry, dust-free cabinet or compartment.

4. Carefully clean the sampling valve or plug and allow enough insulating liquid to run out to remove any moisture or foreign matter which may have collected.

5. Rinse the bottle carefully, at least three times, with small portions of liquid drawn from the sampling valve. Allow the sampling bottle to drain thoroughly between rinses.

6. Draw a sample into the bottle, leaving sufficient air space to allow for possible expansion of the liquid. Reseal the transformer and carefully seal the container to prevent exposure to the atmosphere.

7. When making repeated samplings, observe the transformer liquid level and add make-up as required.

SAMPLING FROM DRUMS

1. Drums should remain undisturbed for at least eight hours before being sampled.

2. Glass thieves should be cleaned.

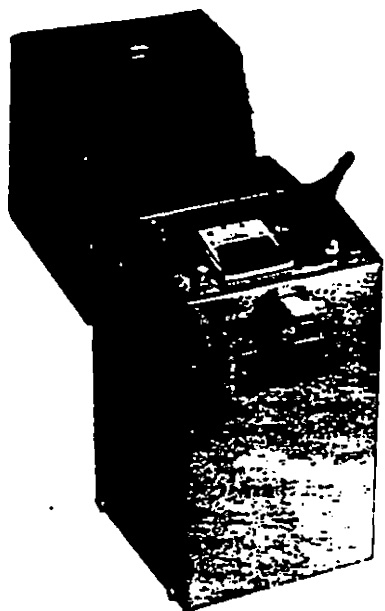


Fig. 1 Typical portable dielectric test set

dried, and stored in the same manner as outlined for bottles.

3. Take the sample from the top of the drum, observing the precautions previously outlined.

TESTING

Field and laboratory test samples, washings, etc., should also be collected for proper disposal. Prior to testing, the sample should be examined visually for the presence of moisture, either in the form of separate droplets or as a cloud dispersed throughout the Pyranol, and for particles of insulation, evidence of carbonization, etc.

DIELECTRIC STRENGTH

A variety of high-voltage dielectric testing equipment may be purchased from the General Electric Company. A typical portable test set (Model No. 9T11Y8454) is shown in Fig. 1 and various console models are also available. Follow the technique specified by the American Society for Testing and Materials, Designation: D877. The following paragraphs give a general outline of the procedure.

1. Set the spacing of the 1-inch diameter electrodes at 0.100-inch.

2. Wipe the test cup and electrodes clean with dry, calendered tissue or clean, dry chamois and thoroughly rinse with non-leaded, oil-free, dry gasoline.

3. Fill the test cup with dry gasoline and make a breakdown test under

standard conditions of voltage application (3kV per second rise). If the cup has a dielectric strength above 25 kV, it is considered suitable for testing purposes. Observe the usual precautions in handling gasoline.

4. Immediately after the final rinsing with gasoline, rinse the test cup with the sample under investigation, and proceed with the test at once.

5. The temperature of the sample when tested should be the same as that of the room, which should be between 20 C and 30 C (68 F and 86 F). Tests made on samples above this temperature can be misleading. Under no circumstances should the test cup be colder than the sample being tested.

6. Agitate the sample gently before each filling to prevent variations in results due to a settling of contaminants. Pour the liquid into the receptacle slowly to avoid the formation of air bubbles and fill to overflowing. If air bubbles are present, gently rock the test cup a few times and wait at least 3 minutes before applying voltage.

7. Fill the cup at least five times, making one test per filling, and average the results.

Since the Pyranol is a major portion of the insulation system in the transformer, its dielectric strength should be maintained as high as possible. A low breakdown voltage is an indication that impurities such as moisture, conducting dust, lint, or carbonized particles have entered the liquid. Pyranol testing lower than 26kV (30 kV when new) should either be filtered to bring it back to its original condition or be replaced, depending on the condition of the liquid and economic considerations. Under normal operating conditions values of 30 kV and above can be maintained.

FIELD TEST FOR MOISTURE CONTENT

The following field test can be used to detect the presence of excessive amounts of moisture in the insulating liquid:

1. Obtain a sample of the insulating liquid when the transformer is at operating temperature. (Preferably above 40 C.)

2. Starting with the hot sample, rinse a clean, dry test tube with the liquid to be tested, fill half full and stir continuously with a centigrade thermometer while cooling to approximately 20 C. Cool as much as possible in the ambient air and complete the cooling by momentarily dipping the test tube

in an ice bath, removing and stirring and then redipping, etc.

3. Observe the sample carefully and note the temperature at which initial cloudiness appears. Wipe the outside of the tube with a clean rag or paper towel to facilitate observation of the slight moisture cloud that may form. Compare to clean insulating liquid at ambient temperature in a similar tube if necessary. Examination for the presence of a cloud should preferably be made against a dark background and not directly into the sunlight.

4. If cloudiness appears at 20 C or above, high to excessive moisture content is indicated.

A. Inspect the unit for free water on the surface of the Pyranol.

B. If free water is not present, a sample should be forwarded to the Laboratory for a quantitative analysis and recommendations on treatment of the unit. See "Testing Service."

5. If cloudiness does not appear until the temperature is below 20 C, an acceptable moisture content range is indicated.

6. This field test for moisture should be regarded as a rough test only and if there is any reason to question the condition of the insulating liquid, a sample should be sent to a laboratory for an accurate analysis.

TESTING SERVICE

Where suitable equipment and qualified personnel are not available for conducting the necessary tests, the user may wish to avail himself of the following testing service offered by the General Electric Company. This service includes preparation of the sample bottle, laboratory analysis, report of test results and recommendations on continued use or treatment.

Upon receipt of an order through one of its apparatus Sales Offices, the Company will furnish the required one-quart sample bottles. These will be cleaned and dried at the factory and to insure dryness will be shipped containing a small desiccant which is to be discarded prior to sampling. Since reliable tests are dependent upon reliable samples, the sampling procedures described under "Sample" and on the bottle itself should be carefully observed.

Return sample containers to the Laboratory, Medium Transformer Pro-

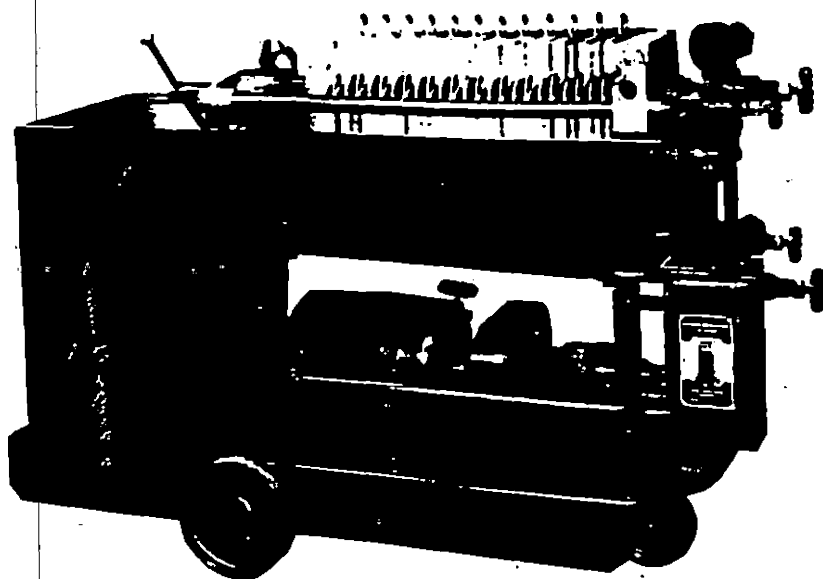


Fig. 2 Typical Pyranol purifier

ducts Department, General Electric Company, Rome, Georgia 30161. Pack these samples carefully to avoid breakage in transit. Recommendations for continued use or treatment will be furnished based on the following tests conducted in accordance with the indicated ASTM methods.

1. Dielectric strength, D877
2. Acidity, D974
3. Water content, D1533
4. Color, D2129
5. Condition (Visual), D1702
6. Scavenger content (when requested), D1701

Be sure to answer the questions on the sample bottle label. This information is essential if conclusions or recommendations are to be made concerning the sample. For further information concerning specific problems, consult the nearest apparatus Sales Office of the General Electric Company. If the Pyranol in question is known to be highly contaminated, transactions concerning sampling, testing, returning for reclamation or credit, etc., should be handled directly with the Monsanto Chemical Co., St. Louis, Missouri.

FILTERING

If test results indicate that moisture or other contaminants are present, they can usually be removed by passing the insulating liquid through a Pyranol purifier (Fig. 2). This device may be used either as a paper filter press for drying or with fuller's earth and paper for purifying. For details of

the filtering procedure refer to instructions GEH-1031, copies of which are available upon request. For information on drying and filtering equipment contact the nearest apparatus Sales Office of the General Electric Company.

When filtering or conditioning Pyranol, all of the precautions previously described for handling and disposal also apply to the filter papers, fuller's earth, etc. involved in this operation. See "Disposal".

Filtration can be accomplished in the transformer or other container by circulating the Pyranol from the top to the bottom through a filter press. However, this method is quite slow since the filtered Pyranol is continuously being mixed with the unfiltered. Filtering can be done faster and more efficiently by passing the liquid from the transformer, through the filter and into a separate, clean, dry container and then back through the filter again to refill the transformer. In this manner all of the Pyranol will be given two complete passes through the filter press. If additional filtering is still required, the entire procedure can be repeated.

The filter press will not remove large quantities of free water from the Pyranol. When a large quantity of free water is introduced into the filter it will be passed on through, emerging as finely divided droplets dispersed throughout the Pyranol. Therefore, if free water is present it should be removed before filtering is started. As moisture is extracted from the Pyranol during the drying process, the filtering medium will become wet. Frequent samples of the outgoing Pyranol should be tested

to determine when the filtering medium should be replaced.

NOTE - A scavenger has been added to the Pyranol to chemically neutralize any hydrogen chloride gas which may be absorbed by the liquid as a result of arcing. A portion of this scavenger may be lost during filtering operations, especially if the Pyranol is passed through fuller's earth. A test should therefore be made following filtering to determine how much of the scavenger has been lost and the quantity required to restore the Pyranol to its original condition. Laboratory testing facilities are available through the General Electric Company as outlined under "Testing Service."

A transformer contaminated with moisture may not only have moisture suspended in the insulating liquid, but may also have it in the windings and insulation. The most efficient temperature for filtering moisture from the Pyranol is between 20 C and 40 C, but at this temperature the transfer of moisture from the windings and insulation to the insulating liquid is quite slow.

If the dielectric strength of the Pyranol is still below 30 kV after filtering, consult the nearest apparatus Sales Office of the General Electric Company for additional information including possible recommendations on drying the entire transformer.

DISPOSAL

Disposal of Pyranol and Pyranol-soaked materials should be accomplished by means in which there is no significant release of Pyranol to the environment. Methods employed for this purpose include incineration of liquids and soaked software under carefully controlled conditions at very high temperatures and by controlled landfill burial of apparatus and other hardware. A number of commercial firms have established Pyranol disposal facilities of this type as indicated under "Disposal Services".

The ultimate disposal of a Pyranol-filled transformer may be accomplished by draining the Pyranol and then thoroughly flushing the interior with kerosene or other approved solvent such as perchloroethylene or trichloroethylene. After removal of the PCB's in this manner the transformer is to be dismantled with the burnable solids such as wood, cellulosic insulation, gaskets, etc. being set aside for proper disposal along with the accumulation of all liquids, washings, soaked rags, etc. The remaining metallic components

can then be handled as normal scrap.

Shipping drums should likewise be drained and flushed before being handled as normal scrap.

DISPOSAL SERVICES

In addition to the supervised dry landfill sites which may be used for the disposal of Pyranol-contaminated scrap, the following organizations may be contacted concerning use of their incineration and/or landfill facilities. These firms offer a variety of services at a number of locations and therefore

it is generally advisable to make several inquiries in order to determine which is best suited to handle a particular disposal problem. Specific disposal procedures, shipping instructions and cost should be discussed. Other firms may also offer suitable facilities from time to time so additional inquiries may be in order. If preferred, any of the General Electric Company Apparatus Service Shops may be contacted to serve as an intermediary. Known home offices and phone numbers include:

Chem-Trol Pollution Services, Inc.
4818 Lake Avenue

Blasdell, New York 14219
716*826-5850

Monsanto Company
800 N. Lindbergh Blvd.
St. Louis, Missouri 63166
314*694-3352

Nuclear Engineering Company
P. O. Box 148
Morehead, Kentucky 40351
606*784-6811

Rollins-Purle, Inc.
P. O. Box 3349
Wilmington, Delaware 19899
302*478-5150

772551

GENP 004592

MEDIUM TRANSFORMER PRODUCTS DEPARTMENT
GENERAL ELECTRIC COMPANY
ROME, GEORGIA 30161

GENERAL  ELECTRIC

772552

GENP 004593



Pyranol® Insulating Liquid AND Transformer Drying

INTRODUCTION

Pyranol insulating liquid is compounded to General Electric specifications and is available in several different forms. The type used in any particular transformer can be determined from the nameplate. Materials that are unaffected by Pyranol have been selected for use in constructing Pyranol transformers and no substitutes should be made for these materials without the approval of the General Electric Company.

Pyranol contains polychlorinated biphenyls, which some studies have shown may be an environmental contaminant. Extreme care should be taken to prevent any entry into the environment through spills, leakage, use, disposal, vaporization or otherwise. For further information, refer to the nearest Sales Office of the General Electric Company.

HANDLING AND STORING

Transformer Pyranol can be handled in the same manner as mineral oil. Although continued exposure to liquid Pyranol may produce local skin irritations, cleanliness among workmen constitutes an adequate safeguard against such effects. Ordinary medicinal washes will remove any irritation caused by Pyranol coming into contact with an open cut or skin abrasion. A drop of castor oil will neutralize any irritation caused by contact of Pyranol with the eyes. As with most volatile materials, exposure to concentrated Pyranol vapors in unventilated rooms should be avoided.

CAUTION—Hydrogen chloride gas is formed when Pyranol is decomposed by an electrical arc. Although a scavenger is added to chemically neutralize any of this gas dissolved in the liquid, some free gas may be present. This gas is an irritant and the inhalation of large quantities can be dangerous and harmful to personnel. The presence of hydrogen chloride gas even in small quantities is readily detectable by its strong odor and irritant action on the nasal membranes. Should anyone be exposed to a quantity of this gas, immediately

escort him to fresh air.

On those infrequent occasions when the Pyranol is removed for shipment, the transformer will be shipped gas filled and is to be liquid filled at installation. Refer to separate instructions on "Installation and Maintenance". If the transformer is located outdoors, adequate precautions must be taken to insure that no dirt or moisture enters the Pyranol during the filling operation. Before opening a container of Pyranol allow it to stand until the liquid is at least as warm as the surrounding air.

Before placing the Pyranol insulating liquid in the transformer take a sample from each container and make dielectric test as outlined under "Sampling" and "Testing". If the tests are unsatisfactory, restore the dielectric strength before placing the Pyranol in the transformer. When transferring from containers to the transformer it is recommended that the liquid be passed through a filter press to remove any undetected moisture or sediment which may be present.

Pyranol must be handled in containers, pipes, all-metal hoses, etc., which are free from oil, grease, pitch, or other foreign materials, since these contaminate the liquid and decrease its non-flammable properties. It is desirable that all apparatus used in sampling, filtering, storing, or transporting Pyranol be maintained for exclusive use with Pyranol, since it is extremely difficult to remove all traces of oil or other Pyranol contaminants from equipment of this type. Also, mineral oil is completely miscible in Pyranol, and it is practically impossible to separate the two liquids after they have been mixed.

All-metal hose must be used in handling Pyranol since rubber and rubber-lined hoses are dissolved by Pyranol. This is also true of synthetic rubber hose.

Use a petroleum solvent to remove all traces of Pyranol on the outside of the transformer tank. This precaution should be taken since Pyranol has a tendency to soften the paint. Examine

the external surfaces of the transformer at intervals to see that the paint is unharmed. If places are found where the paint has been attacked, thoroughly clean the surface and repaint with a good grade of durable paint recommended by the General Electric Company.

If necessary to store drums or cans containing Pyranol outdoors, protect the containers from the weather and direct contact with water. Regardless of location, all drums should be stored in a position which results in the bungs being under a positive pressure. Do not open a drum or can until the Pyranol is actually needed. Any change in temperature while the containers are open will cause an exchange of air with the possibility of moisture entering the Pyranol. Partially emptied drums must be tightly resealed and stored in the same manner as above.

PERIODIC INSPECTION

The Pyranol must be maintained at the proper level in the transformer and its dielectric strength should be tested after the first few days of operation, again after six months, and yearly thereafter. Keep accurate records of the tests and filter or replace the Pyranol as required.

SAMPLING

The accuracy of test data can be seriously affected by improper sampling. In order to obtain consistent results it is recommended that the methods outlined in the following paragraphs be observed.

Strict attention should be given to the cleaning and drying of sampling and testing receptacles. Samples should be taken when the insulating liquid is at least as warm as the surrounding air to avoid the possibility of moisture condensation. If the transformer or drum is outdoors, the sample should be taken on a clear day with precautions being taken to guard against contamination by windblown dust, etc. The most important features of the sampling procedures are outlined in the following steps:

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.



Fig. 1. Typical high-voltage A-C test set

SAMPLING FROM TRANSFORMERS

1. Impurities which tend to affect the dielectric strength of Pyranol will generally be found at the top and therefore the sampling valve is located on the side of the tank about one inch below the 25C liquid level.

2. A one-quart, small-neck, brown-glass bottle is recommended for sampling purposes. Do not use rubber stoppers or rings. If desired, glass sampling bottles may be obtained from the General Electric Company as explained under "Testing Service."

3. To clean the bottles, rinse with non-leaded, oil-free gasoline. Then wash with strong soapsuds, rinse thoroughly with distilled water, and dry in an oven at 105C to 110C for at least 8 hours. After drying, the bottles must be tightly sealed. Store them in a dry, dust-free cabinet or compartment.

4. Carefully clean the sampling valve or plug and allow enough insulating liquid to run out to remove any moisture or foreign matter which may have collected.

5. Rinse the bottle carefully, at least three times, with small portions of liquid drawn from the sampling valve. Allow the sampling bottle to drain thoroughly between rinses.

6. Draw a sample into the bottle, leaving sufficient air space to allow for possible expansion of the liquid. Re-seal the transformer and carefully seal the container to prevent exposure to the atmosphere.

7. When making repeated samplings, observe the transformer liquid level and oil make-up as required.

SAMPLING FROM DRUMS

1. Drums should remain undisturbed for at least eight hours before being sampled.

2. Glass thieves should be cleaned, dried, and stored in the same manner as outlined for bottles.

3. Take the sample from the top of the drum, observing the precautions previously outlined.

TESTING

DIELECTRIC STRENGTH

A variety of high-voltage dielectric testing equipment may be purchased from the General Electric Company. Typical stationary test equipment is shown in Figs. 1 and 2. A smaller, lightweight, portable unit is also available. Follow the technique specified by the American Society for Testing and Materials, Designation: D877. The following paragraphs give a general outline of the procedure:

1. Set the spacing of the 1-inch diameter electrodes at 0.100-inch.

2. Wipe the test cup and electrodes clean with dry, calendered tissue or clean, dry chamois and thoroughly rinse with non-leaded, oil-free, dry gasoline.

3. Fill the test cup with dry gasoline and make a breakdown test under standard conditions of voltage application (3kv per second rise). If the cup has a dielectric strength above 25 kv, it is considered suitable for testing purposes. Observe the usual precautions in handling gasoline.

4. Immediately after the final rinsing with gasoline, rinse the test cup with the sample under investigation, and proceed with the test at once.

5. The temperature of the sample when tested should be the same as that of the room, which should be between 20 C and 30 C (68 F and 86 F). Tests made on samples above this temperature can be misleading. Under no circumstances should the test cup be colder than the sample being tested.

6. Agitate the sample gently before each filling to prevent variations in results due to a settling of contaminants. Pour the liquid into the receptacle slowly to avoid the formation of air bubbles and fill to overflowing. If air bubbles are present, gently rock the test cup a few times and wait at least 3 minutes before applying voltage.

7. Fill the cup at least five times, making one test per filling, and average the results.

Since the Pyranol is a major portion of the insulation system in the trans-

former, its dielectric strength should be maintained as high as possible. A low breakdown voltage is an indication that impurities such as moisture, conducting dust, lint, or carbonized particles have entered the liquid. Pyranol testing lower than 26kv (30 kv when new) should either be filtered to bring it back to its original condition or be replaced, depending on the condition of the liquid and economic considerations. Under normal operating conditions values of 30 kv and above can be maintained.

OTHER TESTS

Although a low dielectric strength indicates the presence of contaminants, a high value is not always a certain indication of their absence. A number of other tests can be performed on an insulating liquid to determine its condition and therefore no one test should be considered conclusive. ASTM Designation: D 901 defines the standard tests and contains cross references to other ASTM Designations for detailed descriptions of each method. Where suitable equipment and qualified personnel are not available for conducting these tests, samples can be returned to the factory for laboratory analysis as outlined under "Testing Service". Use sample bottles supplied by the General Electric Company for this purpose.

Water Content

The presence of free water may be disclosed by visual examination in the form of separate droplets or as a cloud dispersed throughout the Pyranol. However, water in solution cannot be detected visually and therefore the Karl Fischer Reagent method (ASTM Designation: D1533) is recommended as a means of determining total water in the Pyranol in parts per million.

TESTING SERVICE

For convenience in sampling and test-



Fig. 2. ASTM test cell mounted on cage

ing, the General Electric Company will, upon receipt of an order covering the actual cost of testing, furnish one-quart sample bottles. These will be cleaned and dried at the factory and to insure dryness will be shipped containing a small desiccant which is to be discarded prior to sampling. Since reliable tests are dependent upon reliable samples, the sampling procedures described under "Sampling" and on the bottle itself should be carefully observed.

Send samples to the Laboratory, Medium Transformer Department, General Electric Company, Rome, Georgia. Pack these samples carefully to avoid breakage in transit. Recommendations for continued use or treatment will be furnished, based on the following tests:

1. Dielectric strength
2. Acidity
3. Water content
4. Color
5. Condition
6. Scavenger content (when requested)

Be sure to answer the questions on the sample bottle label. This information is essential if conclusions or recommendations are to be made concerning the sample. Additional testing services are available should the need arise. For further information concerning specific problems, consult the nearest Apparatus Sales Office of the General Electric Company. If the Pyranol in question is known to be highly contaminated, transactions concerning sampling, testing, returning for reclamation or credit, etc., should be handled directly with the Monsanto Chemical Co., St. Louis, Missouri.

FILTERING

If test results indicate that moisture or other contaminants are present, they can usually be removed by passing the insulating liquid through a Pyranol purifier (Fig. 3). This device may be used either as a paper filter press for drying or with fuller's earth and paper for purifying. For details of the filtering procedure refer to instructions GEH-1031, copies of which are available upon request. For information on drying and filtering equipment contact the nearest Apparatus Sales Office of the General Electric Company.

Filtration can be accomplished in the transformer or other container by circulating the Pyranol from the top to the bottom through a filter press. However, this method is quite slow since the filtered Pyranol is continuously being mixed with the unfiltered. Filtering

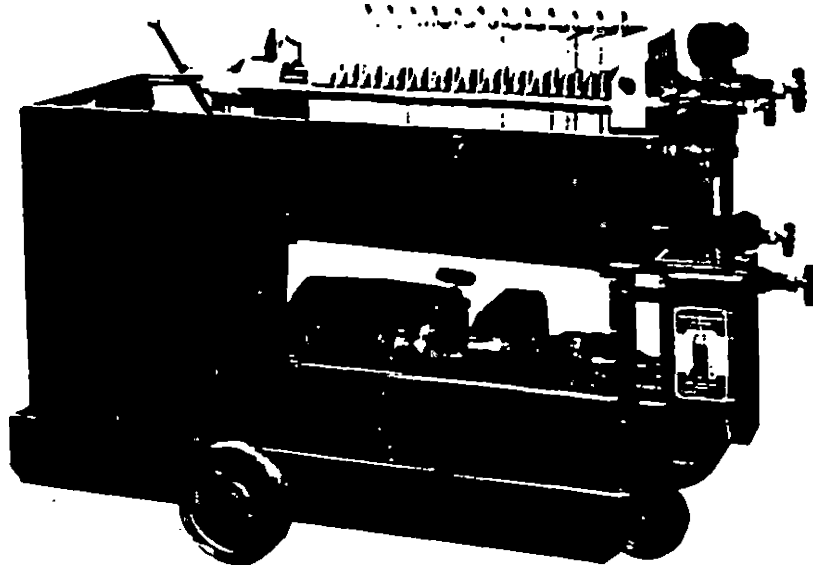


Fig. 3. Typical Pyranol purifier

can be done faster and more efficiently by passing the liquid into a separate, clean, dry container. In this manner, all of the Pyranol is given one complete pass through the filter press. If additional filtering is required, the Pyranol can then be filtered back into the transformer.

The filter press will not remove large quantities of free water from the Pyranol. When a large quantity of free water is introduced into the filter it will be passed on through, emerging as finely divided droplets dispersed throughout the Pyranol. Therefore, if free water is present it should be removed before filtering is started. As moisture is extracted from the Pyranol during the drying process, the filtering medium will become wet. Frequent samples of the outgoing Pyranol should be tested and when the dielectric strength drops below 25 kv, the filtering medium should be replaced.

NOTE—A portion of the scavenger may be lost during filtering operations if the Pyranol is passed through fuller's earth. A test should therefore be made following filtering to determine how much of the scavenger has been lost and the quantity required to restore the Pyranol to its original condition. Laboratory testing facilities are available through the General Electric Company as outlined under "Testing Service".

A transformer contaminated with moisture will not only have moisture suspended in the insulating liquid, but also in the windings and insulation. The most efficient temperature for filtering moisture from the Pyranol is between 20°C and 40°C, but at this temperature the transfer of moisture from the windings and insulation to the insulating liquid is quite slow. In order

to completely dry the transformer, the filter-press operation should be followed by a drying run as described under "Drying a Transformer".

DRYING A TRANSFORMER

Drying of Pyranol transformers is necessary when evidence of moisture is found, either by visual inspection or as a result of tests on the insulating liquid. The dryness of transformers that have been disassembled or out of Pyranol depends on the care taken to keep all parts dry while exposed. Unless proper care has been taken and it is certain that no moisture has been allowed to enter, the transformer should be dried.

Recommendations regarding the drying of any particular transformer can be obtained from the nearest Apparatus Sales Office of the General Electric Company. Requests for this information should include the serial number of the transformer and the voltages and kva available for drying, including any available step-up or step-down transformers.

The first step in drying a transformer consists of removing any free water and the water in solution with the Pyranol as previously explained under "Filtering". The second step involves removal of the moisture from the windings and insulation as outlined in the following paragraphs. Exercise caution when heating the transformer to avoid damaging the insulation.

OVEN DRYING

Oven drying is the preferred method of removing moisture from a transformer. When suitable facilities are not available, arrangements for oven drying of Pyranol transformers can be made

through your nearest General Electric Service Shop.

Drying is performed by first monitoring the winding resistance to determine when the core and coils reach oven temperature (100C-120C). Then insulation resistance or power factor measurements are made at 4 to 8 hour intervals until the curve levels off for four consecutive readings. If any of the coils have been replaced, the coil clamps are to be checked for tightness after the drying operation is completed. Failure to get the coils tight will permit movement and may result in eventual failure of the transformer.

SHORT-CIRCUIT METHOD

This method consists of heating the windings and Pyranol with one winding short-circuited and a suitable voltage applied to the other winding. The maximum winding temperature as determined by resistance measurements should not be allowed to exceed 95C. The moisture, which is driven off in the form of vapor, is vented to the atmosphere by removing the manhole covers and pressure relief device. Air circulation above the Pyranol can be improved by the use of fans. Protect all openings in the cover of the transformer from inclement weather and provide adequate room ventilation when the drying operation is performed indoors.

Proper liquid temperatures can be obtained more readily by blanketing the transformer. The amount required will have to be determined by trial. Begin at the bottom and wrap the transformer with heavy paper, cloth, or building felt until sufficient radiating surface has been covered. Another effective means of limiting heat losses is to restrict or prevent circulation of the Pyranol through the cooling tubes by lowering the liquid level slightly. Make sure all live parts remain covered.

Regardless of the amount of blanketing around the main tank, the cover and sides of the transformer down to the liquid level must be insulated to prevent condensation on the inside.

POWER REQUIREMENTS FOR TWO-WINDING TRANSFORMERS

When drying a transformer by the short-circuit method, one winding of the transformer is short-circuited and voltage is applied to the other winding. Only a fraction of the rated voltage of the winding can be applied and to insure proper drying, all portions of all the windings must be in the circuit. Be sure the conductor used to short-circuit the winding will carry the required current.

While the equations which follow show the method of computing the re-

quired voltage and kva at FULL LOAD CURRENT, it should be noted from Table I that it is preferable to hold less than full load current in order to permit higher top liquid temperatures for more effective and faster drying. However, having once established from the equations the voltage and kva required at full voltage load current, corresponding values of current and kva at available voltages can be readily calculated by noting that the current will vary directly as the ratio of

$$\frac{E \text{ (Available)}}{E}$$

$$E$$

and kva will vary as the square of this ratio.

The equations for computing the required voltage and kva for drying a SINGLE-PHASE, TWO-WINDING transformer at full load current are as follows:

$$E = \%IZ \times E_R$$

$$KVA = \frac{E \times I}{1000}$$

The equations for computing the required voltage and kva for drying a THREE-PHASE, TWO-WINDING transformer at full load current are as follows:

$$E = \%IZ \times E_R$$

$$KVA = \frac{1.732 \times E \times I}{1000}$$

$\%IZ$ = percent transformer impedance volts from nameplate.

E_R = nameplate voltage of winding to which power is applied. When tap changers, terminal boards, or load-tap-changing equipment are located in either or both windings, they must be set on the position which places all sections of the windings in the circuit, leaving no turns idle.

I = full load current corresponding to maximum rated voltage.

E = required drying voltage for full load current.

KVA = required kilovolt-amperes for full load current.

If it is necessary to obtain drying voltage over a long transmission line, overvoltage protection should be provided.

OTHER TRANSFORMERS

The drying of three-winding transformers and autotransformers with ter-

tiary windings by the short-circuit method usually is more complicated than that of two-winding transformers because of the differences in impedance and capacity of the windings. It is frequently necessary to make two separate drying runs on such units to assure that all windings will be properly dried. In some cases, division of the load current in the various portions of the windings can be obtained by the insertion of an additional reactance, permitting all three windings to be dried simultaneously. It is recommended that detailed information for drying three-winding transformers be obtained from the nearest Apparatus Sales Office of the General Electric Company.

LOADS AND TEMPERATURES

If power is available, up to 125 percent load current can be held at the start of the drying run until the top-liquid temperature reaches 65 C. The load on the transformer must then be reduced to obtain a constant top-liquid temperature in accordance with the following table:

TABLE I

Max. Allowable Short-Circuit Amps in Percent of Full Load Based on Min. Rating	Maximum Allowable Top-Liquid Temperature in Deg C
50	100
75	90

It is recommended that a 100 C top-liquid temperature be held with 50 percent load, if possible, since the fastest drying will take place at the highest temperature. If this is unobtainable, use the next highest percent load and corresponding value of top-liquid temperature.

Do not allow the top-liquid temperature to exceed the value specified for a given percent load, since the windings are at a higher temperature than the Pyranol and damage to the insulation may result. It is recommended that the top-liquid temperature never be allowed to exceed 100 C. Make sure that the thermometers used are accurate and that the temperatures are accurately observed. Only spirit thermometers should be used inside the transformer.

WHEN TO DISCONTINUE DRYING

During the drying run, take Pyranol samples from the top of the transformer every four hours and test them for dielectric strength. Take the sample from a manhole opening and allow it to cool to room temperature (not more than 40 C) before testing. Plot curves of the Pyranol tests, top-liquid temperatures and the load current against time. These curves will picture the progress of the drying.

A decrease in the dielectric strength of the Pyranol indicates that moisture is passing from the transformer windings into the Pyranol. When the windings and insulation are dry, the dielectric strength of the Pyranol will begin to increase. Continue drying until seven

consecutive samples taken at four hour intervals test at least 30 kv. .

After termination of the drying run, add clean, dry Pyranol of high dielectric strength (30 kv or above) to fill the tank to the proper level. It is recom-

mended that the filling of the transformer be completed from the top of the tank rather than through the drain valve, as, in the latter case, air bubbles accidentally entering with the Pyranol may be trapped in the windings and insulation.

MEDIUM TRANSFORMER DEPARTMENT
GENERAL ELECTRIC
ROME, GEORGIA





Pyranol® Insulating Liquid AND Transformer Drying

INTRODUCTION

Pyranol insulating liquid is compounded to General Electric specifications and is available in several different forms. The type used in any particular transformer can be determined from the nameplate. Materials that are unaffected by Pyranol have been selected for use in constructing Pyranol transformers and no substitutes should be made for these materials without the approval of the General Electric Company.

HANDLING AND STORING

Transformer Pyranol can be handled in the same manner as mineral oil. Although continued exposure to liquid Pyranol may produce local skin irritations, cleanliness among workmen constitutes an adequate safeguard against such effects. Ordinary medicinal washes will remove any irritation caused by Pyranol coming into contact with an open cut or skin abrasion. A drop of castor oil will neutralize any irritation caused by contact of Pyranol with the eyes. As with most volatile materials, exposure to concentrated Pyranol vapors in unventilated rooms should be avoided.

CAUTION—Hydrogen chloride gas is formed when Pyranol is decomposed by an electrical arc. Although a scavenger is added to chemically neutralize any of this gas dissolved in the liquid, some free gas may be present. This gas is an irritant and the inhalation of large quantities can be dangerous and harmful to personnel. The presence of hydrogen chloride gas even in small quantities is readily detectable by its strong odor and irritant action on the nasal membranes. Should anyone be exposed to a quantity of this gas, immediately escort him to fresh air.

On those infrequent occasions when the Pyranol is removed for shipment, the transformer will be shipped gas filled and is to be liquid filled at installation. Refer to separate instructions on "Installation and Maintenance". If the transformer is located outdoors, adequate precautions must be taken to insure that no dirt or moisture enters the

Pyranol during the filling operation. Before opening a container of Pyranol allow it to stand until the liquid is at least as warm as the surrounding air.

Before placing the Pyranol insulating liquid in the transformer take a sample from each container and make dielectric test as outlined under "Sampling" and "Testing". If the tests are unsatisfactory, restore the dielectric strength before placing the Pyranol in the transformer. When transferring from containers to the transformer it is recommended that the liquid be passed through a filter press to remove any undetected moisture or sediment which may be present.

Pyranol must be handled in containers, pipes, all-metal hoses, etc., which are free from oil, grease, pitch, or other foreign materials, since these contaminate the liquid and decrease its non-flammable properties. It is desirable that all apparatus used in sampling, filtering, storing, or transporting Pyranol be maintained for exclusive use with Pyranol, since it is extremely difficult to remove all traces of oil or other Pyranol contaminants from equipment of this type. Also, mineral oil is completely miscible in Pyranol, and it is practically impossible to separate the two liquids after they have been mixed.

All-metal hose must be used in handling Pyranol since rubber and rubber-lined hoses are dissolved by Pyranol. This is also true of synthetic rubber hoses.

Use a petroleum solvent to remove all traces of Pyranol on the outside of the transformer tank. This precaution should be taken since Pyranol has a tendency to soften the paint. Examine the external surfaces of the transformer at intervals to see that the paint is unharmed. If places are found where the paint has been attacked, thoroughly clean the surface and repaint with a good grade of durable paint recommended by the General Electric Company.

If necessary to store drums or cans containing Pyranol outdoors, protect the containers from the weather and direct contact with water. Regardless of loca-

tion, all drums should be stored in a position which results in the bungs being under a positive pressure. Do not open a drum or can until the Pyranol is actually needed. Any change in temperature while the containers are open will cause an exchange of air with the possibility of moisture entering the Pyranol. Partially emptied drums must be tightly resealed and stored in the same manner as above.

PERIODIC INSPECTION

The Pyranol must be maintained at the proper level in the transformer and its dielectric strength should be tested after the first few days of operation, again after six months, and yearly thereafter. Keep accurate records of the tests and filter or replace the Pyranol as required.

SAMPLING

The accuracy of test data can be seriously affected by improper sampling. In order to obtain consistent results it is recommended that the methods outlined in the following paragraphs be observed.

Strict attention should be given to the cleaning and drying of sampling and testing receptacles. Samples should be taken when the insulating liquid is at least as warm as the surrounding air to avoid the possibility of moisture condensation. If the transformer or drum is outdoors, the sample should be taken on a clear day with precautions being taken to guard against contamination by windblown dust, etc. The most important features of the sampling procedures are outlined in the following steps:

SAMPLING FROM TRANSFORMERS

1. Impurities which tend to affect the dielectric strength of Pyranol will generally be found at the top and therefore the sampling valve is located on the side of the tank about one inch below the 25C liquid level.
2. Three types of containers are recommended for sampling purposes—a

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

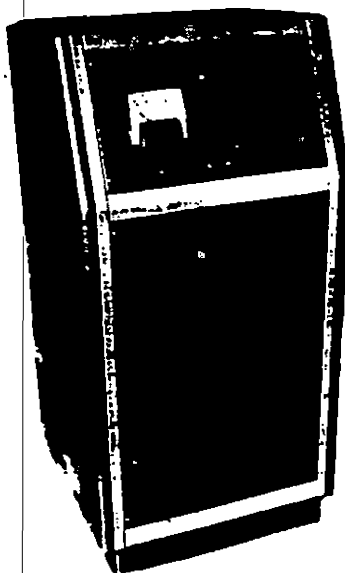


Fig. 1. Typical high-voltage A-C test set

one-quart, small-neck, brown glass bottle; a clear glass bottle in a light-proof carton; or a one-quart tin can that has had the solder seams thoroughly cleaned to remove all traces of soldering flux. Do not use rubber stoppers or rings. If desired, glass sampling bottles may be obtained from the General Electric Company as explained under "Testing Service."

3. To clean the bottles, rinse with non-leaded, oil-free gasoline. Then wash with strong soapuds, rinse thoroughly with distilled water, and dry in an oven at 105C to 110C for at least 8 hours. After drying, the bottles must be tightly sealed with glass stoppers or with clean corks protected by clean metal foil. Store them in a dry, dust-free cabinet or compartment.

4. Carefully clean the sampling valve or plug and allow enough insulating liquid to run out to remove any moisture or foreign matter which may have collected.

5. Rinse the bottle carefully, at least three times, with small portions of liquid drawn from the sampling valve. Allow the sampling bottle to drain thoroughly between rinses.

6. Draw a sample into the bottle, leaving sufficient air space to allow for possible expansion of the liquid. Re-seal the transformer and carefully seal the container to prevent exposure to the atmosphere.

7. When making repeated samplings, observe the transformer liquid level and add make-up as required.

SAMPLING FROM DRUMS

1. Drums should remain undisturbed

for at least eight hours before being sampled.

2. Glass thieves should be cleaned, dried, and stored in the same manner as outlined for bottles.

3. Take the sample from the top of the drum, observing the precautions previously outlined.

TESTING

DIELECTRIC STRENGTH

A variety of high-voltage dielectric testing equipment may be purchased from the General Electric Company. Typical stationary test equipment is shown in Figs. 1 and 2. A smaller, lightweight, portable unit is also available. Follow the technique specified by the American Society for Testing and Materials, Designation: D877. The following paragraphs give a general outline of the procedure:

1. Set the spacing of the 1-inch diameter electrodes at 0.100-inch.

2. Wipe the test cup and electrodes clean with dry, calendered tissue or clean, dry chamois and thoroughly rinse with non-leaded, oil-free, dry gasoline.

3. Fill the test cup with dry gasoline and make a breakdown test under standard conditions of voltage application (3kv per second rise). If the cup has a dielectric strength above 25 kv, it is considered suitable for testing purposes. Observe the usual precautions in handling gasoline.

4. Immediately after the final rinsing with gasoline, rinse the test cup with the sample under investigation, and proceed with the test at once.

5. The temperature of the sample when tested should be the same as that of the room, which should be between 20 C and 30 C (68 F and 86 F). Tests made on samples above this temperature can be misleading. Under no circumstances should the test cup be colder than the sample being tested.

6. Agitate the sample gently before each filling to prevent variations in results due to a settling of contaminants. Pour the liquid into the receptacle slowly to avoid the formation of air bubbles and fill to overflowing. If air bubbles are present, gently rock the test cup a few times and wait at least 3 minutes before applying voltage.

7. Fill the cup at least five times, making one test per filling, and average the results.

Since the Pyranol is a major portion of the insulation system in the transformer, its dielectric strength should be maintained as high as possible. A low breakdown voltage is an indication

that impurities such as moisture, conducting dust, lint, or carbonized particles have entered the liquid. Pyranol testing lower than 26kv (30 kv when new) should either be filtered to bring it back to its original condition or be replaced, depending on the condition of the liquid and economic considerations. Under normal operating conditions values of 30 kv and above can be maintained.

OTHER TESTS

Although a low dielectric strength indicates the presence of contaminants, a high value is not always a certain indication of their absence. A number of other tests can be performed on an insulating liquid to determine its condition and therefore no one test should be considered conclusive. ASTM Designation: D 901 defines the standard tests and contains cross references to other ASTM Designations for detailed descriptions of each method. Where suitable equipment and qualified personnel are not available for conducting these tests, samples can be returned to the factory for laboratory analysis as outlined under "Testing Service". Use sample bottles supplied by the General Electric Company for this purpose.

Water Content

The presence of free water may be disclosed by visual examination in the form of separate droplets or as a cloud dispersed throughout the Pyranol. However, water in solution cannot be detected visually and therefore the Karl Fischer Reagent method (ASTM Designation: D1533) is recommended as a means of determining total water in the Pyranol in parts per million.

TESTING SERVICE

For convenience in sampling and testing, the General Electric Company will, upon receipt of an order covering the actual cost of testing, furnish one-quart



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Fig. 2. ASTM test cell mounted on cage

sample containers. These will be supplied with clean, dry Pyranol to prevent contamination of the bottle. This liquid can be used as a replacement for the sample if the transformer is already open and it is convenient to add it; otherwise it should be discarded. After emptying the container, immediately refill with the Pyranol to be tested. Since reliable tests are dependent on reliable samples, follow the technique outlined under "Sampling".

Send samples to the Laboratory, Medium Transformer Department, General Electric Company, Rome, Georgia. Pack these samples carefully to avoid breakage in transit. Recommendations for continued use or treatment will be furnished, based on the following tests:

1. Dielectric strength
2. Acidity
3. Water content
4. Color
5. Condition
6. Scavenger content (when requested)

Be sure to answer the questions on the sample bottle label. This information is essential if conclusions or recommendations are to be made concerning the sample. Additional testing services are available should the need arise. For further information concerning specific problems, consult the nearest Apparatus Sales Office of the General Electric Company. If the Pyranol in question is known to be highly contaminated, transactions concerning sampling, testing, returning for reclamation or credit, etc., should be handled directly with the Monsanto Chemical Co., St. Louis, Missouri.

FILTERING

If test results indicate that moisture or other contaminants are present, they can usually be removed by passing the insulating liquid through a Pyranol purifier (Fig. 3). This device may be used either as a paper filter press for drying or with fuller's earth and paper for purifying. For details of the filtering procedure refer to instructions GEH-1031, copies of which are available upon request. For information on drying and filtering equipment contact the nearest Apparatus Sales Office of the General Electric Company.

Filtration can be accomplished in the transformer or other container by circulating the Pyranol from the top to the bottom through a filter press. However, this method is quite slow since the filtered Pyranol is continuously being mixed with the unfiltered. Filtering can be done faster and more efficiently

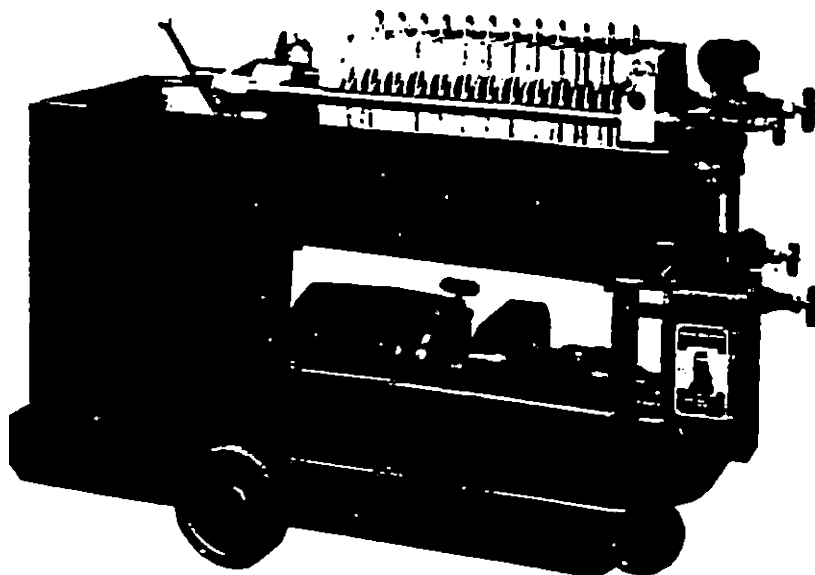


Fig. 3. Typical Pyranol purifier

by passing the liquid into a separate, clean, dry container. In this manner, all of the Pyranol is given one complete pass through the filter press. If additional filtering is required, the Pyranol can then be filtered back into the transformer.

The filter press will not remove large quantities of free water from the Pyranol. When a large quantity of free water is introduced into the filter it will be passed on through, emerging as finely divided droplets dispersed throughout the Pyranol. Therefore, if free water is present it should be removed before filtering is started. As moisture is extracted from the Pyranol during the drying process, the filtering medium will become wet. Frequent samples of the outgoing Pyranol should be tested and, when the dielectric strength drops below 26 kv, the filtering medium should be replaced.

NOTE—A portion of the scavenger may be lost during filtering operations if the Pyranol is passed through fuller's earth. A test should therefore be made following filtering to determine how much of the scavenger has been lost and the quantity required to restore the Pyranol to its original condition. Laboratory testing facilities are available through the General Electric Company as outlined under "Testing Service".

A transformer contaminated with moisture will not only have moisture suspended in the insulating liquid, but also in the windings and insulation. The most efficient temperature for filtering moisture from the Pyranol is between 20C and 40 C, but at this temperature the transfer of moisture from the windings and insulation to the insulating liquid is quite slow. In order to completely dry the transformer, the

filter-press operation should be followed by a drying run as described under "Drying a Transformer".

DRYING A TRANSFORMER

Drying of Pyranol transformers is necessary when evidence of moisture is found, either by visual inspection or as a result of tests on the insulating liquid. The dryness of transformers that have been disassembled or out of Pyranol depends on the care taken to keep all parts dry while exposed. Unless proper care has been taken and it is certain that no moisture has been allowed to enter, the transformer should be dried.

Recommendations regarding the drying of any particular transformer can be obtained from the nearest Apparatus Sales Office of the General Electric Company. Requests for this information should include the serial number of the transformer and the voltages and kva available for drying, including any available step-up or step-down transformers.

The first step in drying a transformer consists of removing any free water and the water in solution with the Pyranol as previously explained under "Filtering". The second step involves removal of the moisture from the windings and insulation as outlined in the following paragraphs. *Exercise caution when heating the transformer to avoid damaging the insulation.* The maximum winding temperature as determined by resistance measurements should not be allowed to exceed 95 C.

SHORT-CIRCUIT METHOD

This method consists of heating the windings and Pyranol to a specified temperature with one winding short-

circuited and a suitable voltage applied to the other winding. The moisture, which is driven off in the form of vapor, is vented to the atmosphere by removing the manhole covers and pressure relief device. Air circulation above the Pyranol can be improved by the use of fans. Protect all openings in the cover of the transformer from inclement weather and provide adequate room ventilation when the drying operation is performed indoors.

Proper liquid temperatures can be obtained more readily by blanketing the transformer. The amount required will have to be determined by trial. Begin at the bottom and wrap the transformer with heavy paper, cloth, or building felt until sufficient radiating surface has been covered. Another effective means of limiting heat losses is to restrict or prevent circulation of the Pyranol through the cooling tubes by lowering the liquid level slightly. Make sure all live parts remain covered.

Regardless of the amount of blanketing around the main tank, the cover and sides of the transformer down to the liquid level must be insulated to prevent condensation on the inside.

POWER REQUIREMENTS FOR TWO-WINDING TRANSFORMERS

When drying a transformer by the short-circuit method, one winding of the transformer is short-circuited and voltage is applied to the other winding. Only a fraction of the rated voltage of the winding can be applied and to insure proper drying, all portions of all the windings must be in the circuit. Be sure the conductor used to short-circuit the winding will carry the required current.

While the equations which follow show the method of computing the required voltage and kva at FULL LOAD CURRENT, it should be noted from Table I that it is preferable to hold less than full load current in order to permit higher top liquid temperatures for more effective and faster drying. However, having once established from the equations the voltage and kva required at full voltage load current, corresponding values of current and kva at available voltages can be readily calculated by noting that the current will vary directly as the ratio of

$$\frac{E \text{ (Available)}}{E}$$

and kva will vary as the square of this ratio.

The equations for computing the required voltage and kva for drying a SINGLE-PHASE, TWO-WINDING

transformer at full load current are as follows:

$$E = \%IZ \times E_R$$

$$KVA = \frac{E \times I}{1000}$$

The equations for computing the required voltage and kva for drying a THREE-PHASE, TWO-WINDING transformer at full load current are as follows:

$$E = \%IZ \times E_R$$

$$KVA = \frac{1.732 \times E \times I}{1000}$$

$\%IZ$ = percent transformer impedance volts from nameplate.

E_R = nameplate voltage of winding to which power is applied. When tap changers, terminal boards, or load-tap-changing equipment are located in either or both windings, they must be set on the position which places all sections of the windings in the circuit, leaving no turns idle.

I = full load current corresponding to maximum rated voltage.

E = required drying voltage for full load current.

KVA = required kilovolt-amperes for full load current.

If it is necessary to obtain drying voltage over a long transmission line, overvoltage protection should be provided.

OTHER TRANSFORMERS

The drying of three-winding transformers and autotransformers with tertiary windings by the short-circuit method usually is more complicated than that of two-winding transformers because of the differences in impedance and capacity of the windings. It is frequently necessary to make two separate drying runs on such units to assure that all windings will be properly dried. In some cases, division of the load current in the various portions of the windings can be obtained by the insertion of an additional reactance, permitting all three windings to be dried simultaneously. It is recommended that detailed information for drying three-winding transformers be obtained from the nearest Apparatus Sales Office of the General Electric Company.

LOADS AND TEMPERATURES

If power is available, up to 125 per-

cent load current can be held at the start of the drying run until the top-liquid temperature reaches 65 C. The load on the transformer must then be reduced to obtain a constant top-liquid temperature in accordance with the following table:

TABLE I

Max. Allowable Short-Circuit Amps in Percent of Full Load Based on Min. Rating	Maximum Allowable Top-Liquid Temperature in Deg. C
50	100
75	90

It is recommended that a 100 C top-liquid temperature be held with 50 percent load, if possible, since the fastest drying will take place at the highest temperature. If this is unobtainable, use the next highest percent load and corresponding value of top-liquid temperature.

Do not allow the top-liquid temperature to exceed the value specified for a given percent load, since the windings are at a higher temperature than the Pyranol and damage to the insulation may result. It is recommended that the top-liquid temperature never be allowed to exceed 100 C. Make sure that the thermometers used are accurate and that the temperatures are accurately observed. Only spirit thermometers should be used inside the transformer.

WHEN TO DISCONTINUE DRYING

During the drying run, take Pyranol samples from the top of the transformer every four hours and test them for dielectric strength. Take the sample from a manhole opening and allow it to cool to room temperature (not more than 40 C) before testing. Plot curves of the Pyranol tests, top-liquid temperatures, and the load current against time. These curves will picture the progress of the drying.

A decrease in the dielectric strength of the Pyranol indicates that moisture is passing from the transformer windings into the Pyranol. When the windings and insulation are dry, the dielectric strength of the Pyranol will begin to increase. Continue drying until seven consecutive samples taken at four hour intervals test at least 30 kv.

After termination of the drying run, add clean, dry Pyranol of high dielectric strength (30 kv or above) to fill the tank to the proper level. It is recommended that the filling of the transformer be completed from the top of the tank rather than through the drain valve, as, in the latter case, air bubbles accidentally entering with the Pyranol may be trapped in the windings and insulation.

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-inflammable. 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 generally recognized as a standard means of improving power factor. More than 20,000,000 small Pyranol capacitor units are in service for various applications, such as capacitor-motors, radio transmitters, and luminous-tube transformers.

Pyranol was first used commercially in transformers in 1932. Since then, more than 16,000 Pyranol transformers, ranging in size from $1\frac{1}{2}$ to 15,000 kva and totalling more than 4,000,000 kva, have established an excellent operating record. Many of these installations include Pyranol current transformers and Pyranol potential transformers.

The first Pyranol induction voltage regulators were built in 1938, and there are now more than 250 units in service, totalling more than 21,000 kva.

The Laboratories of the National Board of Fire Underwriters have investigated transformer, regulator, and capacitor Pyranols, and their Report 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 frequently asked by users and prospective users of Pyranol equipment.

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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 noninflammable 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 noninflammable 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. 1467), and (2) the capacitor type (No. 1476). Both types have the distinctive Pyranol characteristics of high dielectric strength and noninflammability.

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

	Transformer Pyranol No. 1467	Capacitor Pyranol No. 1476
Color.....	straw-yellow	straw-yellow
Burning point.....	none	none
Viscosity at 37.8 C (Saybolt).....	54 sec	2400 sec
Flow point (A.S.T.M.), -32 C	lower than -32 C	+10 C
Dielectric constant (specific inductive capacity).....	1.5	1.5

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 16 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 gases and finely divided carbon in the following approximate proportions:

	Transformer Pyranol, No. 1467	Capacitor Pyranol, No. 1476
Hydrogen chloride.....	97.50%	99.00%
Oxygen.....	0.00	0.10
Unsaturated hydrocarbons..	.00	.10
Carbon dioxide.....	.28	.00
Carbon monoxide.....	.28	.00
Phosgene.....	.00	.00
Saturated hydrocarbons..	.00	.00
Hydrogen.....	.00	.00
Chlorine.....	.00	.00
Inert (gases).....	1.31	.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 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

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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 regu-

lator 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, a small amount of hydrogen-chloride gas is produced. The new No. 1467 Pyranol, 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 Pyranol 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 can be completely mixed 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 noninflammability 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 noninflammable 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 inflammable 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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YOU CAN'T BURN



PYRANOL

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SCHENECTADY, N. Y.

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GENP 004607

Q DENOTES CHANGE

GENERAL ELECTRIC MEDIUM TRANSFORMER DEPT		MFG. PROCESS INSTRUCT 1		DATE OF ISSUE: 9/28/73	REVIEW DATE:	API () P23A-FMI
		CONFIDENTIAL: FOR USE OF GENERAL ELECTRIC EMPLOYEES ONLY		SUPERSEDES DATE: 12/6/72	REVIEWED:	
SUBJECT: INSTALLATION OF CAUTION SIGNS ON PYRANOL TRANSFORMERS				WHERE USED: SECTION 665-693		PAGE 1 CONT'D ON 2
PREPARED BY: <i>William E. Burnett</i>		APPROVED - MFG. ENGINEERING <i>[Signature]</i> 9/28/73		APPROVED - ENGINEERING <i>[Signature]</i> 9/28/73		APPROVED - QUALITY CONTROL <i>[Signature]</i> 9/28/73
REVIEWED BY: Shop Operations <i>[Signature]</i> 9/28/73		REVIEWED BY: Methods & Work Measurements <i>[Signature]</i> 9/28/73				
PURPOSE: To provide instructions for the application of caution signs - NP 229A3316 and "Notice to Carrier" signs to all pyranol transformers MATERIAL: Caution signs NP 229A3316 with peel-off backing and pre-applied adhesive. (See Exhibit A) "Notice to Carrier" signs. (See Exhibit B) APPLICATION: After a unit has been inspected and found acceptable, the tags should be applied as follows: One at each sampling valve location and at the area of the base closest to the drain valve. In addition, if the unit has a handhole or manhole in the cover a caution tag should be placed on these also. In the event that a unit is not equipped with a sampling valve, the caution tag must be placed on the tank wall as close to the nameplate as possible. QUALITY CONTROL: All pyranol transformers must carry this caution sign. Final inspection appraisal plans should be modified to include these items. SHIPPING: In addition to the self-adhering tags placed on the tanks, it will be necessary for Shipping to wire one of the "Notice to Carrier" signs to each pyranol unit. These signs (Exhibit B) are bright orange in color, and pre-punched on the four corners. The signs should be located on the left side of the transformer at a point readily seen by the truck driver.						

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P23A-FMI

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GENERAL ELECTRIC	MFG. PROCESS INSTRUCTION	DATE OF ISSUE: 9/28/73	REVIEW DATE:	MFGENP 004609
	CONFIDENTIAL: FOR USE OF GENERAL ELECTRIC EMPLOYEES ONLY	SUPERSEDES DATE: 12/6/72	REVIEWED:	
MEDIUM TRANSFORMER DEPT				P23A-PM1
SUBJECT: INSTALLATION OF CAUTION SIGNS ON PYRANOL TRANSFORMERS		WHERE USED: Section 665-693		PAGE <u>2</u> CONT'D ON <u>3</u>

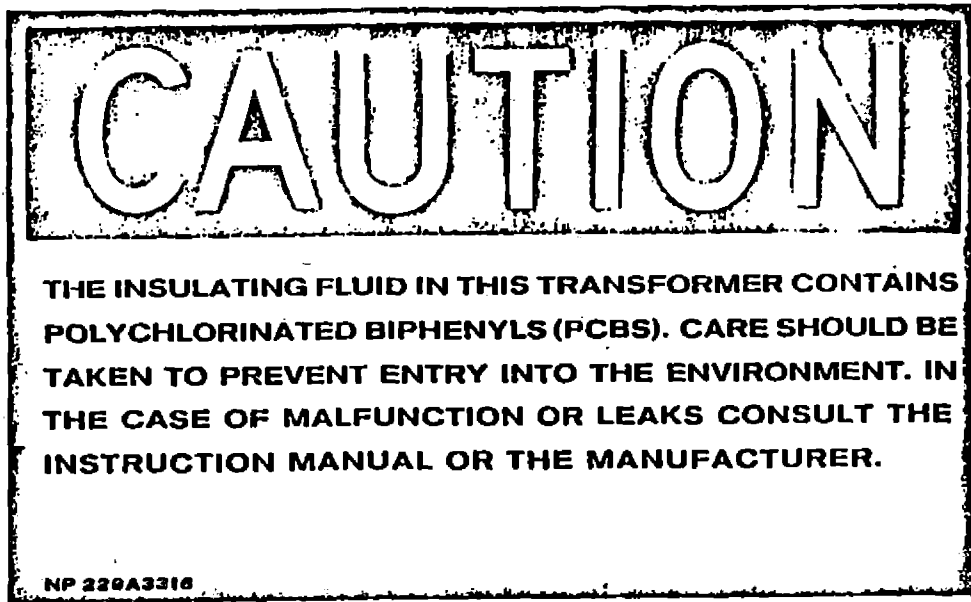


EXHIBIT A

772568

API NO

MPI NO

NOTICE TO CARRIER

YOU ARE HAULING A TRANSFORMER WHICH IS FILLED WITH AN INSULATING LIQUID. CARE SHOULD BE TAKEN TO PREVENT ANY ENTRY OF THIS MATERIAL INTO THE ENVIRONMENT THROUGH SPILLS OR LEAKAGE.

SHOULD ANY LIQUID LEAK BE DETECTED OR ANY SPILL BE NOTED ANYTIME DURING TRANSIT, PULL YOUR TRUCK OFF THE HIGHWAY OR PLACE CAR IN NEAREST RAIL SIDING AS SOON AS POSSIBLE. WHEN OFF THE HIGHWAY OR MAIN LINE, TRY TO STOP THE LEAK IF POSSIBLE. DO NOT WELD ON THE UNIT.

ANY LIQUID THAT IS SPILLED ON THE TRUCK OR CAR BED OR ROADWAY SHOULD BE CLEANED OR CONTAINED WITH RAGS, DRY-RITE AND/OR DRY SAND AS SOON AS POSSIBLE.

DO NOT MOVE THE TRANSFORMER IF THERE IS ANY DANGER OF THE LIQUID SPILLING OUT ON THE ROAD OR GROUND.

CALL COLLECT THE GENERAL ELECTRIC COMPANY, ROME, GEORGIA, AREA CODE 404. PHONE 234-0211, SERVICE ENGINEERING UNIT, FOR FURTHER INSTRUCTIONS.

IF AFTER 5:00 P.M., OR ON WEEKENDS, PLEASE CALL THE ABOVE NUMBER, GIVE YOUR NAME, COMPANY NAME AND WHERE YOU CAN BE REACHED BY PHONE. SERVICE ENGINEERING WILL CALL YOU BACK WITHIN A FEW MINUTES.

EXHIBIT B

772569

11-4433

NP 00 1610

✓ DENOTES CHANGE

GENERAL ELECTRIC  MEDIUM TRANSFORMER DEPT	MFG. PROCESS INSTRUCTION CONFIDENTIAL: FOR USE OF GENERAL ELECTRIC EMPLOYEES ONLY	DATE OF ISSUE: 9/28/73	REVIEW DATE:	MPI NO P23A-PMI	PAGE CONT'D ON 3
		SUPERSEDES DATE: 12/6/72	REVIEWED:		
SUBJECT: INSTALLATION OF CAUTION SIGNS ON PYRANOL TRANSFORMERS		WHERE USED: Section 665-693			

MT-401-B



MEDIUM TRANSFORMER DEPARTMENT
DEPARTMENT INSTRUCTION

SUBJECT	ENVIRONMENTAL CONTROL - PYRANOL AND 10-C OIL TRANSFORMER IN TRAVEL TO CUSTOMER	DATE EFFECTIVE 12/19/73	NO. MG-5.8
PREPARED BY MANUFACTURING ENGINEERING PLANT ENGG & EQUIPT PROTECT	APPROVALS MANAGER - MANUFACTURING MANAGER - ENGINEERING	SUPERSEDES NO. DATE 9/1/73	PAGE 1 OF

PURPOSE:

THIS INSTRUCTION OUTLINES THE SPECIFIC ACTIONS TO BE TAKEN BY THE MTPD TO ASSIST TRANSFORMER CARRIERS, RAIL AND TRUCK, IN THE EVENT THAT 10-C OIL OR PYRANOL LEAKS OR SPILLS FROM UNITS IN TRAVEL TO THE CUSTOMER. SUCH ACTIONS ARE REQUIRED REGARDLESS OF ASSIGNED RESPONSIBILITY, CARRIER OR MTPD, TO PREVENT CONTAMINATION OF THE ENVIRONMENT AND TO PROTECT THE INTERESTS OF THE GENERAL ELECTRIC COMPANY.

RESPONSIBILITY:

THE PLANT ENGINEERING UNIT, MANUFACTURING ENGINEERING SUB-SECTION WILL BE RESPONSIBLE FOR COMMUNICATING AND REVIEWING THE CONTENT OF THIS INSTRUCTION AS NECESSARY TO ASSURE THAT ADEQUATE AND RESPONSIVE CONTROL PROCEDURES ARE MAINTAINED.

THE SERVICE ENGINEERING FUNCTION WILL BE RESPONSIBLE FOR FOLLOWING THE DIRECTION OF THIS PROCEDURE AS STATED.

THE ADE LABORATORY WILL PROVIDE TECHNICAL ASSISTANCE AS OUTLINED AND WILL RECOMMEND ACCORDINGLY.

IT SHALL BE THE RESPONSIBILITY OF QUALITY CONTROL TO PROVIDE THE FINAL INSPECTION NECESSARY TO ASSURE THAT:

A. PYRANOL SHIPPED IN TRANSFORMERS.

1. A CAUTION LABEL AS SPECIFIED ON MPI #P23A-FM1 IS ATTACHED AT EACH DRAIN POINT (TEST VALVES AND TANK VALVES).
2. ONE (1) CAUTION TAG IS ATTACHED TO THE UNIT WHERE IT CAN BE READILY SEEN BY THE CARRIER. WORDING FOR THIS NOTICE IS ATTACHMENT C OF THIS INSTRUCTION.

B. PYRANOL SHIPPED IN CONTAINERS OTHER THAN TRANSFORMERS.

1. ONE (1) CAUTION TAG FOR CAN OR DRUMMED PYRANOL WILL BE ATTACHED TO EACH CONTAINER AT OR NEAR THE ADDRESS LABEL SO IT CAN BE READILY SEEN BY THE CARRIER. WORDING FOR THIS NOTICE IS ATTACHMENT D OF THIS INSTRUCTION.

PROCEDURE:**SECTION I - ACTION TO BE TAKEN UPON NOTIFICATION OF SPILL OR LEAK**

R B LANDT
BLDG 1 145
1070

- A) ALL CALLS FOR MALFUNCTION, LEAKS OR SPILLS SHALL BE DIRECTED TO SERVICE ENGINEERING, MEDIUM TRANSFORMER PRODUCTS DEPARTMENT. THE PLANT PROTECTION UNIT OF EMR SHALL INSTRUCT ALL GUARDS THAT ANY CALLS AFTER HOURS OR ON WEEKENDS FROM THE CARRIERS SHALL BE REPORTED TO ONE OF THE FOLLOWING AS SOON AS POSSIBLE:

MANAGER, SERVICE ENGINEERING
SERVICE ENGINEERS
MANAGER, PLANT ENGINEERING
SUPERVISOR, PLANT PROTECTION

NO. MG-5.8	SUPERSEDES NO.	DATE EFFECTIVE	MEDIUM TRANSFORMER DEPARTMENT
PAGE 2 OF 4	DATED 9/1/73	12/19/73	DEPARTMENT INSTRUCTION

- b) Service Engineering shall advise the carriers of the action to be taken (example: try to plug leak or broken bushing, minor leaks, etc., to go to nearest Service Shop). If there is a major spill or leak, the carrier should be instructed to remain where he is or move the unit as little as possible, and await further instructions.
- c) The Manager of Service Engineering shall advise the Manager of Plant Engineering as soon as possible of the spill or leak, giving name of who made the report, his company, and any information received concerning the nature of the spill or leak.
- d) When notified by Service Engineering, the following action will be taken by Plant Engineering Unit, Manufacturing Engineering Sub-Section:
 1. Contact the carrier or individual reporting the spill or leak and obtain pertinent facts concerning the incident - example: type of leak -- oil or Pyranol; magnitude -- gallons; geographic location; action taken to contain fluid, etc.).
 2. Advise the carrier, or individual reporting, as to emergency measures to be taken until assistance can be dispatched to the spill site.
 3. Contact the EPA Regional Office responsible for the spill area (see Attachment "A") and report the nature of the spill, geographic location, and other information requested. The time and date of reporting and the name of the EPA official contacted will be recorded.
 4. Contact the State Environmental Protection Agency.
NOTE: This could be a problem as the unit may be known as Environmental Quality Control, or be a sub-unit under another department in the state. If a problem is encountered in identifying proper reporting official, contact the nearest state office and make inquiry on unit. The time and date of reporting and the name of the official(s) contacted will be recorded.
 5. After reviewing the information received, dispatch Plant Engineering personnel and appropriate Laboratory technical personnel to the site to assist in containing spill or leak and direct activities. "Emergency Equipment" (see Section V) will be taken to the site.

Section II - ACTION TO BE TAKEN -- SPILL/LEAK SITE

- a) Investigate spill or leak source, and if transformer fluid is continuing to leak from the unit, attempt to stop the flow by use of the material in the "Emergency Material Container".
- b) Contain transformer fluid that has leaked upon the ground or surrounding area by utilizing the materials provided in the "Emergency Materials Container" or by building a soil barrier or other suitable containment using materials available at the site.
- c) Stake off the contaminated area, if possible, by blocking any movement through the area by person, animal or vehicle.

MEDIUM TRANSFORMER DEPARTMENT DEPARTMENT INSTRUCTION	DATE EFFECTIVE 12/19/73	SUPERSEDES NO. DATED 9/1/73	NO. YG-5. PAGE 3 OF
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Section III - COMMUNICATION OF DEGREE OF CONTAMINATION AND PLANS

After emergency action has been taken to contain the spilled oil or Pyranol, Plant Engineering personnel at the site will report conditions to MTPD management, Manager, Service Engineering and/or Manager, Manufacturing Engineering.

Items to be reported:

1. Extent of contamination
2. Impact on community
3. Action taken to contain spill and effectiveness
4. Action taken to isolate area from contaminating other areas such as blocking off by markers, earth dams, etc.
5. Availability of local assistance for containment and clean-up
6. Other pertinent information

Section IV - CLEAN-UP OF CONTAMINATED AREA

Based on the technical support and recommendations of the ADE Laboratory, MTPD, Environmental Protection Agencies, Federal and State; and MTPD Service Engineering, the Plant Engineering Unit, Manufacturing Engineering Unit will proceed as follows:

- a) Establish actual area of contamination.
- b) Identify equipment and manpower needs for accomplishing the clean-up.
- c) Develop work plan and proceed with clean-up, working through the I&SE representative or on our own.

Section V - EMERGENCY EQUIPMENT

The emergency equipment container will be equipped with, but not limited to, the following items:

1. 2 packages of duct seal
2. 12 rolls 2" cloth tape
3. 6 rolls 2" cloth masking tape
4. 10 lbs. rags
5. 12 transformer field repair kits
6. Dow Chemical Beads
7. 1 wooden plug kit (miscellaneous sizes)
8. Collapsible plastic tank or bag
9. 50 aluminum stakes 48" long painted International Orange
10. 1 wedge ax
11. 3 lb. hammer
12. 100 ft. steel tape
13. Miscellaneous common hand tools

772572

The above material will be placed in a shipping container and be prepared for shipment in the following manner:

1. The shipping container will be light-weight material for air shipment.

GENP 004612

NO. MG-5.8	SUPERSEDED NO.	DATE EFFECTIVE	MEDIUM TRANSFORMER DEPARTMENT DEPARTMENT INSTRUCTION
PAGE 4 OF 4	DATED 9/1/73	12/19/73	

2. AN INVENTORY LIST WILL BE FIRMLY ATTACHED TO THE OUTSIDE OF THE CONTAINER.
3. THE DATE THE CONTAINER WAS PREPARED FOR SHIPMENT WILL BE SHOWN AND THE NEXT INVENTORY DATE WILL BE INDICATED. AN INVENTORY WILL ONLY BE REQUIRED IF THE CONTAINER HAS BEEN OPENED OR THE SHELF LIFE OF ANY OF THE MATERIAL WILL BE THE NEXT INVENTORY DATE.

A STATEMENT TO THE CARRIER THAT THE CONTAINER DOES NOT CONTAIN ANY EXPLOSIVES OR CORROSIVE MATERIAL WILL BE WRITTEN ON THE CONTAINER.

SECTION VI - REPORTS

PROGRESS REPORTS BY PHONE ARE REQUIRED WHEN A MAJOR CHANGE HAS TAKEN PLACE, SUCH AS ADDITIONAL CONTAMINATION IS DISCOVERED OR OTHER CHANGES TO WORK PLANS ARE INVOLVED.

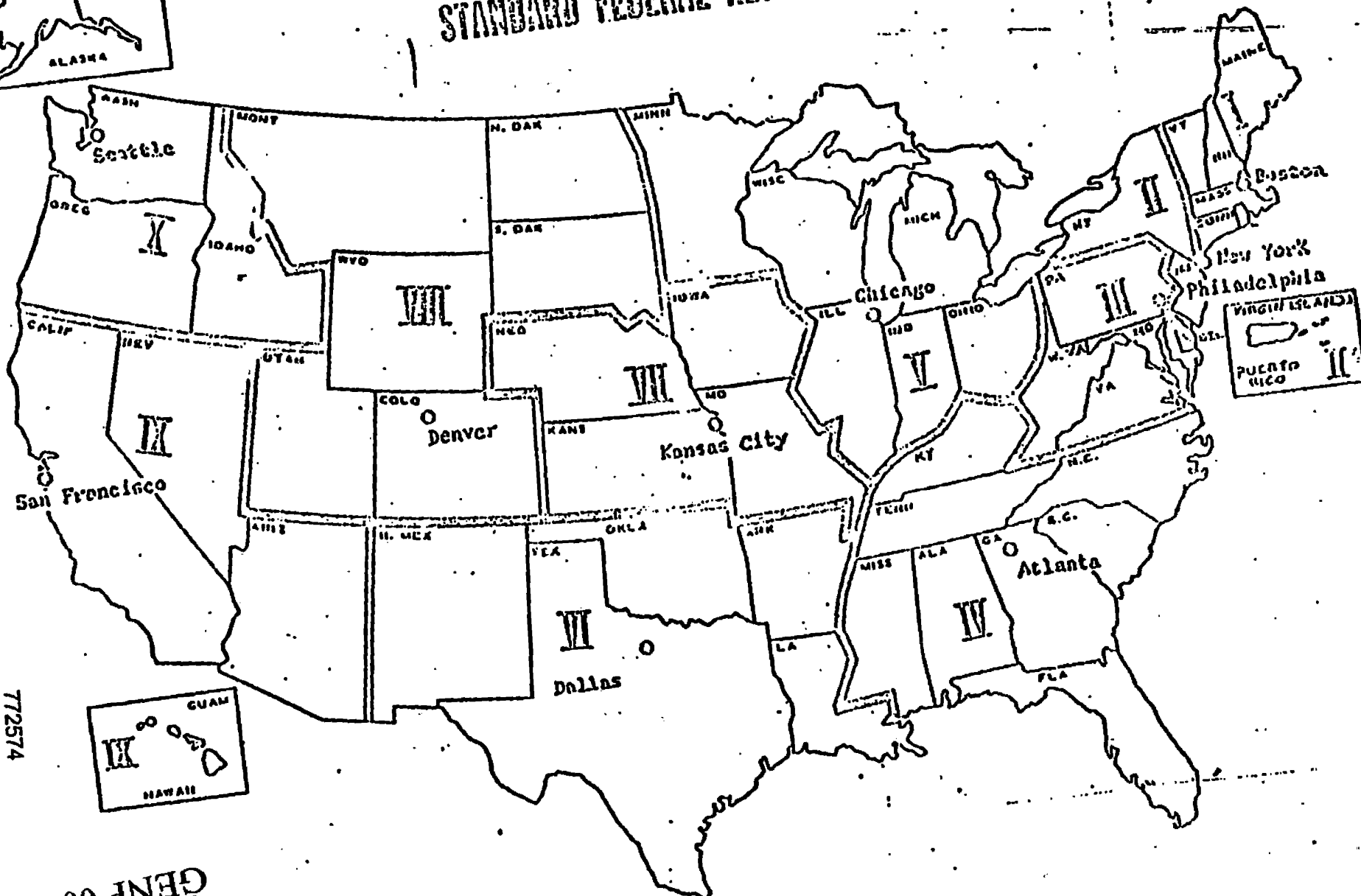
A COMPLETE WRITTEN REPORT WILL BE REQUIRED UPON COMPLETION OF THE PROJECT.

OTHER REPORTS AT THE DISCRETION OF THE PERSONNEL CONCERNED MAY BE REQUIRED.

ATTACHMENTS:

- A - ENVIRONMENTAL PROTECTION AGENCY
STANDARD FEDERAL REGIONS
- B - ENVIRONMENTAL PROTECTION AGENCY
REGIONAL OFFICES
- C - TRANSFORMER FILLED WITH PYRANOL
CAUTION TAG
- D - CONTAINER FILLED WITH PYRANOL
CAUTION TAG

ENVIRONMENTAL PROTECTION AGENCY REGIONAL OFFICES STANDARD FEDERAL REGIONS



ATTACHMENT A

772574

GENP 004615

ENVIRONMENTAL PROTECTION AGENCY REGIONAL OFFICES

<u>REGION</u>	<u>ADDRESS</u>
I	John F. Kennedy Federal Building Boston, Massachusetts 02203
II	Federal Office Building 26 Federal Plaza (Foley Square) New York, New York 10007
III	Curtis Building Sixth & Walnut Streets Philadelphia, Pennsylvania 19102
IV	1421 Peachtree Street, N.E. Atlanta, Georgia 30309
V	1 North Wacker Drive Chicago, Illinois 60606
VI	1600 Patterson Street Dallas, Texas 75201
VII	1735 Baltimore Avenue Kansas City, Missouri 64108
VIII	Lincoln Tower Building 1860 Lincoln Street Denver, Colorado 80203
IX	100 California Street San Francisco, California 94111
X	1200 Sixth Avenue Seattle, Washington 98108

ATTACHMENT B

772575

GENP 004616

CAUTION

THIS TRANSFORMER IS FILLED WITH AN INSULATING LIQUID CONTAINING POLYCHLORINATED BIPHENYL MATERIALS (PCB'S) WHICH MAY BE HARMFUL TO THE ENVIRONMENT. EVERY EFFORT SHOULD BE MADE TO PREVENT THE ESCAPE OF PCB'S INTO THE ENVIRONMENT AND TO CONTAIN ALL LEAKS OR SPILLS.

SHOULD ANY LIQUID LEAK BE DETECTED OR ANY SPILL BE NOTED ANYTIME DURING TRANSIT, PULL YOUR TRUCK OFF THE HIGHWAY OR PLACE CAR IN NEAREST RAIL SIDING AS SOON AS POSSIBLE. WHEN OFF THE HIGHWAY OR MAIN LINE, TRY TO STOP THE LEAK IF POSSIBLE. DO NOT WELD ON THE UNIT.

PREVENT THE LIQUID FROM SPREADING AND GETTING INTO WATER DRAINAGE AREAS. ANY LIQUID THAT IS SPILLED ON THE TRUCK OR CAR BED OR ROADWAY SHOULD BE CLEANED OR CONTAINED WITH RAGS, DRY-RITE AND/OR DRY SAND AS SOON AS POSSIBLE.

DO NOT MOVE THE TRANSFORMER IF THERE IS ANY DANGER OF THE LIQUID SPILLING OUT ON THE ROAD OR GROUND. Do NOT OPEN ANY VALVES OR ATTEMPT TO DRAIN THE TRANSFORMER.

CALL COLLECT THE GENERAL ELECTRIC COMPANY, ROME, GEORGIA - TELEPHONE AREA CODE 404, 234-0211, SERVICE ENGINEERING UNIT, FOR FURTHER INSTRUCTIONS.

IF AFTER 5:00 P.M. OR ON WEEKENDS, PLEASE CALL THE ABOVE NUMBER, GIVE YOUR NAME, COMPANY NAME AND WHERE YOU CAN BE REACHED BY PHONE. SERVICE ENGINEERING WILL CALL YOU BACK WITHIN A FEW MINUTES.

MT-4439

ATTACHMENT C

772576

GENP 004617

CAUTION
FOR CAN AND DRUMMED PYRANOL

THIS CONTAINER IS FILLED WITH AN INSULATING LIQUID CONTAINING POLYCHLORINATED BIPHENYL MATERIALS (PCB'S) WHICH MAY BE HARMFUL TO THE ENVIRONMENT. EVERY EFFORT SHOULD BE MADE TO PREVENT THE ESCAPE OF PCB'S INTO THE ENVIRONMENT AND TO CONTAIN ALL LEAKS OR SPILLS.

SHOULD ANY LIQUID LEAK BE DETECTED ANY TIME DURING TRANSIT, PULL YOUR TRUCK OFF THE HIGHWAY OR PLACE CAR IN NEAREST RAIL SIDING AS SOON AS POSSIBLE. WHEN OFF THE HIGHWAY OR MAIN LINE, TRY TO STOP THE LEAK IF POSSIBLE.

PREVENT THE LIQUID FROM SPREADING AND GETTING INTO WATER DRAINAGE AREAS. ANY LIQUID THAT IS SPILLED ON THE TRUCK OR CAR BED OR ROADWAY SHOULD BE CLEANED OR CONTAINED WITH RAGS, DRY-RITE AND/OR DRY SAND AS SOON AS POSSIBLE. PLACE CONTAINER IN DRIP PAN OR OTHER TYPE CATCH BASIN IF AVAILABLE; IF NOT, BUILD A BARRIER WITH RAGS, DRY-RITE OR SAND AROUND THE BOTTOM OF THE CONTAINER.

CALL COLLECT THE GENERAL ELECTRIC COMPANY, ROME, GEORGIA - TELEPHONE AREA CODE 404-234-0211, SERVICE ENGINEERING UNIT, FOR FURTHER INSTRUCTIONS.

IF AFTER 5:00 P.M. OR ON WEEKENDS, PLEASE CALL THE ABOVE NUMBER, GIVE YOUR NAME, COMPANY NAME, AND STATE YOU HAVE AN OIL LEAK AND WHERE YOU CAN BE REACHED BY PHONE. SERVICE ENGINEERING WILL CALL YOU BACK WITHIN A FEW MINUTES.

MT-4446

ATTACHMENT D

772577

GENP 004618

GENERAL ELECTRIC

DIAL COMM# 8*236-2923

DATE# October 19, 1973

COPIES# EL Dobbins 42-526

DEPT# Power Transformer Products

ADDRESS# Pittsfield, Massachusetts

SUBJECT#

PYRANOL -PT

RECEIVED

OCT 24 1973

EDWARD L. DOBBINS

SG Hamilton	Erie	14-3
CB Lewis	Erie	12-2
L MacMonagle	Erie	12-2
RM Smith	Erie	14-4
LD Sweatman	Erie	14-3
JJ Farrell		16-200
EW Feuerstein		16-140
WB Gaither		16-175
DL Johnston		16-250
WK Mallon		16-140
JR Vincent		16-100

Mr. A. P. Engel
LPD
Erie Works

Mr. J. K. McCall
TSPD
Erie Works

Consistent with our prior discussions you are aware of the considerable concern that has been expressed over the effects of polychlorinated biphenyls (PCB) on the environment. In an effort to protect the General Electric Company from unreasonable risks in this area, we are forwarding the attached information. This information must be communicated to your customers which have purchased PyranolTM filled transformers as part of your equipment.

The first attachment is an indemnification clause which we suggest you use with your ultimate customer on all new proposals. This indemnification clause will be included in all new Power Transformer Products Department proposals for Pyranol[®] transformers. The second attachment is a draft of emergency instructions in case of Pyranol[®] leaks or spills. At a later date, this will probably be issued as a Company Policy, but it should not deter us from using it now with your customers. The third attachment is NEMA Standard Publication CP-P1-1973*, entitled "Guidelines for Handling and Disposal of Capacitor and Transformer-Grade Askarels". We have been advised that a change has been proposed in the Standards to include specific procedures to be followed in the event of leaks or accidents. No date for completion of this change is available. The third attachment is a copy of a caution tag which will shortly be added to all new shipments of Pyranol[®] filled Pittsfield Transformers. The fourth attachment is a copy of a Pyranol[®] Caution Nameplate (NP229A3316) which we attach to every Pyranol[®] filled unit.

772578

GENP 004619

Messrs. Engel & McCall
October 19, 1973
Page 2

Should you desire additional copies of this caution nameplate to place on existing equipment, please advise me of the number required and the serial numbers of the units on which they will be mounted.

In accordance with above information, please incorporate the attached indemnification clause on Pyranol[®] into your terms and conditions for products equipped with Pyranol[®] transformers.

D.B. Anderson
Product Sales Engineer
Apparatus Transformer Sales

-pal

-attachments

- Registered Trademark

* - To be forwarded under separate cover.

772579

GENP 004620

CAUTION

THE INSULATING FLUID IN THIS TRANSFORMER CONTAINS
POLYCHLORINATED BIPHENYLE, WHICH SOME STUDIES
HAVE SHOWN MAY BE AN ENVIRONMENTAL CONTAMINANT.
CARE SHOULD BE TAKEN TO PREVENT ENTRY INTO THE
ENVIRONMENT. IN THE CASE OF MALFUNCTION OR LEAKS
CONSULT THE INSTRUCTION MANUAL OR THE
MANUFACTURER.

NP 229A3316

772580

GENP 004621

C A U T I O N

THIS TRANSFORMER IS FILLED WITH A NONFLAMMABLE INSULATING LIQUID CONTAINING POLYCHLORINATED BIPHENYL MATERIALS (PCB'S) WHICH MAY BE HARMFUL TO THE ENVIRONMENT. EVERY EFFORT SHOULD BE MADE TO PREVENT THE ESCAPE OF PCB'S INTO THE ENVIRONMENT AND TO CONTAIN ALL LEAKS OR SPILLS.

SHOULD ANY LIQUID LEAK BE DETECTED OR ANY SPILL BE NOTED ANYTIME DURING TRANSIT, PULL YOUR TRUCK OFF THE HIGHWAY OR PLACE CAR IN NEAREST RAIL SIDING AS SOON AS POSSIBLE. WHEN OFF THE HIGHWAY OR MAIN LINE, TRY TO STOP THE LEAK IF POSSIBLE. DO NOT WELD ON THE UNIT.

PREVENT THE LIQUID FROM SPREADING AND GETTING INTO WATER DRAINAGE AREAS. ANY LIQUID THAT IS SPILLED ON THE TRUCK OR CAR BED OR ROADWAY SHOULD BE CLEANED OR CONTAINED WITH RAGS, DRY-RITE AND/OR DRY SAND AS SOON AS POSSIBLE.

DO NOT MOVE THE TRANSFORMER IF THERE IS ANY DANGER OF THE LIQUID SPILLING OUT ON THE ROAD OR GROUND. DO NOT OPEN ANY VALVES OR ATTEMPT TO DRAIN THE TRANSFORMER.

CALL COLLECT THE GENERAL ELECTRIC COMPANY, PITTSFIELD, MASSACHUSETTS -
TELEPHONE AREA CODE 413, 494-1110, POWER TRANSFORMER CUSTOMER SERVICE
ENGINEERING, FOR FURTHER INSTRUCTIONS.

IF AFTER 5:00 P.M. OR ON WEEKENDS, PLEASE CALL THE ABOVE NUMBER, GIVE YOUR NAME, COMPANY NAME AND WHERE YOU CAN BE REACHED BY PHONE. CUSTOMER SERVICE ENGINEERING WILL CALL YOU BACK WITHIN A FEW MINUTES.

EMERGENCY INSTRUCTIONS IN THE CASE OF PYRANOL LEAKS OR SPILLS

There has been considerable concern over the effects of the polychlorinated biphenyl (PCB) effect on the environment. The Environmental Protective Agency of the federal government issued proposed regulations covering the potentially harmful effect of the PCB's. In order to conform to these proposed regulations and to insure that any environmental impact of pyranol leakage or spillage be minimized, this paper will document suggested emergency procedures for handling such leakage or spills.

Some general comments are appropriate to lead into this subject. First, the paramount consideration in treating spills or leakage is "containment". Any leakage or spillage should not be allowed to spread unnecessarily. The second thing to be kept in mind is that the PCB's must be kept out of streams, drains, sewers, or other areas that could leak it into the major waterways. This includes the possible effects of rain washing the PCB's over large areas.

Specific suggestions for the handling of leaks or spills are detailed as follows. While these suggestions are detailed, they do not cover all possible situations and do not list all actions which might be necessary in a particular situation. The two cautions mentioned above should be kept in mind and common sense should prevail.

1. Should any leak be detected or any spill be noted during the transit of pyranol filled equipments, the highway vehicle should be pulled off of the highway or the railroad car should be taken to the nearest railroad siding as soon as possible.
2. When the vehicle is off the highway or main line, correct the cause of the leak if at all possible. Caution: Do not weld on the unit without contacting Customer Service Engineering, Power Transformer Products Dept., Pittsfield, Mass.
3. Soak up any spillage with absorbent materials such as sawdust, dry-rite, dry sand/or rags as soon as possible. Follow this with a clean up of the affected area with rags soaked with kerosene or other approved solvent such as perchloroephylene or trichloroethylene. Collect all materials used for this clean up and prepare them for disposal.
4. Contact Customer Service Engineering, Power Transformer Products Dept., Pittsfield, Mass. for consultation and further instructions.
5. Any pyranol containing material used to clean up spillage from #4 above should be placed in open head drums with suitable closures. The drum then should be properly labeled for shipment to any of several companies offering an acceptable disposal service. Section 4 of NEMA Standard Publication #CP-P1-1973 contains a list of companies offering PCB waste disposal.

D. R. Bair
6/14/73

772582

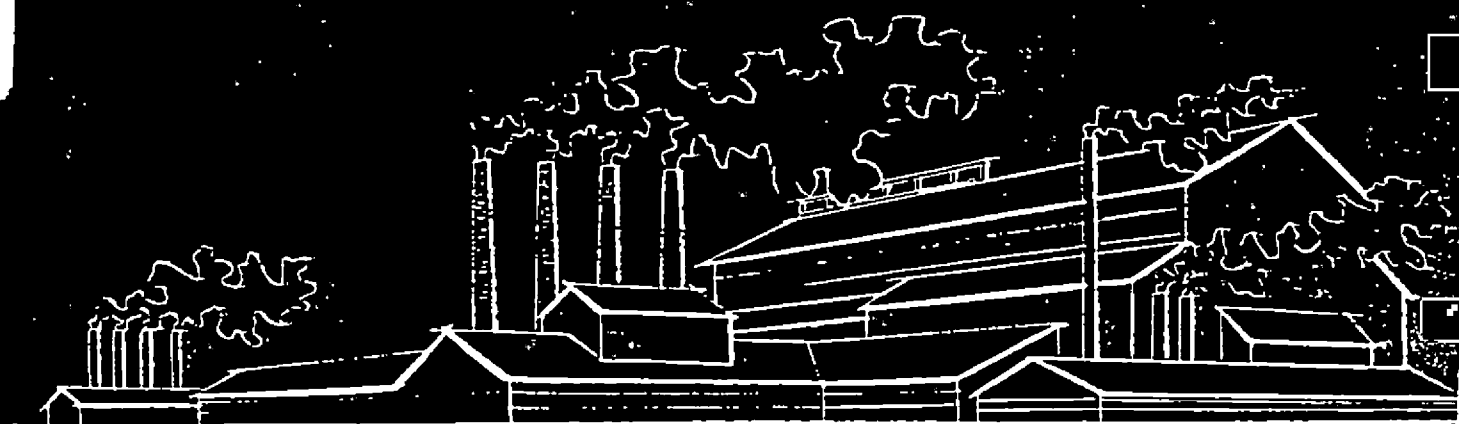
GENP 004623

INDEMNIFICATION CLAUSE - PYRANOL[®]

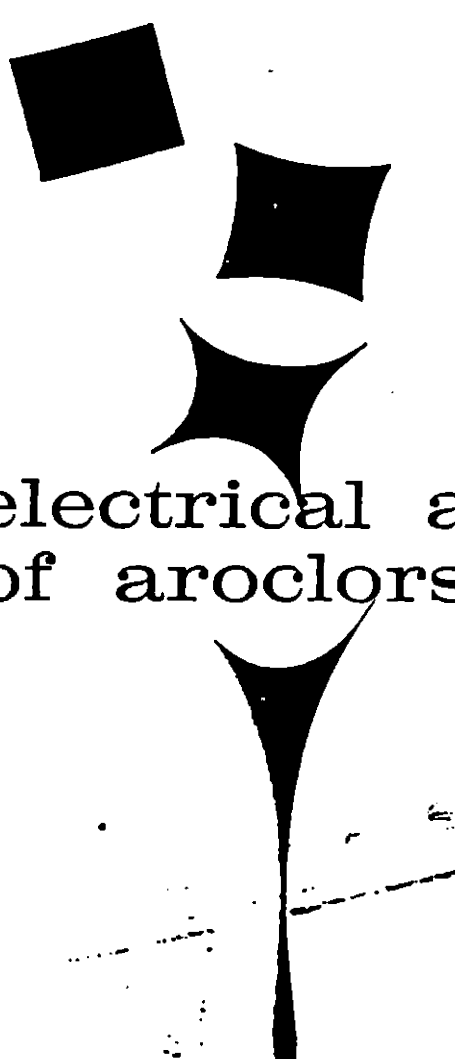
Pyranol[®] contains polychlorinated byphenyls (PCB's) which tend to persist in the environment and, therefore, special care is required in the handling, possession, use and disposition of Pyranol[®] to prevent its entry into the environment. Accordingly, Buyer agrees to defend, indemnify and hold harmless Seller, its directors, officers, employees, and agents from and against any and all liability, loss, damage or expense which Seller, its directors, officers, employees or agents may suffer as a result of claims, demands, costs, proceedings or judgments arising out of, or in connection with, the possession, handling, use, sale, or disposition of any Pyranol[®] purchased by Buyer, or delivered to Buyer, pursuant to this order.

[®] - Registered Trademark

industrial applications of the aroclors



772584



electrical applications of aroclors

Aroclors are among the purest commercial chemical compounds, virtually free of even traces of conducting impurities. For this reason, the Aroclors' dielectric properties closely approximate the theoretical maximum for the particular organic compound. With their stability, heat resistance and flame resistance — Aroclors can be used for a variety of heavy-duty dielectric applications.

DIELECTRICS FOR ASKAREL TYPE TRANSFORMERS AND CAPACITORS

Monsanto Aroclors are used *per se* and are formulated for the liquid coolant-insulation fluids in transformers and capacitors. Such dielectrics must be highly pure with dependably minimal traces of electrolytes. They must be chemically stable and non-corrosive to a wide variety of structural materials. Most important, the dielectric fluid must be fire-resistant.

Aroclors are the only liquids in low cost commercial supply that meet these exacting requirements.

Liquid Aroclors "1242," "1248," "1254," and "1260" are used directly, or these are carefully formulated with chlorinated benzene and other additives to make askarel fluid for particular needs. Typical formulated askarel fluids are shown on the following pages.

Aroclors "1242" and "1254" themselves or in special formulations are used as the dielectric in fixed-paper capacitors, for the power factor correction in utility transmission lines; for home appliances such as air conditioners, furnaces, washers and driers; for electric motors; and for ballast in fluo-

rescent fixtures. There are also a number of applications in DC systems, in condensers, and the new energy storage capacitors.

The Aroclor fluids can be used in a wide variety of applications requiring a specialized dielectric. Monsanto works closely with electrical equipment makers to develop the proper dielectric with the exact physical properties required by the engineering of the equipment.

IMPREGNATING COMPOUNDS

Because of their nonflammability, high resistivity, and dielectric strength and low power factor, the liquid and resinous Aroclors are extremely useful materials for many applications as impregnating compounds. An important application of Aroclors in the electrical field is the use of Aroclors 1260, 4465 and 5460 in wire or cable coatings and as impregnants for cotton and asbestos braided insulation. Because they possess high purity and excellent electrical resistance, Aroclor 1254, 5460 and 1268 make excellent dielectric sealants: to close the pores of carbon resistors, and to seal electrical bushings and terminals.

Since the liquid Aroclors will absorb sufficient moisture from the atmosphere to impair the electrical characteristics, it is customary to treat Aroclor intended for this application before use with a dehydrating clay. An effective product for this purpose is Attapulugus clay 80,300 mesh dried for 4 hours at 400°C. and used at the rate of 0.10% based on the weight of Aroclor, followed by filtration. Treatment is improved if the Aroclor is heated to 50-55°C.

ELECTRICAL PROPERTIES

Dielectric Constant at 1,000 Cycles (1)			Volume Resistivity (2)	Dielectric Strength (3)	Power Factor (4)
Aroclor	25°C	100°C	Ohm-cm at 100°C, 500 Volts D.C.		100°C, 1,000 Cycles
1232	5.7	4.6			
1242	5.8	4.5	Above 500x10 ⁹	Greater than 35KV	<0.1%
1248	5.6	4.6	Above 500x10 ⁹	Greater than 35KV	<0.1%
1254	5.0	4.3	Above 500x10 ⁹	Greater than 35KV	<0.1%
1260	4.3	3.8	Above 500x10 ⁹	Greater than 35KV	<0.1%
1268	2.5	—			
5442	3.0	4.8	Above 500x10 ⁹		
5454	2.7	4.2			
5460	2.5	3.2			
4465	2.7	3.3			

(1) ASTM D-150-47T

(2) ASTM D-257-46

(3) ASTM D-148-44

(4) ASTM D-150-47T

TYPICAL TRANSFORMER ASKAREL

(MIXTURE OF AROCLOR AND CHLOROBENZENES)

Property	Typical
Visc. @ 37.8°C. (ASTM D88)	41-45 Sec. Saybolt Univ.
Spec. Gravity @ 15.5/15.5°C. (ASTM D287)	1.563-1.571
Color, APHA	150 max.
Condition	Clear
Acidity, mg. KOH/g.	0.01 max.
Pour Pt., °C. (ASTM D97)	-44°C. or lower
Inorganic Chlorides, ppm	0.10 max.
Refractive Index @ 25°C.	1.6075-1.6085

Distillation Range (ASTM D20)
Corrected for steel and barometric pressure
First drop
35%
65%
65%
95%

Corrosion

Water Content, ppm.
Resistivity, 100°C., 500v., 0.1" gap
Dielectric Strength, 25°C.
Dielectric Constant, 100°C., 1000 cycles
Tin Tetraphenyl*
Burn Point, (ASTM D92)
Fixed Chlorine*
Arc Formed Gases*
(Oxygen Free Liquid @ 25°C.)

Electrical Stability*

210°C. min.
250°C.
290-300°C.
350-400°C.
395-410°C.

After heating with aluminum for 6 hrs. at 200-250°C. and aluminum must not be corroded on visual or weight inspection.

Oil must meet the following

Refractive Index 1.6075-1.6085
Color, APHA 200 max.
Acidity, mg. KOH/g. 0.01 max.
Inorganic Chlorides 5 max.
Condition Clear

30 max.
1100-1200 ohm-cm., min.
30 MV. min.

384
0.15% at 100°C. by weight
None at boiling point

None at boiling point
Total combustible gases including carbon monoxide, hydrogen and volatile hydrocarbons

After heating for 96 hours @ 100°C in a closed container, the resistivity should not decrease more than 10%.

TYPICAL CAPACITOR AROCLOR

Property	Typical
Visc. @ 37.8°C. (ASTM D88)	82-92 seconds Saybolt Univ.
Specific Gravity @ 25/15.5°C (ASTM D287)	1.381-1.392
Color, APHA	50 max.
Condition	Clear
Acidity, mg. KOH/g.	0.01 max.

*Determined by special request.

Typical Capacitor Aroclor (continued)

Property

Pour Pt., °C. (ASTM D97)
Inorganic Chlorides, ppm.
Refractive Index @ 25°C.
Distillation Range (ASTM D20)
Corrected for stem and barometric pressure
Corrosion

Typical

-14 or lower

0.10 max.

1.6240-1.6260

10"; 325°C. min.

90% 360°C. max.

After heating with aluminum for six hours at 210°C ± 10°C the aluminum must not be corroded either on visual or weight inspection and the Aroclor 1242 should meet the following specs.:

Color, APHA 60 max.
Acidity, mg. KOH/g. 0.01 max.
Inorg. Chlorides, ppm 0.10 max.
Condition Clear

Water Content, ppm

Resistivity 100°C. 500 volts DC @ 0.1" gap

Dielectric Constant 100°C. @ 1000 cycles (ASTM D924)

Flash Point Cleve. Open Cup*

Fire Point °C.*

Sulfates (ASTM-D117-31)*

Fixed chlorine content (Carius)*

Specific Heat @ 25°C.*

Evaporation @ 100°C for 6 hrs.*

Dielectric Strength (KV) (ASTM D877)*

35 max.

500 x 10⁹ ohm-cm., min.

4.7-4.9

170°C., min.

None to boiling point

None

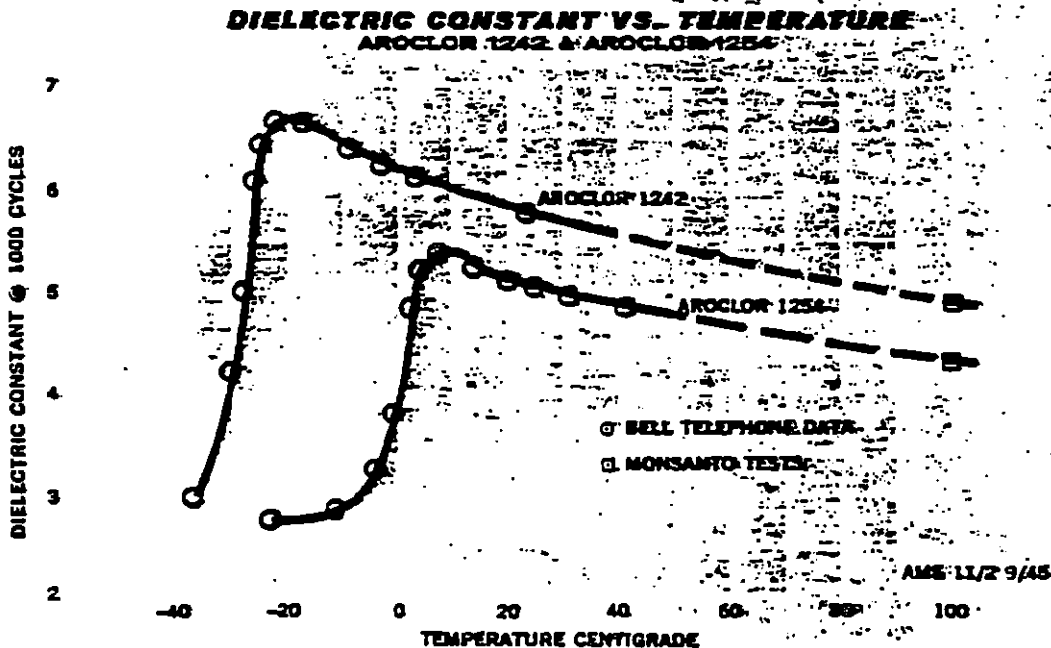
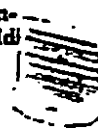
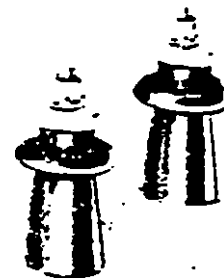
41.5-42.5%

0.29

0.4% max.

35 Min.

*Determined by special request.



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AND BELL TELEPHONE LABORATORIES

UENF 004629

Because Aroclors have excellent shear resistance, heat stability, and are chemically stable . . . they can serve in dozens of mechanical applications for transferring mechanical power, heat, and variable pressures. Aroclors do not attack metals even at high temperature; they resist oxidation, chemical and mechanical breakdown under a wide variety of environmental conditions. In addition, the Aroclor liquids used as lubricants impart a high degree of extreme pressure lubricity.

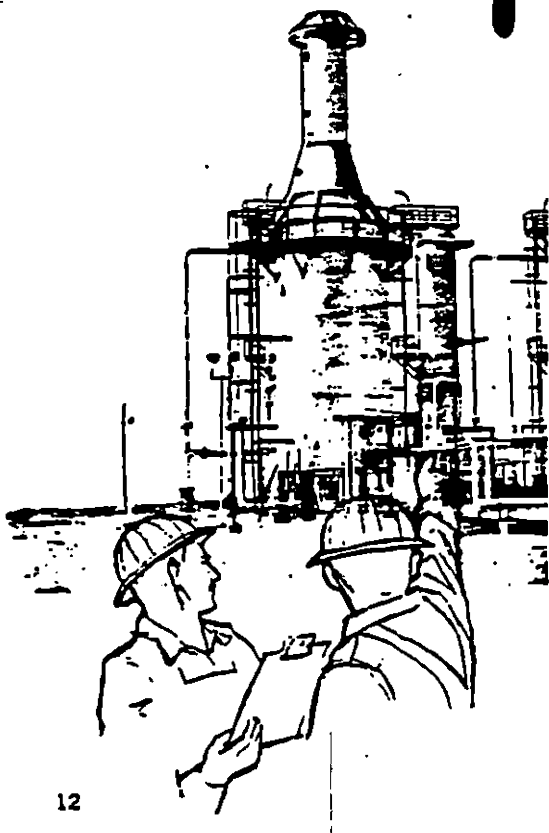
mechanical applications of aroclors

HEAT TRANSFER

Aroclors are outstanding for use as the heat transfer liquids in indirect heating systems. Aroclor systems can transfer closely controllable, uniform heat to chemical processing vessels, food cookers, potato chip fryers, drying ovens and other installations where the fire source must be removed from the point where the processing heat is used. Aroclor 1248 is used most frequently in such indirect heating systems.

Heat transfer with Aroclors has many advantages. Processing heat up to 600°F. can be delivered in a *non-pressurized* system, reducing the construction costs of the heating system. The fluid in properly engineered systems will last without significant degradation for from five to seven years. The systems present no fire or explosion hazard, since the Aroclor does not support combustion. In addition, there is no day to day conditioning of boiler water, inasmuch as the Aroclor requires no conditioning, and Aroclor systems require a minimum amount of insulation. Aroclor systems operating at atmospheric pressure have been used successfully since 1941. Aroclor systems can operate safely and efficiently on gas, oil or electricity.

Photos courtesy of
Petro-Chem Development Division
Vulco Consolidated Industries, Inc.



Aroclors 1242, 1248 and 1254 are used as a circulating heat transfer medium with great success. Good circulation and a well designed heating system are necessary to prevent local overheating. Aroclor 1248, however, is recommended for universal use up to 315°C (600°F) because of its fluidity at low temperatures and its fire-resistance. The liquid Aroclor 1248 is readily pumpable with centrifugal pumps to temperatures as low as 50°F.

In processes where a cooling cycle must also be introduced, provision can easily be made for shunting circulating Aroclor through a water cooled heat exchanger, thus employing one medium for both heating and cooling.

In special cases, Aroclors 1242 and 1232 can be substituted for the Aroclor 1248. If low outside temperatures are encountered, the less viscous Aroclor 1242 can be used.

Aroclor 1232 may be used where outdoor temperatures as low as 20°F are encountered. While Aroclor 1232 is serviceable for unpressurized heat transfer, this Aroclor compound is not quite as fire resistant as "1248" or "1242."

Monsanto has available an "Engineering Heat Transfer Data" booklet that gives design guidance on Aroclor systems. In addition, Monsanto can suggest sources for Aroclor heaters and equipment.

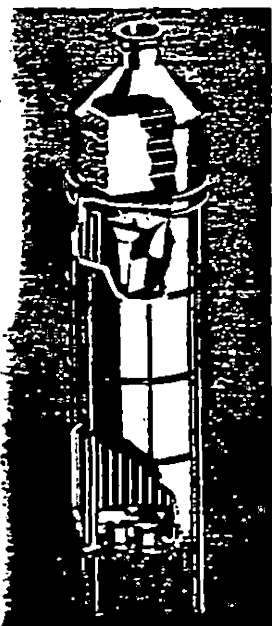


Photo courtesy of Western Precipitation Corp.

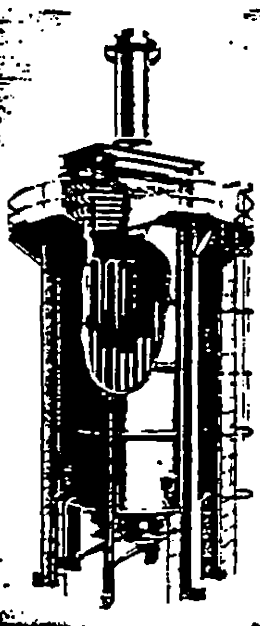


Photo courtesy of Struthers Wells Corp.

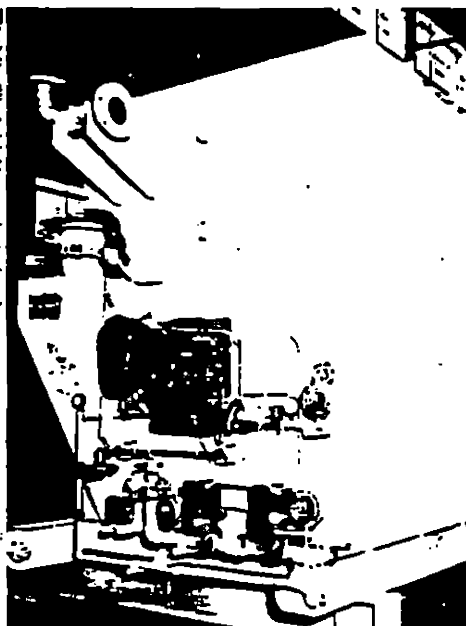


Photo courtesy of Union Iron Works

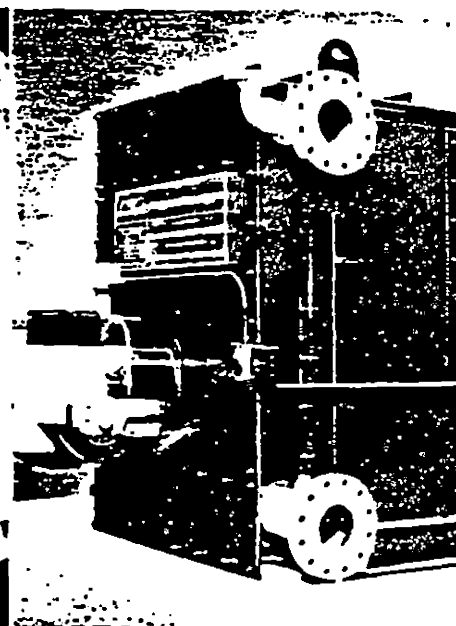
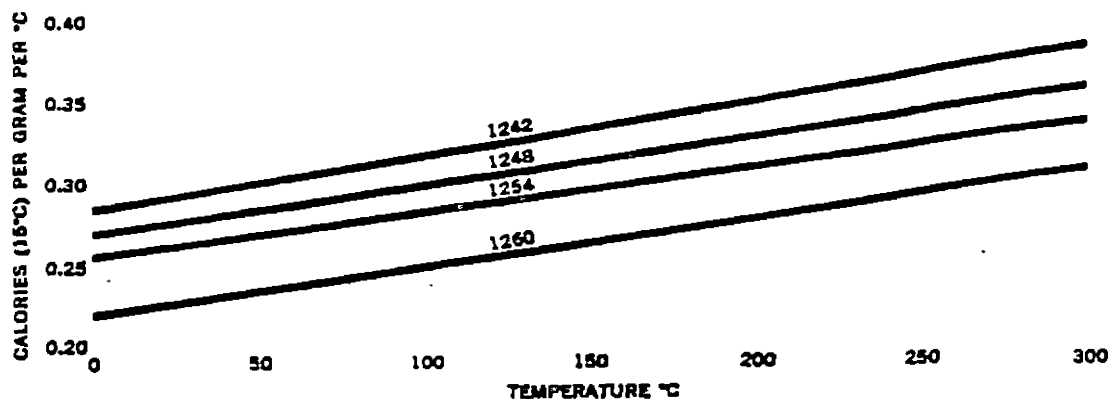


Photo courtesy of The International Boiler Works Co.

HEAT CAPACITY OF AROCLORS AT VARIOUS TEMPERATURES



THERMAL CONDUCTIVITY OF AROCLOR 1248

Temperature		BTU./Hr./Sq. Ft./ °F./Ft.	Calories, gram/Sec./ Sq.Cm./°C./Cm.
°C.	°F.		
30	86	0.0570	236×10^{-4}
60	140	0.0564	233×10^{-4}
100	212	0.0555	229×10^{-4}

GENP 004632



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EXPANSION MEDIUM

Because of their stability at high temperatures and ability to withstand frequent temperature cycles without gum formation, the liquid Aroclors are used as the actuating medium in bellows controls, thermostats, industrial temperature control regulators and other kinds of automation equipment.

The average coefficient of expansion of Aroclor 1248 per degree F. within the various temperature ranges indicated in the table below was determined by using the simple formula $V_t = V_{t'} [1 + a (t - t')]$. The coefficient, a , has been calculated at 100°F increments, as follows:

<u>Temp. Range F</u>	<u>Average Coefficient of Expansion cc/cc/F</u>
0 to 100	0.00037
100 to 200	0.00039
200 to 300	0.00040
300 to 400	0.00046
400 to 500	0.00048
500 to 600	0.00051

The specific volume of Aroclor 1248 at different temperatures is as follows:

<u>Temp. °F.</u>	<u>Specific Volume ml/gm</u>
0	0.674
100	0.699
200	0.726
300	0.755
400	0.790
500	0.828
600	0.870

LIQUID SEALANT FOR FURNACE ROOFS

The liquid Aroclors 1248 and 1254, because of their low vapor pressures and fire-resistance, make excellent liquid sealants. These non-evaporating fluids have good flow at slightly elevated temperatures and are chemically stable at elevated temperatures. Consequently, the liquid Aroclors make excellent fluid sealants for any application where the use of oil would create a fire hazard. In the trough of annealing furnaces, for example, Aroclors make dependable fire-safe roof seals.

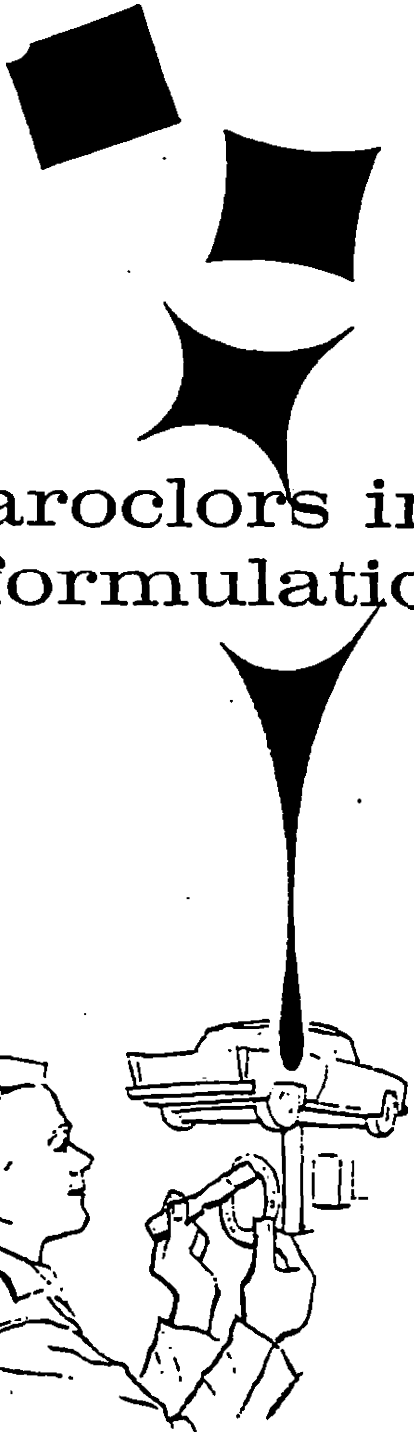
VACUUM DIFFUSION PUMP OIL

The fluid Aroclors 1248 and 1254 are highly stable to air; they make good oils for vacuum pumps at a much lower cost than high priced silicone type oils. These Aroclors operate efficiently in vacuum diffusion pumps used to pull high vacuum for metalizing plastics; dehydrating foods, medicinals; and for drying capacitor cones.

DUST ENTRAPMENT

Because Aroclors are non-drying and tacky, they make excellent coatings for capturing dust, lint and other fine air-borne particles. Aroclors 1260 and 5460 are used successfully to coat fibrous glass air filter pads, metal mesh and other materials used for filtering air and gas streams.

GENP 004633



With their wide range of physical properties, their inertness, lubricity, and vapor-suppressing characteristics — Aroclors can be valuable ingredients in an extraordinary variety of formulated products. They are compatible with a variety of solvents, oils, resins. They are virtually non-volatile and permanently thermoplastic; they will not react with other chemicals in the formulation. In addition, their low cost makes their use for special purposes eminently practical and economical.

aroclors in special product formulations

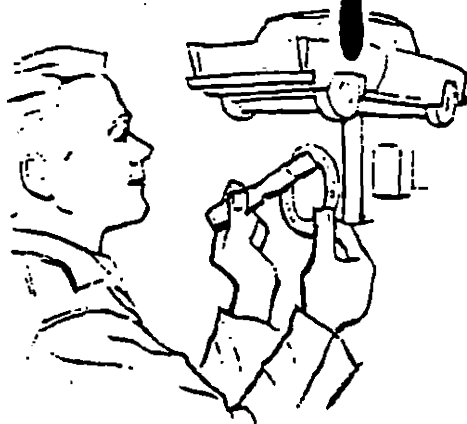
SEALERS FOR GASKETS

Aroclors — particularly when hot — swell rubbers like Hycar, Koroseal, PerBuna N, and Neoprene. Wherever seals and gaskets of natural or synthetic rubber tend to shrink under heat and use, Aroclors 1232, 1242 or 1254 can be used as a swelling agent to tighten the shrunken seal. An example is in automotive transmission oil: a small amount of Aroclor in the oil swells the seal *in place*, saving the cost of tearing down the equipment to replace the seal or gasket. Aroclors can be used in gasket sealing compounds to swell the rubber after the gasket or seal is in place.

DEDUSTING AGENT

Aroclor 1254 is a low cost dedusting agent which can "hold down" the dusting of a variety of chemical products. Because Aroclor 1254 resists both combustion and oxidation, it can be used to control dusting of highly reactive compounds. As a typical example,* a few tenths of one percent will control the dusting of calcium hypochlorite.

*Covered by U. S. Patent No. 2,921,911, issued January 19, 1960, and assigned to Pennwalt Chemicals Corp.



Aroclor 5460 and 1254 act as vapor suppressants. The United States Department of Agriculture scientists reported that the inclusion of from 5 to 25 parts per hundred by weight of Aroclor increased the effective kill-life of a lindane spray up to ten times. A painted or metallic surface sprayed with certain chlorinated insecticides fortified with Aroclor will remain toxic to flies, ants, roaches, silverfish up to 2 to 3 months. The Aroclor resins suppress the rapid evaporation of the volatile insecticides without adding odor or other objectionable residua. Formulation into insecticides is quite simple; the Aroclor is dissolved in a suitable solvent compatible with the insecticide formulation, and mixed in. The most pronounced effect for increasing the kill-life of the insecticide is obtained with lindane, chlordane and BHC. Aroclors are recommended for chlorinated insecticide formulations to be used for non-crop spraying. Their low cost makes this use a most practical way to lower the ultimate cost of insect control.

Aroclors are compatible with various natural waxes, such as carnauba and others, including those used to formulate casting wax. Aroclors help impart to the finished casting wax a number of desirable properties: hardness without brittleness; resistance to shrinking; sharp definition; sharp melting point; and fire-resistance. Waxes formulated with Aroclors are non-tacky and highly stable. Aroclor-containing waxes are widely used in making dental castings, in the precision casting of aircraft parts, and for casting costume jewelry. Aroclors 1254, 4465 and 5460 are the ones most frequently used, the proportions dependent upon the properties required in the finished wax. Much of the highest quality precision casting wax used in the "lost wax" process is formulated with Aroclors.

Aroclors 1254, 1268 and 5460 are used in the manufacture of specialized abrasives. Because of their excellent bonding characteristics, high thermal stability and resistance to oxidation and corrosion — Aroclors are used as the carriers for abrasive materials. A major use is as part of the bonding agent in specialized grinding wheels.

For specialized lubricants requiring good extreme pressure (EP) characteristics, the liquid Aroclors make excellent additives. The Aroclors impart high temperature stability, excellent lubricating qualities, and weather and corrosion resistance. As an example, Aroclors are used to formulate grease and pipe thread compounds for use in oxygen systems. Greases formulated with Aroclors have a high chemical resistance, are suitable for use in contact with corrosive chemicals. Gear oil lubricants containing Aroclors have good resistance to shear degradation and high

temperature stability. Added in small amounts to railroad car journal box oils, Aroclors impart better extreme pressure lubricity and reduce the incidence of "hot boxes."

The heat-resisting, nonflammable characteristics of the Aroclors make them attractive in themselves as lubricants under conditions of high temperature. As an example: in governor systems of central power stations, Aroclor 1248 is well suited to this lubricating application.

Straight Aroclor 1254 gives excellent results on a roller bearing test operating at 255-260°F with much less carbonization or decomposition than the usual spindle oil under the same conditions.

As an extreme pressure (EP) lubricant base added to a petroleum hydrocarbon oil in amounts up to approximately 15% by weight, Aroclors 1248 and 1254 materially increase the load-carrying properties without reducing the viscosity of the resulting composition. These two Aroclors represent one of the more satisfactory carriers for the element chlorine as an extreme pressure base, possessing the following advantages:

1. **STABILITY** . . . even at higher temperatures, which assures there will be neither separation of components nor appreciable change in physical or chemical properties during long periods of operation.
2. **NON-VOLATILE**. Many other types of chlorine bearing compounds are so volatile as to render them unfit for long periods of service. The Aroclors are non-volatile at normal temperatures.
3. **NON-OXIDIZING**. Aroclors do not oxidize nor "thicken up" to an objectionable degree.
4. **NON-CORROSIVE** . . . toward metal surfaces.
5. **NON-ABRASIVE**. Aroclors exerts no abrasion on the machined surfaces.
6. **NON-HYDROLYSIS**. Aroclors do not hydrolyze in the presence of water, thus avoiding the generation of hydrochloric acid.
7. **COMPATIBILITY**. Aroclors are completely miscible with mineral oils.
8. **COLOR**. Aroclors do not darken or change the color of lubricating oil.

Submerged Lubrication

Under conditions of lubrication subjected to exposure to water displacement such, for example, as lubrication of bridge rollers, a heavier-than-water lubricant can be prepared from mixtures of Aroclor and oil, of which the following are typical examples:

Mix No.	% by weight		Pour Pt.	Gravity at	Approx.
	Oil	Aroclor 1248		15.5°C.	Pounds Gal.
1	50	50	0°F	1.1263	9.4
2	25	75	+5°F	1.2703	10.6

Viscosity 210°F-160 Saybolt Secs.

Color ASTM 7-8

Flash Point 545°F.

Pour Point 15°F.

*Bright Stock: Gravity API 22-23

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GENP 004636

Aroclors in Industrial Cutting Oils

Aroclor 1254 is used to formulate the finest quality "straight" and "soluble" or emulsifiable-type cutting oils. The Aroclor functions as an excellent extreme-pressure lubricant and it is far superior to aliphatic chlorinated hydrocarbons because of its higher order of thermal stability. The heat resistance is most important in cutting oils for machining high grade steel. With Aroclor cutting oils there is a lower degree of hydrolysis which minimizes the staining of the metal.

AROCLORS IN ADHESIVES

Aroclors are outstandingly useful ingredients in the formulation of various types of adhesives. Besides a plasticizing action on the adhesive's resin base, they add valuable properties to the adhesive bond. Aroclors offer a variety of property improvements to adhesives based on polyvinyl acetate, to rubber cements and to hot melt adhesives.

Aroclors strongly resist attack by water, acids, alkalies and other common corrosive influences, as well as microorganism attack. By proper selection of materials, adhesives containing Aroclors can have outstanding resistance to most of the destructive factors that injure bonding properties.

Hot Melt Adhesives

A typical starting formulation for a cellulose acetate butyrate hot melt adhesive with Aroclor 5460 is:

	Parts by Weight
Half-second cellulose acetate butyrate	35.00
Aroclor 5460	30.00
Dioctyl phthalate	15.00
Newport V-40	19.89
Santonox [*]	0.1
Syn Fleur #6	0.01

The above coating can be applied at about 350°F. Ventilation should be provided.

A typical starting formulation for an ethyl cellulose hot melt adhesive with Aroclor 5460 is:

	Parts by weight
Ethyl cellulose, 50 cpr	24
Aroclor 5460	7
Lopor No. 45 Mineral Oil	57
Bakers No. 15 Castor Oil	5
Epoxy soybean oil	3
Paraffin wax (m. p. 135°F)	3
Santonox [*]	1

^{*}Santonox: Monsanto Chem. Co. trademark. Registered U. S. Pat. Off.

Heat Sealing Adhesives

Chlorinated rubber and Aroclors 1254 and 1260 make excellent heat sealing and label adhesives. These adhesives have high chemical resistance and extremely low moisture vapor transmission. A typical starting formulation is:

	Parts by weight
Parlon (125 centipoise type)	20
Aroclor 1254	6
Aroclor 5460	6
Toluene	68

PVAc Emulsion Adhesives

Aroclors 1221, 1232, and 1242 impart excellent tack and strong bonding power to polyvinyl acetate emulsion adhesives. They readily blend with simple stirring and since they are liquid at room temperature no pre-melting is required. The hardness required in the adhesive's end use can be varied to suit simply by selection of the Aroclor without materially changing other properties. The Aroclors are compatible with PVAc emulsions at a level of up to 11 parts of Aroclor in 100 parts of PVAc emulsion.

An excellent type of hot melt book binding adhesive can be made as follows:

	Parts by weight		
	Formula 17	Formula 18	Formula 19
Gelva polyvinyl acetate resin V-7	100	65	—
Ethyl cellulose	—	15	—
Gelva C-SV-16R	—	—	100
Santicizer 160	—	16	—
Rosin WW	75	—	75
Dibutyl phthalate	30	—	30
Aroclor 1254	55	4	55

By changing the type of polyvinyl acetate resin utilized in the hot melt, the viscosity of the melt can be increased or decreased without changing the ratio of resin to plasticizer.

Polyurethane Resin Adhesives

An excellent flocking adhesive containing Aroclor 1254 can be made as follows:

	Parts by weight
Part A — Multiram FLD*	100
Aroclor 1254	20
Mondur C	5
Part B — Multiram FLD*	100
Mondur C*	5-10

Part A is applied to the fabric by knife coating and allowed to dry thoroughly. The fabric is then coated with Part B, and the material is flocked immediately.

*Molloy Chemical Co. trademark. Registered U. S. Pat. Off.

Epoxy Adhesives

Aroclors can be used to extend epoxy resin adhesives. The extending greatly reduces the formulation cost with a minimum effect on the bonding characteristics of the adhesive.

Aroclors can be used to extend or substitute Carnauba Wax and reduce the cost of the wax formulation. Several practical formulas are available using Aroclors to make wax blends that possess the qualities of Carnauba Wax. These blends can be used for automobile, wood, leather and linoleum polishes.

Selected Aroclors such as 5460 used in conjunction with various waxes make excellent impregnating compounds for furniture drawers, etc., to prevent sticking.

Resinous Aroclors used in combination with waxes make excellent and inexpensive sealers for concrete and masonry surfaces, wood, fiber board and paper products.

The Aroclors may be used to impregnate cloth, paper, wood or asbestos in order to impart moisture and gas resistance, adhesion, insulating properties, alkali or other chemical resistance, flame resistance, or lubricating qualities. For this type of formulation they are used in combinations with other materials such as waxes, inorganic pigments, asphalt, tars, aluminum stearate, sulphur, etc., in order to obtain exactly the physical characteristics desired for the specific purpose. Aroclors 1254, 4465 and 5460, or the corresponding dark-colored products, are suggested as most applicable.

Wood impregnated by vacuum-pressure method with the following mixture:

Aroclor 4465	70%
Microcrystalline Wax	20%
Sulfur	10%

... is definitely tougher, harder and more moisture resistant than untreated wood. This coating is very resistant to acids and alkalis but will be attacked by aromatic, aliphatic or chlorinated hydrocarbons. The surface is not appreciably discolored and can be painted. Various degrees of hardness and adhesion can be obtained by varying the Aroclor: wax: sulfur ratio.

GENP 004639

For use as moisture proof coatings on wood, paper, concrete and brick, the Aroclors are best combined with waxes, especially paraffin or Carnauba, oils such as mineral oil or drying oils, and synthetic resins including modified alkyds, phenolics, chlorinated rubber, polystyrene, styrene-butadiene co-polymers, ethyl cellulose, cellulose acetobutyrate, benzyl cellulose or vinyl resins. Selection of materials for use in combination with Aroclors depends on end use requirements of the specific application.

The simplest compositions contain only Aroclor and paraffin. A moisture proofing compound composed of 96% (by weight) of Aroclor 5460 and 4% paraffin (melting point 54°C) has an ASTM softening point of about 82°C and is very efficient. Substituting Aroclor 4465 for Aroclor 5460 produces a compound with a softening point of about 58°C.

Softening point and viscosity when melted may be further decreased by using mixtures of Aroclors. For example, a composition containing 40% of Aroclor 1260, 56% of Aroclor 5460 and 4% of paraffin will be very soft at ordinary temperatures. Increased proportions of paraffin will also produce softer compounds.

An excellent melt coating for paper and cloth was reported by W. M. Gearheart and F. M. Ball, OFFICIAL DIGEST, Vol. 343, 1953:

Half-second Butyrate	50%
Diocetyl phthalate	9.9%
Aroclor 1260	40%
Ionol	0.1%

This coating may be applied by knife or roller at 350°F; the application requires no solvent. This coating on paper or fabric has extremely good flexibility.

Aroclor 4465 is a useful resin for compounding rotogravure and other printing inks. A mimeograph ink suitable for use on bond paper contains the following ingredients:

Aroclor 4465	40%
Lubricating Oil (SUV 1200 @ 100°F)	35%
Paraffin Oil (SUV 76 @ 100°F)	20%
Carbon Black	4%
Oil Soluble Dye	1%

Aroclor 4465 may also be used in the preparation of imitation gold leaf. A thin coating of the Aroclor is applied hot to one side of paper. While it is still hot, bronze powder is spread upon the coating. The bronze powder adheres to the Aroclor completely covering the paper. This product is used in making the "gold

leaf" letters on books, etc. The paper treated with Aroclor and bronze powder is placed upon the book binding. A hot die is pressed upon it. The Aroclor softens and sticks the bronze to the binding and forms a coating over it to protect it from tarnishing.

The Aroclors are also used as vehicles for carrying the pigments used in glass decoration. When the decorations have been applied and the glass is fired, the Aroclors volatilize without carbonization and thus avoid discoloration of the glass. Aroclors 1254 and 4465 are used for ceramic decoration.

PAPER TRANSPARENTIZER

A treating liquid that makes paper transparent for use as tracing paper, window envelopes, and special packaging can be formulated with Aroclor 5460 and polybutenes. A typical economical formulation is:

Aroclor 5460	30%
Indopol H-300	25%
Toluene	45%

In the paper treating formula, the proportions of Aroclor to Indopol may be varied from 2:1 to 1:2 respectively.

MASTICS, SEALING AND CAULKING COMPOUNDS

Aroclors and polybutenes can be blended with inorganic fillers to make excellent sealing and caulking compounds. A typical "filler" would be:

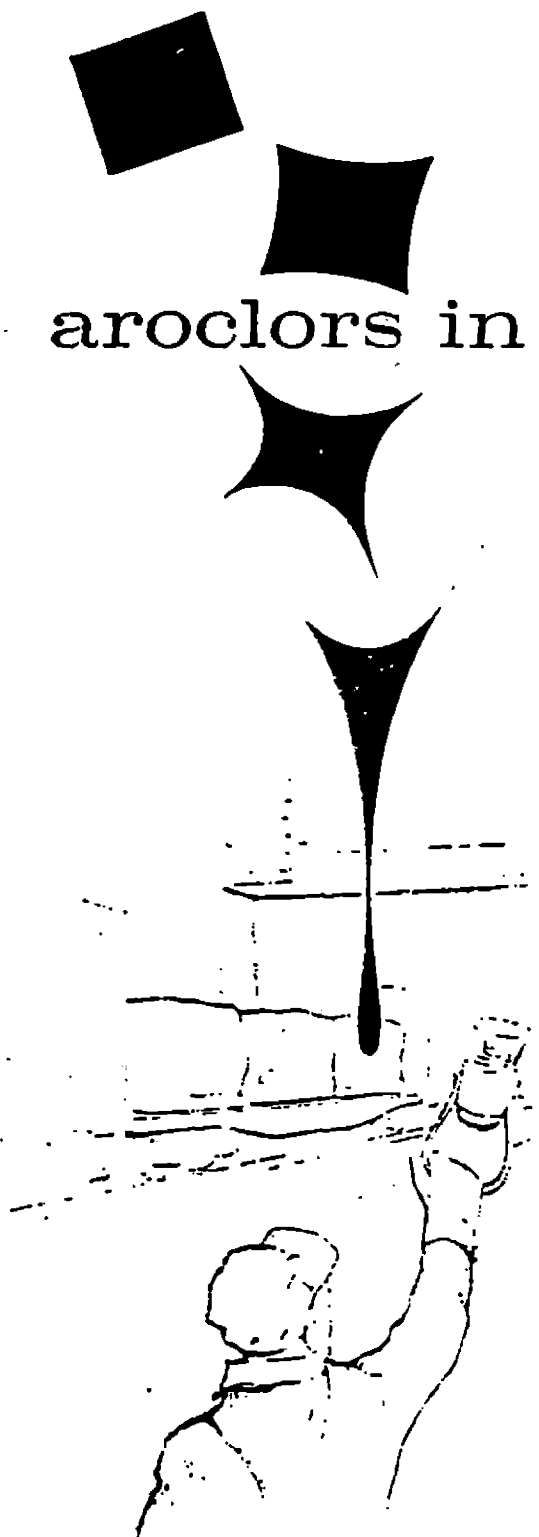
Whiting	50%
Talc	30%
Lithopone	10%
7 M Asbestos	10%

By combining selected Aroclors and Indopol polybutenes, it is possible to produce a wide range of hardness, viscosity, flow and bonding characteristics in durable sealing and caulking compounds.

Excellent mastics, too, can be prepared by blending selected Aroclor resins with Indopol polybutenes. The mastics have good adhesive qualities for specialized uses such as sealing of automobile body construction.

PERMANENT TACK COATINGS

Aroclors and Indopol polybutenes can be blended in a variety of proportions to make permanently tacky coatings. These coatings may be applied to fabric or paper to provide a permanently "sticky" surface. Insecticides, for example, can be blended into such coatings to make insect traps or insect barriers on tree trunks for tree foliage or fruit protection. These coatings can also be used for tapes and sign backing.



aroclors in plastics

Aroclors are valuable as low cost plasticizers for a variety of applications. Aroclors improve chemical resistance, flame retardance, oxidation resistance, and reduce the cost of plasticized elastomers. Depending upon the use, the various Aroclor compounds offer a number of benefits to the user.

In almost all formulations, the use of a selected Aroclor as a plasticizer reduces the cost per pound of the formulation.

Another valuable use of Aroclors in the plastics field is as a grinding and dispersing medium for pigments.

The Aroclor compounds are compatible with most common plastic materials; they are compatible to the extent of practical use with the following:

- Asphalt
- Benzyl Cellulose
- Carnauba Wax
- Cellulose Acetate Butyrate
- Chlorinated Rubber
- Coumarone-Indene Resins
- Dammar Resin
- Ester Gum
- Ethyl Cellulose
- Epoxy Resins
- Manila Gum
- Nitrocellulose
- Paraffin
- Phenolic Resins
- Polyethylene
- Polyester Resins
- Polystyrene Resins
- Polyiso-Butylene
- Polyurethanes
- Polyvinyl Acetate
- Polyvinyl Chloride and
Polyvinyl Butyral
- Polyvinylidene Chloride
- Rosin
- Rubber
- Styrene Butadiene Co-Polymers
- Vinyl Resins

GENP 004642

Aroclors are not compatible with cellulose acetate or with phenolic resins in the final stage of condensation.

In selecting the proper Aroclor for a given use, the degree of *flexibility* imparted increases progressively in the order of: hard resinous Aroclor, soft resinous Aroclor, liquid Aroclor. Conversely, the *hardness* of the plasticized elastomer increases progressively with the choice of: liquid Aroclor, soft resinous Aroclor, hard Aroclor resin.

POLYVINYL CHLORIDE

The Aroclors are valuable as secondary plasticizers, or plasticizer-extenders for polyvinyl chloride formulations. The Aroclors impart greatly improved chemical resistance over conventionally ester-plasticized compositions. For example, a formulation plasticized with 3 parts of DOP and 1 part of Aroclor 1254 shows the best chemical resistance of any plasticized polyvinyl chloride formulation evaluated to date.

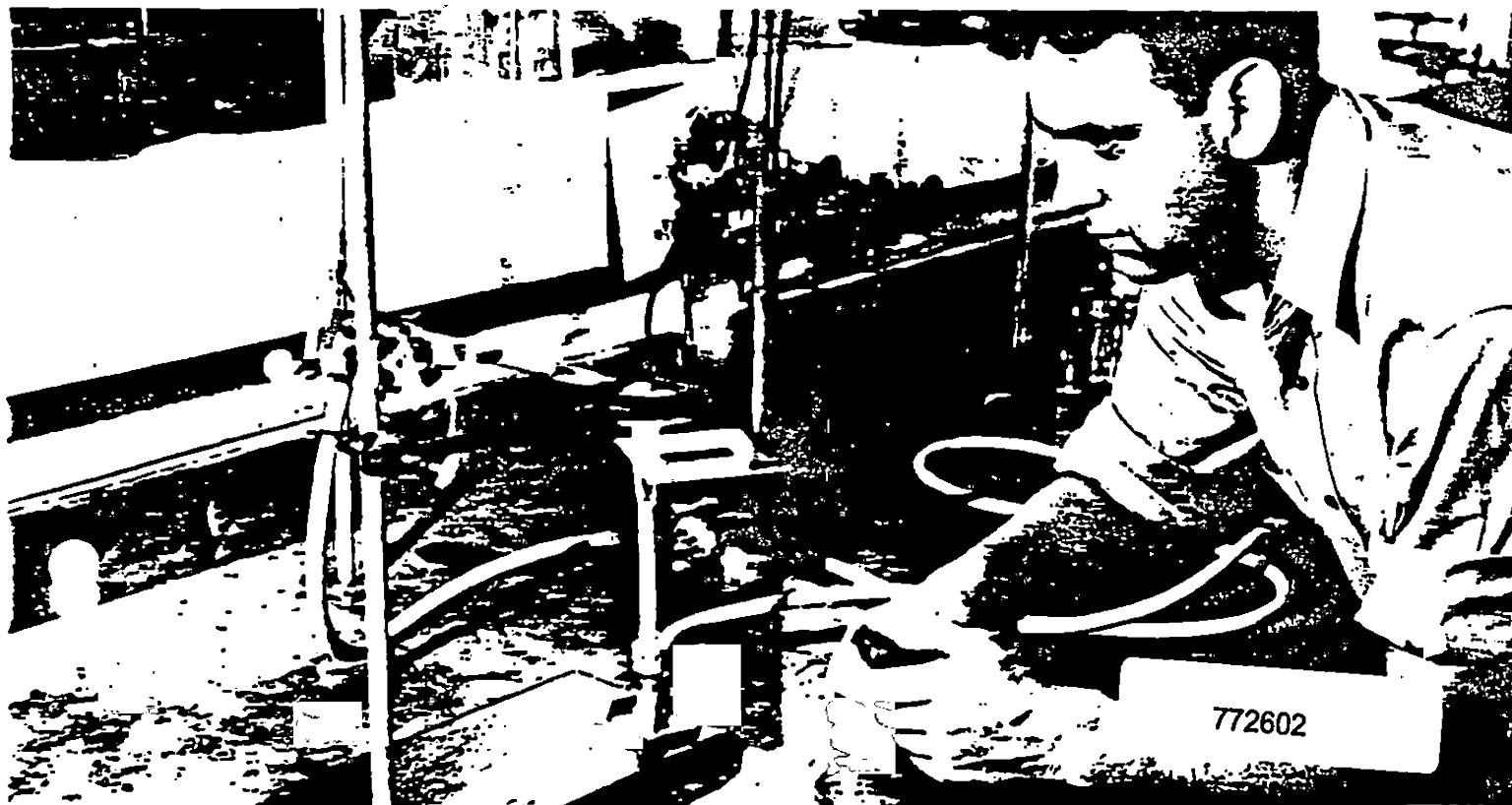
Aroclor 1262, when used as a co-plasticizer with DOP, greatly reduces the amount of migration of the plasticizer to nitrocellulose lacquers. Aroclor 5460 is frequently used as a plasticizer-resin-extender to make flameproof vinyl tiling compositions.

In vinyl chloride co-polymer resins for solution application, the combination of Aroclor 5460 and Aroclor 1254 is widely used because of its outstanding chemical resistance.

RUBBER—NATURAL AND SYNTHETIC

The liquid Aroclor compounds — 1221, 1232, 1242 and 1248 — have a strong plasticizing action on rubber, both natural and synthetic. Aroclors 1254 and 1260,

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when milled into rubber, impart permanent tackiness and adhesion to the composition.

Aroclors 2565, 4465, 5460 and 1268, when incorporated in neoprene rubber in amounts as high as 40 parts per 100 parts of rubber make compositions that are extremely flame retardant.

The Aroclors generally show a high degree of compatibility with epoxy resins; this group of materials is one of the very few plasticizers that possess such high compatibility with these materials. The lower Aroclor numbers, 1221 and 1232, impart a high degree of flexibilizing to epoxy compounds. The more resinous and solid Aroclors have little effect on the flexibility of the compound; in fact, they tend to act as reinforcing materials. Aroclors have little effect on epoxy resins' hardness, tensile or compressive yield strength. The ultimate compressive strength can be improved by using solid Aroclors in phthalic anhydride cured systems.

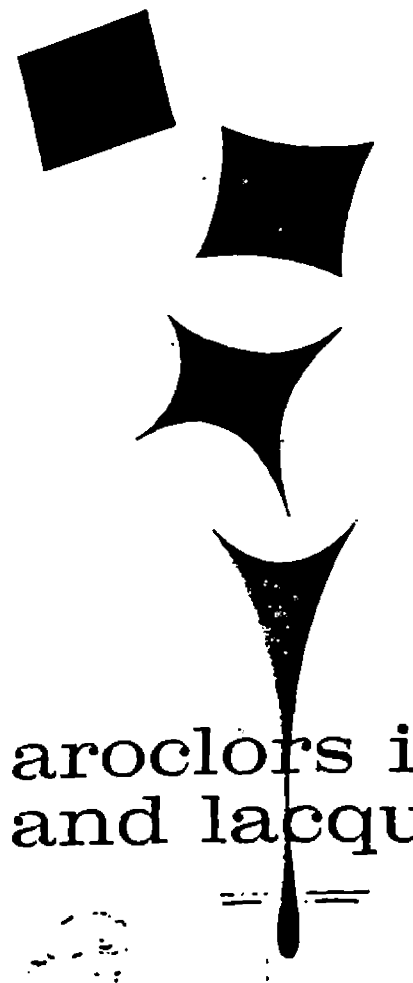
All of the Aroclors, when used at a rate of 15 to 20 parts per hundred of resin, greatly retard the burning rate of epoxy compositions. If a small amount of antimony oxide is added in addition to the Aroclor compounds, the materials then become non-burning.

Aroclor 5460, when used in low density polyethylene to the extent of 20% — in combination with 10% antimony oxide — makes the compound self extinguishing. Compared to other materials that make polyethylene self extinguishing, Aroclor 5460 has much less effect on tensile, yield and elongation properties. In addition, the heat stability of the Aroclor compound is greatly superior to the other materials commonly used to make polyethylene self-extinguishing.

Incorporation of the solid, resinous Aroclors will make asphalt self extinguishing. Possible applications of this type of formulation include caulking compounds, roofing compounds and sound-deadening coatings. Normally, 30% of an Aroclor such as 5460 will make an asphalt mixture that is self extinguishing.

Incorporation of Aroclor in a polyester resin in combination with antimony oxide greatly reduces the burning rate of polyester resins. A mixture of sufficient amounts of selective Aroclors will produce polyesters that are self extinguishing.

Considerable interest has been displayed in the use of Aroclors in phenolic laminating resins, to make compounds that are flame resistant. Normally, the higher molecular weight Aroclor, such as Aroclors 1260, 1262 and 5460 are evaluated for this purpose.



Aroclors are soluble in paint and varnish oils and solvents and are compatible with most film-forming coating resins. The Aroclor compounds improve adhesion to the substrate. Adding Aroclors to paint, varnish or lacquer formulations imparts properties to the film that correspond to the particular character of the Aroclor used. The hard, resinous Aroclors tend to give increased hardness to films; the viscous Aroclors impart flexibility.

Aroclors are excellent grinding and dispersion media for pigments used in paints and varnishes. Aroclor 1254 is used to disperse aluminum powder in a paste form which can be incorporated easily into paints and varnishes. The Aroclor imparts excellent leafing qualities, brightness or luster and does not tarnish the aluminum pigment on aging. Moreover, the coating composition does not support combustion.

aroclors in paint, varnish and lacquer formulations

VARNISHES AND ALKYDS

Aroclors 4465 and 5460 will produce paints that are very quick drying and yet have excellent durability. The weight of Aroclor used may be from 30% to 50% of the weight of the oils.

The Aroclors do not react chemically with oils, hence there is no advantage in heating together in making a varnish. They are best added as a "chill back" or as a cold cut in the thinning operation. As far as incorporation of the Aroclors is concerned, the only reason for heating is to make the Aroclors liquid so they can be more readily mixed with the oils.

Aroclor 1260 is best for short oil varnishes that are required at the same time to be flexible. The Aroclors impart water and alkali resistance, and with these qualities enhance the value of the other resins used in the varnish. The suggested starting formulation is two parts by weight of oil, one part of Aroclor 1260 and one part of other resin. These

GENP 004645

proportions can be varied as required. The Aroclor may be considered to function in the formulation as an oil, with the difference that it does not oxidize and lose its flexibility.

Resins of the alkyd, phenolic or ester gum type, with a harder Aroclor such as 5460, may also be used in making varnish formulations.

EPOXY RESIN COATINGS

The high compatibility of Aroclor compounds with epoxy resins makes these materials of great value in formulating epoxy coatings. Normally, 10 to 15% of Aroclor 1260 or 1262 is added to the epoxy composition to improve flexibility with a minimum effect on the corrosion resistance and adhesive characteristics of the film.

NITROCELLULOSE COATINGS

In pyroxylin or nitrocellulose lacquers, the Aroclors can function both as plasticizers modifying the properties of the film and as film-forming bodying resins. Aroclors are highly compatible with nitrocellulose and with other resins and plasticizers commonly used in lacquer formulating. They impart weather resistance, luster, adhesion and decreased burning rate. The Aroclors' excellent electrical characteristics (high dielectric strength and resistivity and low power factor) and their property of retarding the passage of moisture and gases through nitrocellulose make the Aroclors of special value in coatings for electrical insulating materials.

To illustrate the modification possible to obtain by changes in formulation, three lacquer formulas are given below. All have excellent durability but the third is much softer and more flexible than the other two. Only the solids contents are given. The amounts tabulated are parts by weight.

Aroclor Lacquers

	No. 1	No. 2	No. 3
1/2 second Nitrocellulose (dry)	100	100	100
Dammar resin	80	—	—
Ester Gum	—	80	—
Aroclor 1260	20-39	20	80-70
Dibutyl Phthalate	20-0	20	—
Tricresyl Phosphate	—	—	39-70

No. 1 and No. 2 have excellent sanding and polishing qualities. No. 3 is very flexible but too soft for sanding.

Where extremely high flexibility is desired, as for example in lacquers for high tension automotive cables, the following composition is suggested:

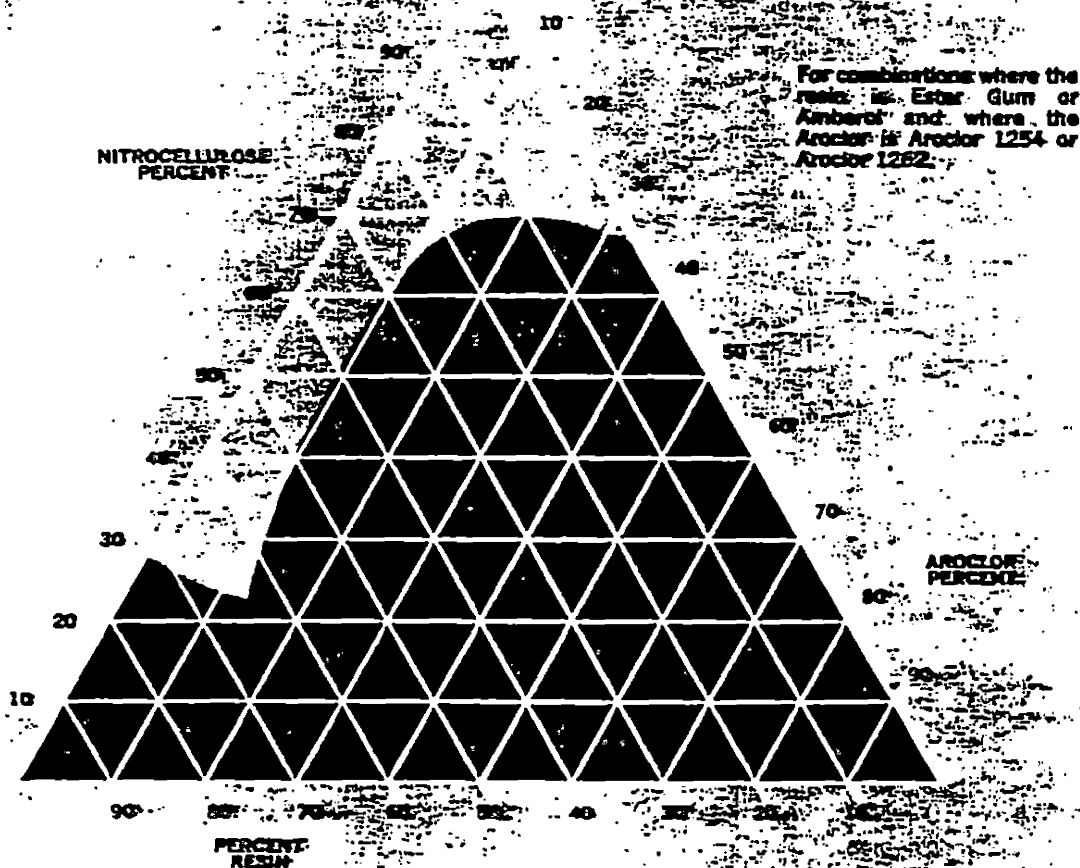
15-20 second R. S. Nitrocellulose	100 parts by weight
Tricresyl Phosphate	120 parts by weight
Aroclor 1242	80 parts by weight

The accompanying trilinear diagrams show the practical compatibility limits of Aroclors 1254 and 1262 when used in combination with some other resins and plasticizers. Aroclor 1260 gives values almost the same as those shown for 1262. The less viscous Aroclors have greater compatibility; the more resinous Aroclors have less compatibility than the ones shown.

On the ternary diagrams, the compositions, represented by any point in the unshaded areas, are those which produce homogeneous lacquer films. On the other hand compositions represented by points in the shaded areas produce impractical, segregated, brittle or soft films. For detailed information as to the derivation and use of these diagrams reference is made to the following articles:

Jenkins & Foster, "Compatibility Relationships of the Aroclors in Nitrocellulose Lacquers," Ind. Eng. Chem. 23, 1362 (1931).

Hofmann & Reid, "Graphical Methods in Lacquer Technology," Ind. Eng. Chem. 20, 431 (1928); "Formulation of Nitrocellulose Lacquers," Ind. Eng. Chem. 20, 687 (1928).

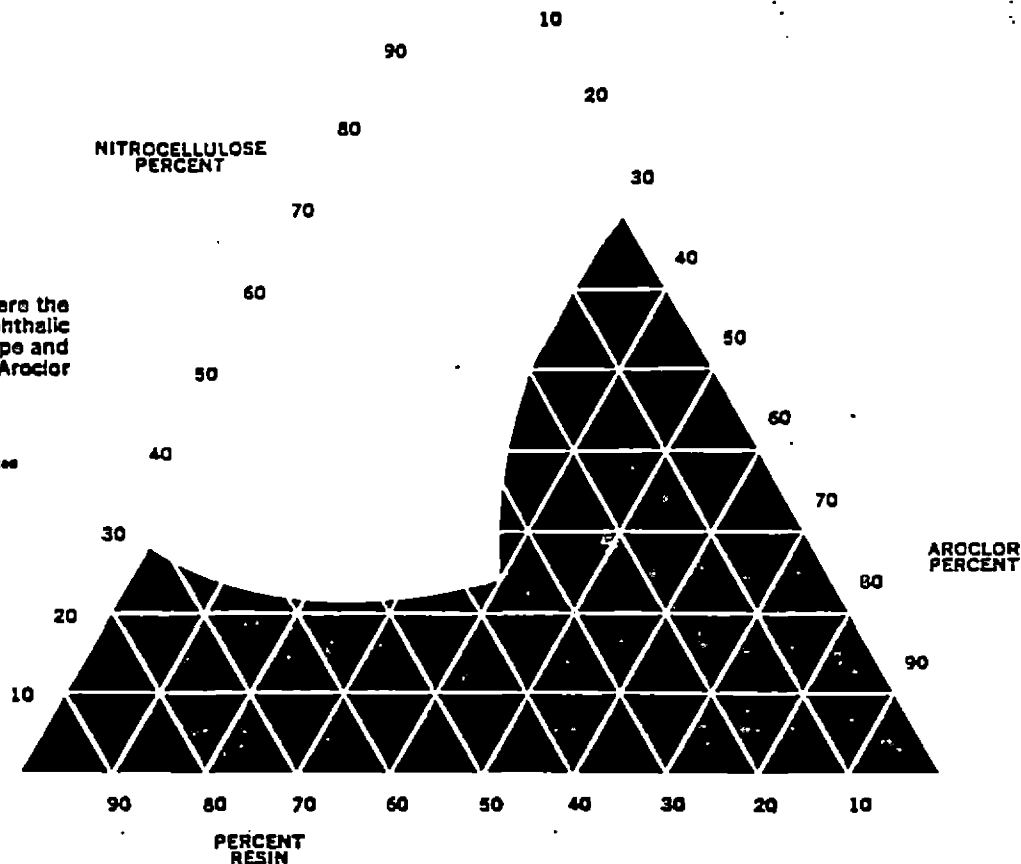


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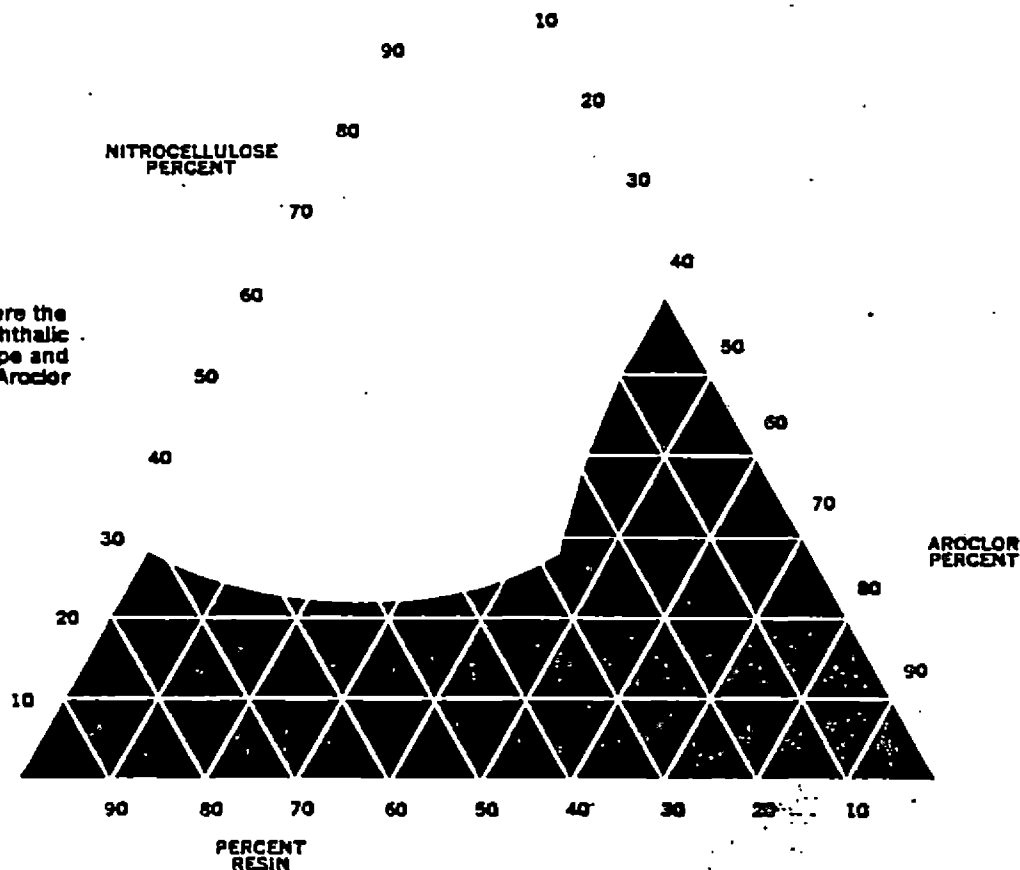
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For combinations where the resin is of the phthalic anhydride-glycerol type and where the Aroclor is Aroclor 1262.*

*Aroclor 1260 may be substituted without material change.

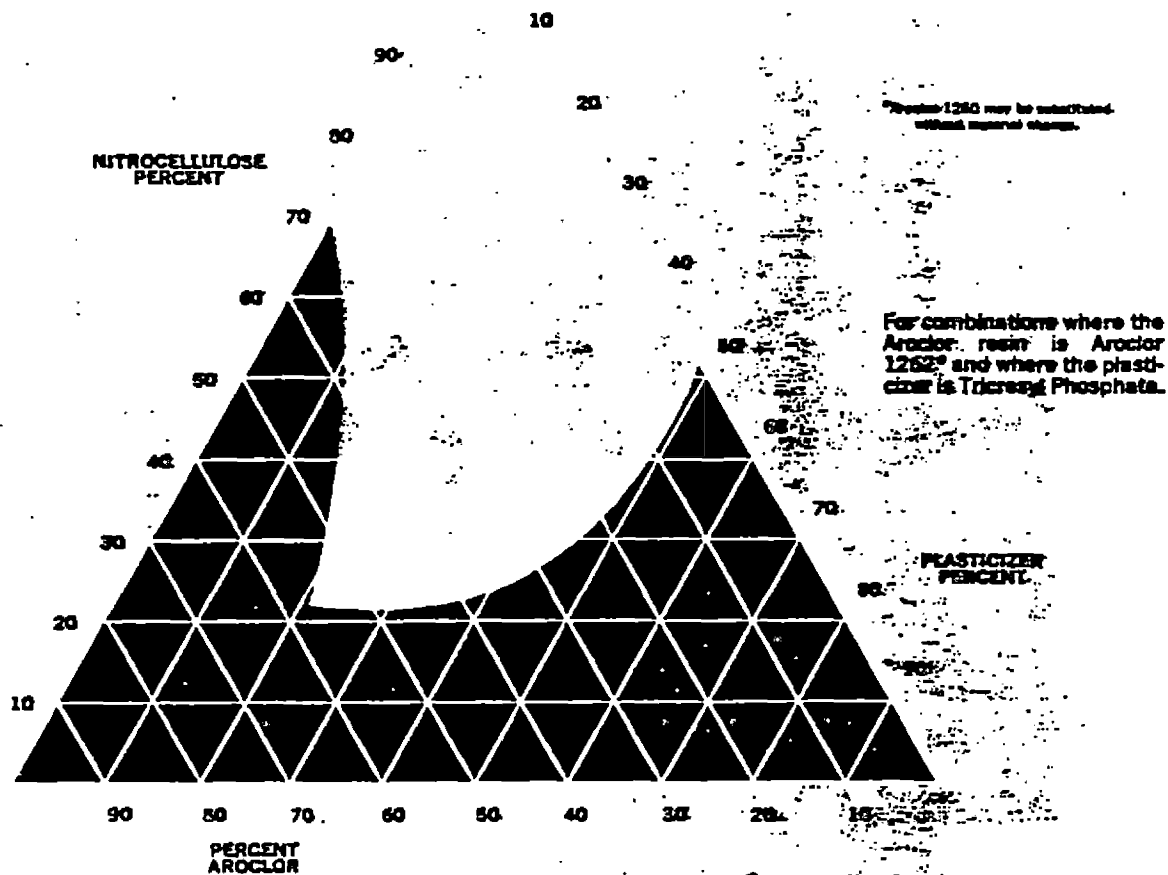
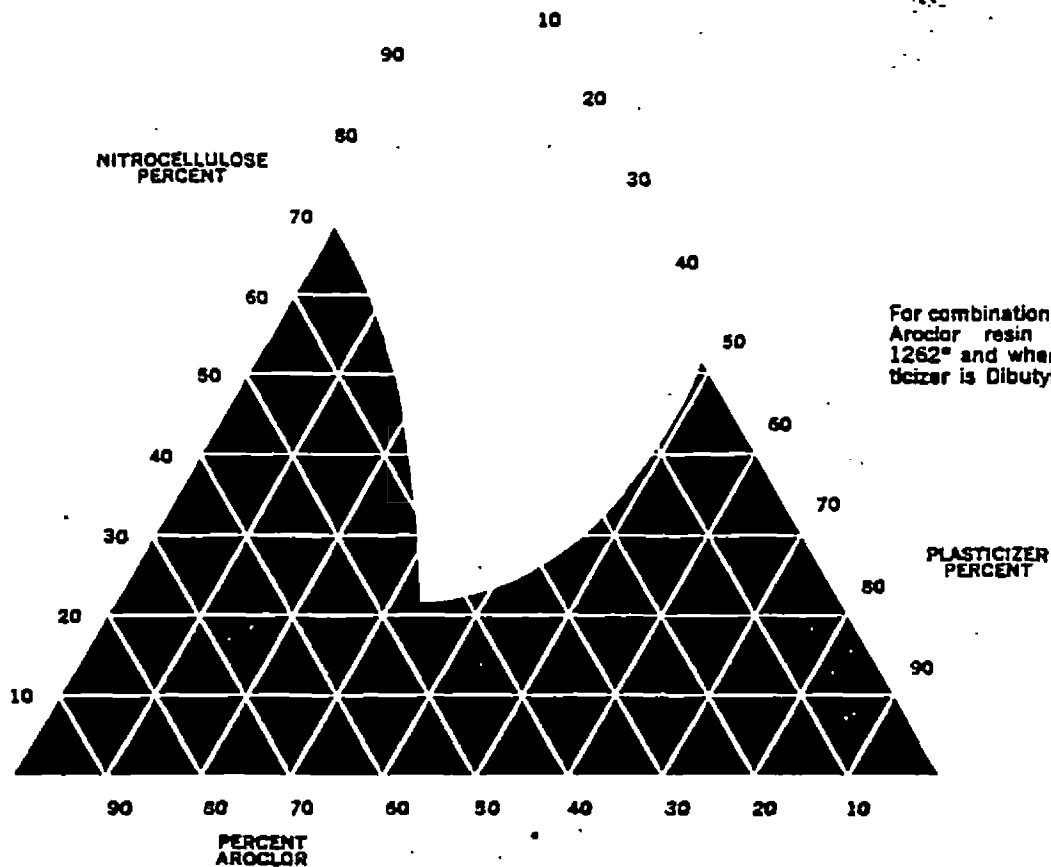


For combinations where the resin is of the phthalic anhydride-glycerol type and where the Aroclor is Aroclor 1254.



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CHLORINATED RUBBER AND STYRENE-BUTADIENE COPOLYMERS

Aroclors are outstanding for compounding modified rubber finishes. They impart exceptional corrosion resistance, chemical resistance, oxidation resistance to these coatings, and improve adhesion. Typical applications include masonry coatings for swimming pools, stucco homes and highway paints, as well as protective and decorative coatings for steel structures, railway tank and gondola cars, wood and metal maritime equipment.

In rubber base coatings, Aroclor 1254 is used as a liquid flexibilizing plasticizer and commonly used in combination with Aroclor 5460 which serves as a resin fortifier. The outstanding chemical resistance, corrosion resistance and oxidation resistance of rubber base Aroclor coatings make them outstanding protective coatings for chemical plants, boats, highway marking, and masonry. Monsanto Technical Bulletins No. PL-306, PL-311, and PL-326 cover the use of Aroclors in rubber base coatings.



CELLULOSE ACETATE BUTYRATE LACQUERS

The higher Aroclor compounds are widely used with cellulose acetate butyrate, in the manufacture of low cost lacquers that are flame resistant. Typical uses for this type of lacquer include paper coating, lacquers for plastics and strippable coatings for paint booths.

A typical paper lacquer with minimum tendency to curl is reported* to contain the following:

	By Weight
Half-second Butyrate	20%
Aroclor 1260	20%
Acetone	10%
Isobutyl Acetate	10%
Ethyl Alcohol	10%
Toluene	30%

ETHYL CELLULOSE COATINGS

The Aroclors are highly compatible with ethyl cellulose. The liquid Aroclors impart great flexibility, the resinous Aroclors impart great hardness. For example, 75 parts by weight of Aroclor 1242 with 100 parts of ethyl cellulose produces great flexibility and a slight tackiness. Aroclor 5460 on the other hand — in the same proportion — produces a very hard and somewhat brittle composition.

For coatings of high gloss and exceptional weathering properties to be applied to rigid surfaces, compositions containing equal parts by weight of Aroclor 5460 and ethyl cellulose are recommended. For more flexibility in the coating one of the softer Aroclors should be used — either alone or as a partial replacement for the Aroclor 5460.

Ethyl cellulose formulations plasticized with Aroclors find end use applications as protective lacquers, adhesives, and as strippable coatings.

The solid Aroclor compounds, such as Aroclor 5460 are widely used in hot melt applications for the protection of tools and metal parts. They are normally used with ethyl cellulose or cellulose acetate-butyrate resins.

CREPE RUBBER COATINGS

Aroclor 1262 is used as a low cost plasticizer for crepe rubber in paint compositions. Used in concentrations of 5 to 50% based on the weight of the rubber polymer, it increases the gloss and alkali resistance of the film and strengthens the adhesion of the film to steel.

*W. M. Gearheart and F. M. Bell, OFFICIAL DIGEST, Vol. 343, 1953.



AROCLO
1242

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appendix

METHODS FOR EMULSIFYING AND MAKING STOCK SOLUTIONS OF AROCLORS

There are several simple methods for making Aroclor emulsions; the one used may be selected to suit the kind of Aroclor and type of formulation in which it will be used.

Emulsifying Viscous Aroclors

(Portion 1)	16 lbs. of Aroclor
	1 lb. of Stearic Acid
(Portion 2)	8 lbs. of water
	4 oz. Triethanolamine

Heat the Aroclor to a workable viscosity (180°F plus) and stir in the stearic acid thoroughly. Heat the water to almost boiling (207°F) and stir in the triethanolamine thoroughly. Pour the Aroclor-stearic acid portion *into* the water portion agitating vigorously. Then process the combined portions with a high-speed emulsifying stirrer . . . or process through a colloid mill.

Emulsifying Liquid Aroclors

(Portion 1)	100 parts Aroclor 1254
	4 parts Oleic Acid
(Portion 2)	92 parts water
	2 parts Ammonium Hydroxide (28%)
	2 parts Lustrex® X-810

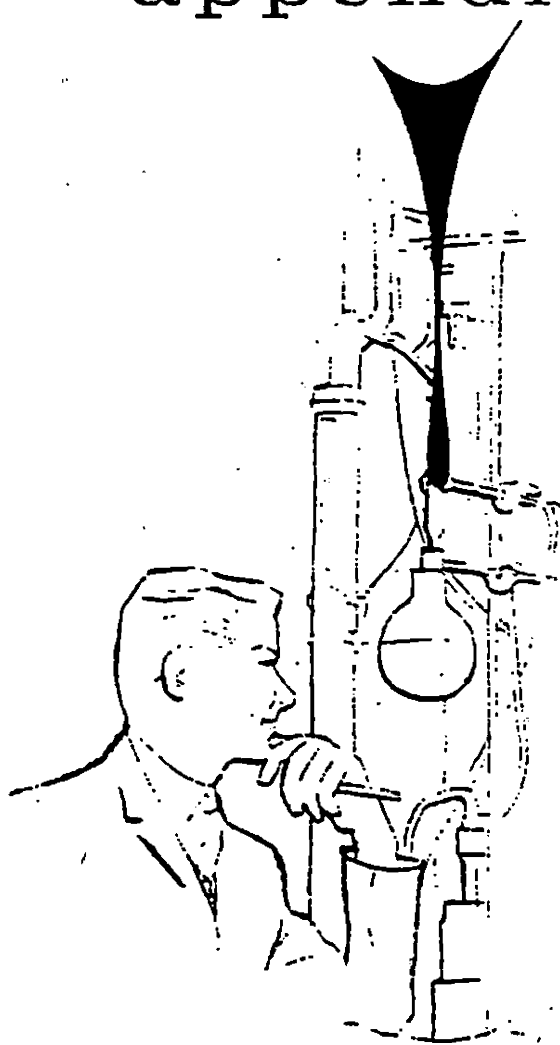
Mix the ammonium hydroxide and Lustrex X-810 thoroughly in the warmed water, using vigorous agitation. Mix the Aroclor 1254 and Oleic Acid, heat to 45°C and agitate vigorously. Maintain the 45°C temperature and agitation — and add in *slowly* the water portion. Continue agitation for one-half hour till phase inversion is complete.

Emulsifiable Concentrated Stock Solutions of Aroclors

79 parts of Aroclor
16.70 parts of toluene
3.55 parts of isopropyl alcohol
1.00 parts of Sterox® CD (non-ionic emulsifier)
0.75 parts of Santomerc® #3 (anionic wetting agent)

The above formulation is readily emulsifiable with water. If the more resinous Aroclors are used, increase the amount of toluene (or xylene) as needed to dissolve the Aroclor resin.

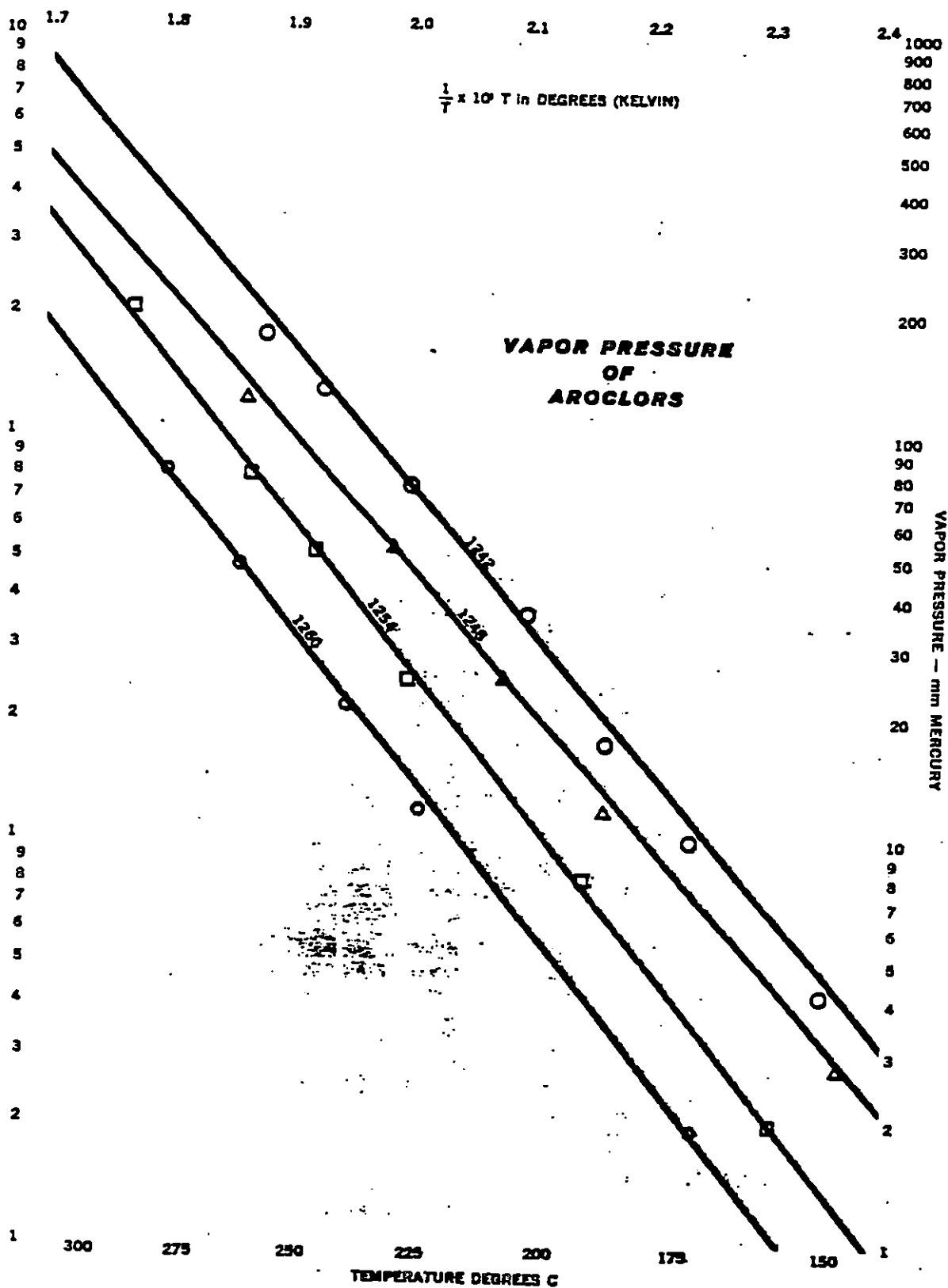
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SOLUBILITY OF AROCLORS IN 100 MILLILITERS OF VARIOUS SOLVENTS

Type of Solvent	1242		1248		1254		4465		5460 25°C
	25°C	Hot	25°C	Hot	25°C	Hot	Cold	Hot	
Acid									
Acetic Acid.....	S	S	—	—	S	S	SS	S	—
Oleic Acid.....	S	S	—	—	S	S	S	VS	—
Benzoic Acid.....	10.0 31°C	—	10.0 32°C	—	—	—	—	—	—
Aldehyde									
40% Formaldehyde.....	I	I	I	I	I	I	I	I	—
Furfural.....	VS	VS	VS	VS	VS	VS	VS	VS	—
Amine									
Aniline.....	S	S	—	—	S	S	VS	VS	—
Pyridine.....	132.5 30°C	440 99°C	—	—	114 31°C	425 100°C	VS	VS	—
Chloro—derivatives									
Amyl chlorides—mixed.....	S	S	S	S	S	S	VS	VS	—
Carbon Tetrachloride.....	S	S	S	S	S	S	VS	VS	156
Chloroform.....	S	S	S	S	S	S	VS	VS	—
Dichloroethylene.....	—	—	—	—	—	—	VS	VS	—
Ethylene Dichloride.....	S	S	S	S	S	S	VS	VS	—
Monochlorobenzene.....	S	S	S	S	S	S	VS	VS	—
Orthodichlorobenzene.....	—	—	—	—	—	—	VS	VS	—
Tetrachlorethane.....	S	S	S	S	S	S	VS	VS	—
Trichlorethane.....	S	S	S	S	S	S	VS	VS	—
Trichloroethylene.....	S	S	S	S	S	S	VS	VS	—
Drying Oil									
Tung Oil.....	S	S	S	S	S	S	VS	VS	—
Linseed Oil.....	S	S	S	S	S	S	VS	VS	—
Ester									
Amyl Acetate.....	S	S	S	S	S	S	VS	VS	—
Butyl Acetate.....	S	S	S	S	S	S	VS	VS	—
Cellulosive Acetate.....	S	S	S	S	S	S	VS	VS	—
Cottonseed Oil.....	S	S	S	S	S	S	S	VS	—
Dibutyl Phthalate.....	S	S	S	S	S	S	S	VS	—
Diethyl Phthalate.....	S	S	S	S	S	S	S	VS	—
Ethyl Acetate.....	S	S	S	S	S	S	S	VS	—
Ethyl Lactate.....	S	S	S	S	S	S	VS	VS	—
Ethylene Glycol Diacetate.....	S	S	S	S	S	S	VS	VS	—
Methyl Acetate.....	S	S	S	S	S	S	S	S	—
Tricresyl Phosphate.....	S	S	S	S	S	S	SS	S	—
Ether: Ethyl Ether.....	S	S	S	S	S	S	S	—	—
Ether Alcohol									
Carbitol.....	224 31°C	307 99°C	VS	VS	173 26°C	259 98°C	SS	—	—
Cellulosive.....	S	S	S	S	S	S	S	—	—
Diethylene Glycol.....	—	—	—	—	—	—	S	—	—
p-p' Dihydroxy Ethyl Ether.....	16.9 23°C	19 99°C	SS	SS	8 30°C	10 100°C	SS	—	—
Hydrocarbon									
Benzene.....	VS	VS	VS	VS	VS	VS	VS	VS	143
Gasoline.....	VS	VS	VS	VS	VS	VS	VS	VS	—
Kerosene.....	VS	VS	VS	VS	VS	VS	VS	VS	—
Mineral Spirits.....	VS	VS	VS	VS	VS	VS	VS	VS	—
Paraffin.....	2.0 17.5°C	S	2.0 21°C	S	—	S	<5.0	S	—
Pine Oil.....	S	S	VS	VS	S	S	S	S	—
Toluene.....	VS	VS	VS	VS	VS	VS	VS	VS	142
Turpentine.....	VS	VS	VS	VS	VS	VS	VS	VS	—
Xylene.....	VS	VS	VS	VS	VS	VS	VS	VS	178
Hydroxy—derivatives									
Amyl Alcohol.....	S	S	—	—	S	S	S	S	—
n-Butyl Alcohol.....	S	S	—	—	S	S	SS	S	—
Ethyl Alcohol (3-A).....	23.3 29°C	80.0 70°C	—	—	10 27°C	28 75°C	SS	—	—
Glycerine.....	I	I	I	I	I	I	I	I	—
Methyl Alcohol.....	42.5 29°C	88.5 60°C	—	—	15 26°C	22.2 65°C	SS	—	—
Phenol—90%.....	194 10°C	S	—	—	SS	S	S	S	—
Ketone									
Acetone.....	S	S	—	—	S	S	S	S	260
Miscellaneous									
Carbon Disulfide.....	S	S	—	—	S	S	VS	VS	—
Nitrobenzene.....	S	S	—	—	S	S	VS	—	—
Water.....	I	I	I	I	I	I	I	I	—

I—Insoluble S—Soluble SS—Slightly Soluble VS—Very Soluble
 Figures show grams of Aroclor per 100 milliliters of solvent at 25°C unless otherwise indicated.



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GENP 004655

VAPORIZATION RATES
At 100°C and 760 mm. Hg.

Sample	Wt. Loss Gms.	Hours Exposure	Surface Area Cm. ²	Vaporization Rate gms./cm. ² hr.
Aroclor 1221	0.5125	24	12.28	0.00174
Aroclor 1232	0.2572	24	12.28	0.000874
Aroclor 1242	0.0995	24	12.28	0.000338
Aroclor 1248	0.0448	24	12.28	0.000152
Clorafin-42-S	0.0745	48	12.28	0.000126
DOP (dioctyl phthalate)	0.0686	48	12.28	0.000117
Dutrex 25	0.0256	24	12.28	0.000087
Aroclor 1254	0.0156	24	12.28	0.000053
Dutrex 20	0.0047	24	12.28	0.000016
Aroclor 1262	0.0039	24	12.28	0.000013
Aroclor 1260	0.0026	24	12.28	0.000009
Aroclor 4465	0.0064	72	12.28	0.000007
Aroclor 1270	0.0045	72	12.28	0.000005
Aroclor 5442	0.0039	72	12.28	0.000004
Aroclor 5460	0.0032	72	12.28	0.000004
Tricresyl phosphate	0.0010	24	12.28	0.000003

APPROXIMATE VAPOR PRESSURES
CALCULATED AT 100° F (37.8° C)

Aroclor 1232	0.005 mm. Hg.
Aroclor 1242	0.001 mm. Hg.
Aroclor 1248	0.00037 mm. Hg.
Aroclor 1254	0.00006 mm. Hg.

RESISTANCE OF STRUCTURAL MATERIALS TO AROCLORS

Metals	Aroclor Number					
	1248		1254		4465	5460
	25°C	125°C	25°C	125°C	125°C	125°C
Aluminum.....	R	R	R	R	*RR	RR
Copper.....	R	D	R	D	D	D
Magnesium.....	RR	R	R	R	RR	*RR
Nickel.....	RR	R	R	RR	RR	R
Silver.....	R	R	R	R	R	R
Tin.....	R	R	R	R	R	R
Zinc.....	R	R	R	R	R	RR
Mild Steel.....	RR	R	RR	RR	R	RR
Phosphor Bronze.....	R	D	R	R	R	R
Red Brass.....	D	D	R	D	R	De
Stainless Steel (Type 316).....	RR	RR	RR	RR	RR	RR
Yellow Brass.....	R	Re	R	De	Re	Re
Plastics						
Alkyd Resin No. 46594-12.....	*P	P	*P	P	P	P
Alkyd Resin No. 46594-13A.....	*D	P	*D	P	P	P
Cellulose Acetate (Fibestos).....	D	P	D	P	P	P
Durite Phenol Furfural Resin.....	*D	P	*R	P	D	P
Formvar Highly Plasticized.....	De	T	Pe	T	T	T
Formvar Low Plasticized.....	PS	T	PS	T	T	T
Glyptal 1276.....	R	P	D	P	P	P
Glyptal 7136.....	*D	T	*R	T	T	T
Maleic Resin No. 46594-13B.....	P	P	*P	P	P	P
Maleic Resin No. 46594-13C.....	P	P	*R	P	P	P
Plexiglas (Methyl Methacrylate).....	*D	P	*D	P	P	P
Polystyrene (Lustron B).....	P	T	P	T	T	T
Resinox Mineral Filled Melamine Resin.....	*D	*P	*R	R	*P	*D
Resinox Wood Flour Filled Melamine Resin.....	*D	P	*R	D	R	P
Resinox Mineral Filled Phenol Formaldehyde.....	*D	D	*D	D	R	P
Resinox Wood Flour Filled Phenol Formaldehyde..	*D	P	*D	*R	D	P
Resinox Rag Filled Phenol Formaldehyde.....	*D	D	*D	*D	*D	P
Urea Formaldehyde Resin (Plaskon Co.).....	*D	P	*D	*P	P	P

Meaning of Abbreviations:

*—Based on weight gain calculated as penetration value shown.

RR—Excellent resistance—less than 1.0×10^{-4} cm/day penetration or .00014 in/yr.

R—Good resistance—less penetration between 1.0×10^{-4} and 10×10^{-4} cm/day or between 0.00014 and 0.0014 in/yr.

D—Doubtful resistance, penetration between 10×10^{-4} cm/day and 100×10^{-4} cm/day or between 0.0014 and 0.014 in/yr.

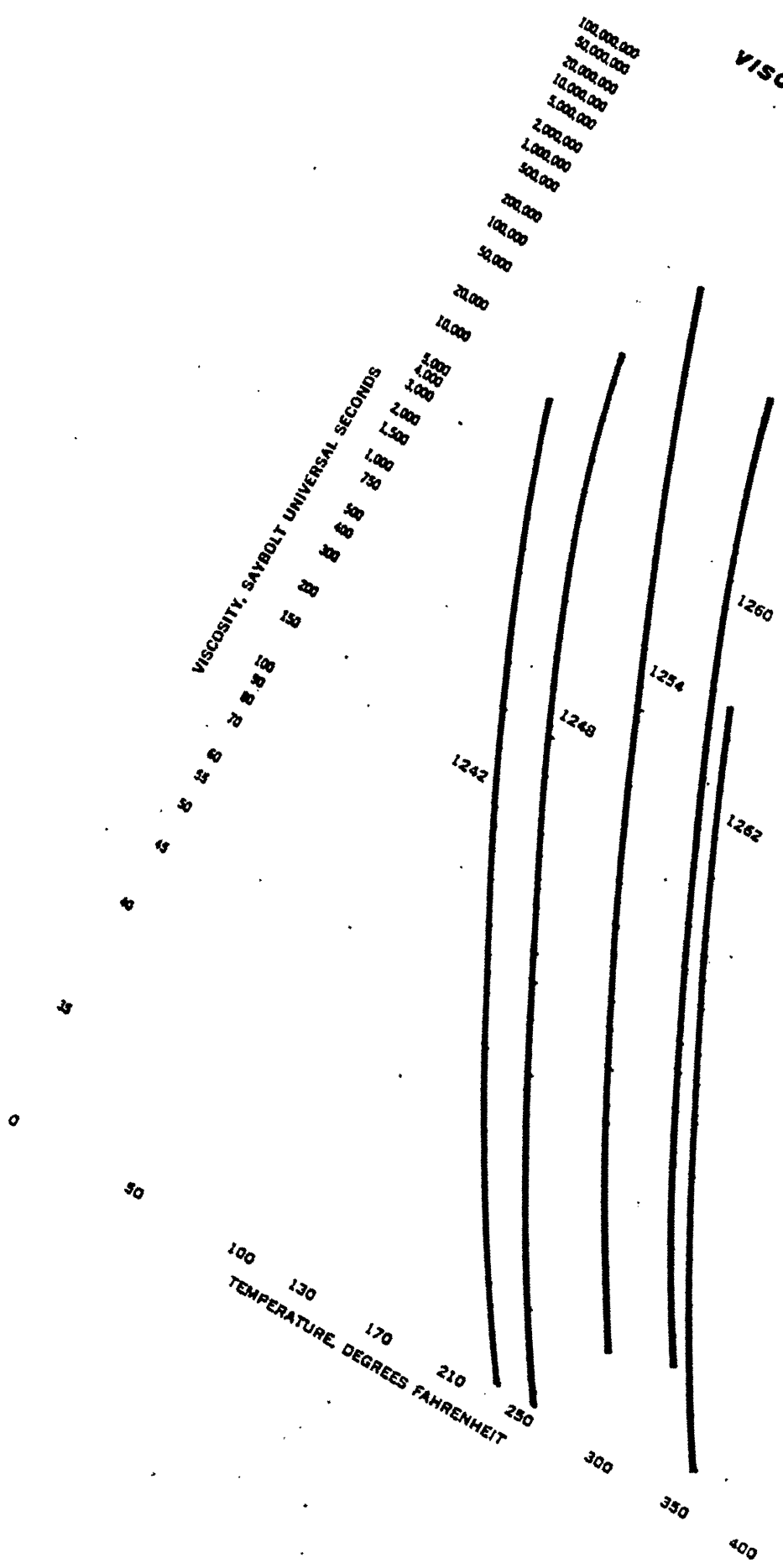
P—Poor resistance—penetration greater than 100×10^{-4} cm/day or 0.014 in/yr.

PS—Poor resistance due to visible local action although weight change indicates greater resistance.

—Following the letter indicating resistance signifies material may be better than indicated if totally immersed since weight loss is believed to come from oxidation of the part of test strip exposed to air.

T—Material alone will not stand temperature.

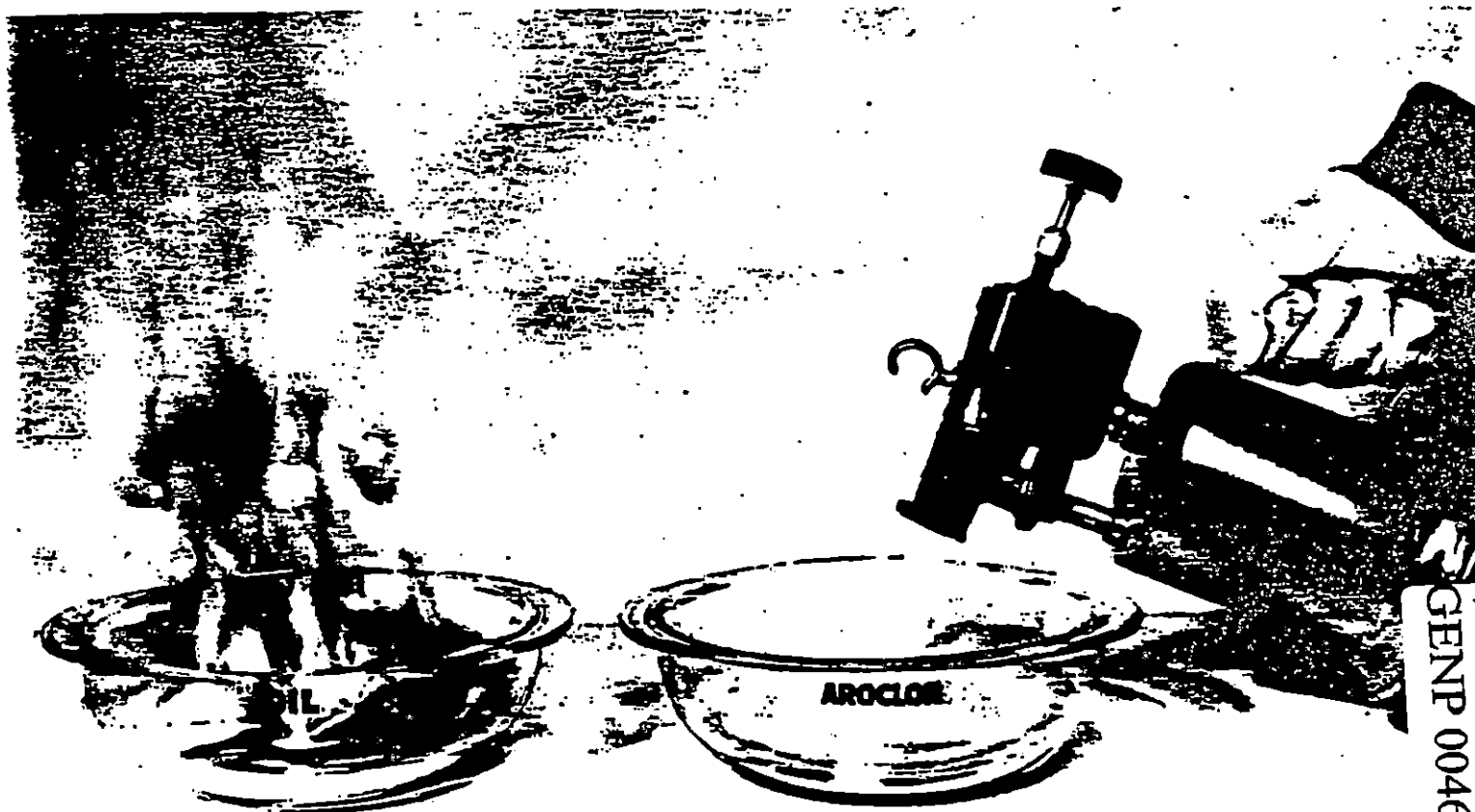
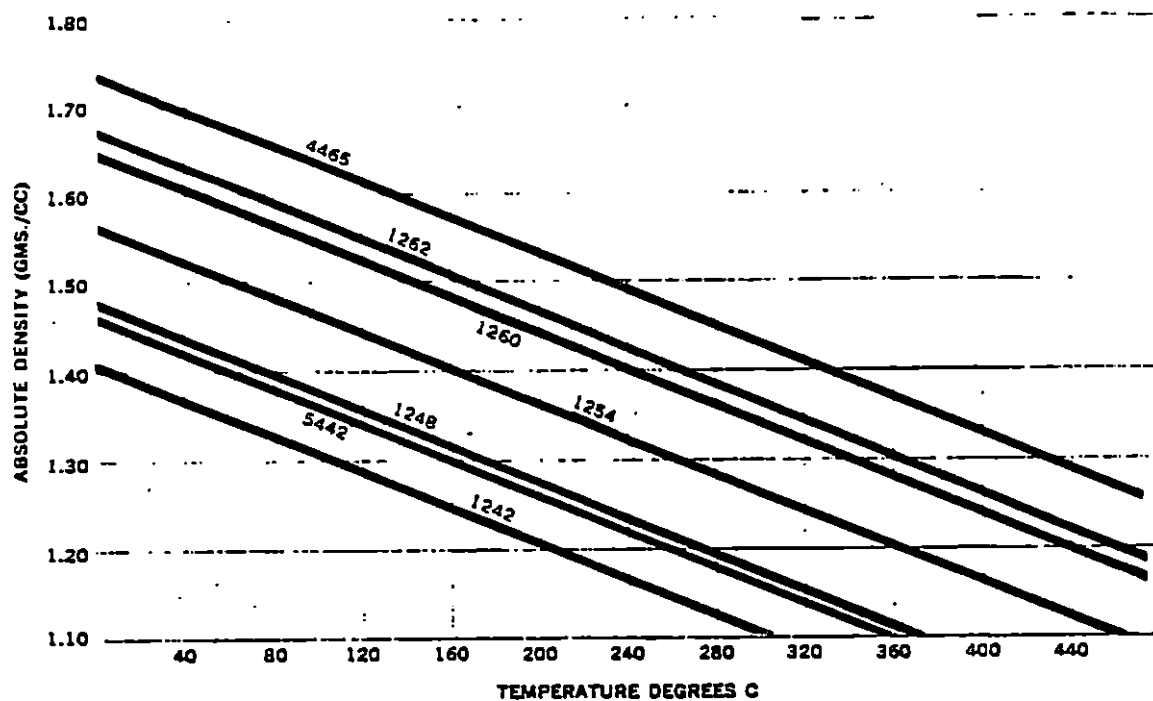
VISCOSITY RANGES OF SOME OF THE AROCLORS



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GENP 004658

DENSITIES OF AROCLORS AT VARIOUS TEMPERATURES



GENP 004659

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At ordinary temperatures Aroclors have not presented industrial toxicological problems. Where Aroclor vapors may be encountered in workrooms, local exhaust ventilation together with general workroom exhaust is recommended.

Skin patch tests with a polyvinyl chloride free film plasticized with 11.5% by weight of Aroclor 1254 (about 25% based on the weight of the vinyl resin) and a similar amount of dioctyl phthalate showed that this film was not a primary irritant or a sensitizer. Skin patch tests with Aroclor 1254 alone applied to gauze and placed in contact with the skin showed no primary irritancy or sensitization. Other skin patch tests using canvas coated with Aroclor 5460 and an oil modified alkyd resin, in such a manner that the Aroclor concentration in the paint film on the fabric was about 17% by weight of paint solids and the finished coated fabric contained approximately 7% by weight of Aroclor 5460 showed that this painted fabric did not produce a primary irritancy or sensitization of the skin.

If Aroclors are spilled on the skin, the skin should be washed in the usual manner with soap solutions. If accidental burns occur from contact with hot Aroclors, the burn should be treated the same as any ordinary burn. Aroclor adhering to the burned area need not be removed immediately unless treatment of the burn demands it, in which case use soap and water or repeated washings with a vegetable oil.

Monsanto

aroclors for...

fire retardant
inert
shear resistant
heat stable
lubricating

physically "adjustable"
adhesive
non-volatile
low cost
thermoplastic

FILM FORMING
IMPREGNATING
INSULATING
HEAT TRANSFER
DEDUSTING
INERT MATRIXES
PLASTICIZING
BULKING
COATING
"TACKIFYING"
REDUCING VOLATILITY

Aroclors are the only low cost, inert, inter-compatible liquids and solids whose intermixing can provide insulating, lubricating, fire retardant liquids ranging from the consistency of light mineral oil to the most viscous syrup (or solid resin) which will do so many jobs in industry.

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