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February 1, 1968

REPORT

on

DIELECTRIC MEDIUM

Westinghouse Electric Corporation
Sharon, Pennsylvania

GENERAL

The product covered by this Report is a liquid chlorinated aromatic hydrocarbon intended for use as a liquid phase dielectric and cooling medium in electrical apparatus.

The object of this investigation was to establish the fire, explosion, and toxic hazards of this product.

In planning the investigation, consideration was given to the general nature of the product, its fire hazard, toxic hazard, corrosive action, stability, and practicability. The method of investigation of each of these features is given below.

Information as to the general nature of the product was obtained from identification tests.

In the study of fire hazard, the product was investigated as to flammability, explosiveness of vapors when mixed with air, and ignition temperature. The tests included flash point test, fire point test, ignition temperature test, tests for explosiveness of vapors in air, tests of behavior in presence of hot metal, and burning tests when disseminated on asbestos.

Since the toxic decomposition products of several similar chlorinated aromatic hydrocarbons have been previously investigated by Underwriters' Laboratories, Inc., this available data was considered to be applicable to this product, and no additional tests for toxicity were considered necessary or conducted.

Corrosion tests of the product on some common metals were conducted.

Information bearing on the stability of the product was obtained from spontaneous heating tests, corrosion tests, and consideration of the chemical properties of the product.

The practicability of the product was considered from the standpoint of its general nature and results obtained in the dielectric strength tests.

D E S C R I P T I O N

PRODUCT COVERED:

Dielectric medium, "Inerteen 54201 CM."

GENERAL CHARACTER AND USE:

This product is a chlorinated aromatic hydrocarbon intended for use as a dielectric and cooling medium in electrical apparatus.

It is not designed to replace oil as a dielectric and cooling medium unless the equipment is designed for either oil or this product.

MARKING:

Listee's name and trade name.

TEST RECORD NO. 1

SAMPLE:

A 5-gal sample of the product "Inerteen 54201 CM" was supplied for test purposes.

IDENTIFICATION TESTS:

METHODS

Specific Gravity - The specific gravity of the product was determined by means of a pycnometer.

Distillation Test - A 100-g sample of the product was distilled in accordance with ASTM Method D20-56.

Quantitative Determination of Chlorine - Samples of the product were heated with powdered calcium hydroxide powder and the resulting calcium chloride determined by the Volhard method.

Qualitative Infrared Analysis - An infrared spectrum of the product was obtained by means of an infrared spectrophotometer.

RESULTS

Specific Gravity - The specific gravity of the product was 1.398 at $\frac{15.6\ C\ (60\ F)}{15.6\ C\ (60\ F)}$.

Distillation Test -

Initial boiling point - 312 C (594 F).
Per cent distilled below 335 C (635 F) - 88.0
Per cent distilled between 335 C (635 F) and 358 C (676 F) - 10.7
End point - 358 C (676 F)
Residue, per cent - 0.5
Distillation loss, per cent - 0.8

Quantitative Determination of Chlorine - The product contains 42.8 per cent chlorine.

Qualitative Infrared Analysis - The spectrum obtained is considered to be representative of the material tested. The recorded spectrum is being made a part of the permanent record of this product.

FLASH POINT TEST:

METHOD

The flash point of the product was determined with the Pensky-Martens closed tester in accordance with ASTM Method D93-66.

RESULTS

The flash point was 179.4 C (355 F).

FIRE POINT TEST:

METHOD

The fire point test of the product was conducted using the Cleveland open cup tester in accordance with ASTM Method D92-66.

RESULTS

The product showed no fire point to boiling. Intermittent flashes were obtained during the test, but the product did not continue to burn.

TESTS FOR EXPLOSIVENESS OF VAPORS IN AIR:

METHOD

The apparatus consisted of a horizontal cylindrical steel vessel, 6 in. in diameter (internal) and 26 in. long. It was provided with a small mica window and an outlet to the atmosphere, this outlet being normally closed by a loosely fitted asbestos plug. Openings were provided halfway between the ends of the vessel to admit electrode terminals connected to the secondary of a high voltage transformer. The electrode terminals were centrally located in the vessel, and were spaced to give a spark gap of 1/4 in.

The vessel was heated externally by gas burners. An iron constantan thermocouple connected to a potentiometer was used for rough measurements of the temperature of the vapor inside the vessel.

The electrical discharge used as a source of ignition in the test vessel is produced by a transformer rated 110 v ac for the primary and 23 ma, 10,000 v for the secondary. A 0.01-mu f capacitor is connected across the secondary of the transformer.

Samples of the liquid product, ranging in volume from 20 to 50 ml, were introduced into the vessel which had been previously heated to a predetermined temperature. The transformer discharge was passed between the electrodes at intervals of 1/2 min, and observations made as to whether flame propagation occurred.

The residual liquid was drained from the vessel, and residual gases and vapors were displaced by a stream of air, in the interval between tests.

RESULTS

The results of the tests conducted on the product in the cylindrical steel vessel were as shown in the following table.

Sample, Ml	Temperature, Degree C	Duration of Test, Min	Results
20	166	2-1/2	Propagated flame with moderate pressure effects.
20	148	30	No flame propagation obtained.
50	152	15-1/2	Propagated flame with moderate pressure effects.
50	147	28	Propagated flame with moderate pressure effects.
50	143	30	No flame propagation obtained.

IGNITION TEMPERATURE TESTS:

METHOD

The apparatus consisted essentially of a combustion chamber surrounded by a molten alloy bath, which was heated at a constant temperature during the test. The temperature of the alloy bath was measured by means of a calibrated thermocouple provided with a quartz tube to protect the hot junction.

The combustion chamber consisted of a quartz flask of conical form with flat bottom, 11.4 cm in height, 6.0 cm in diameter at bottom, and 2.8 cm in diameter at top. It was of about 160 ml capacity (rated capacity 125 ml) having a ratio of surface area to volume of about 1:1.

Measured test samples of the product in the liquid phase were introduced into the heated combustion chamber by means of a pipette. Different amounts of the product were admitted to the chamber in successive tests at progressively lower temperatures in order to determine the minimum temperature at which the vapor, in any proportion with air, will ignite without application of a flame. The residual vapors or gases in the combustion chamber were displaced by a stream of air in the interval between tests.

RESULTS

The ignition temperature of the product was 662 C (1224 F).

TESTS OF BEHAVIOR IN PRESENCE OF HOT METAL:

METHOD

The apparatus consisted essentially of a horizontal steel plate heated to red heat (about 780 C, 1436 F) by gas burners. Flames and hot gases were deflected from the upper surface of the steel plate by a thin sheet of steel extending 10 in. horizontally beyond the edges of the plate. This deflector was bolted to the edges of the plate, asbestos gaskets being provided at the joints.

Various amounts of the product were applied as drops to the surface of the heated steel plate and the behavior observed. In some of the tests, a slow stream of air was applied to the evaporating samples.

RESULTS

The product, when applied to the hot steel plate (about 780 C, 1436 F), evaporated or decomposed without ignition of the vapors or evidence of hazardous reaction with the hot steel.

BURNING TESTS WHEN DISSEMINATED ON ASBESTOS:

METHOD

A 3 by 40-in. strip was cut from heavy (34 oz per sq yd) woven asbestos cloth approximately 0.08 in. thick. The strip was weighed, then saturated with the product, and again weighed. The original weight of the strip, before saturation, was 91 g. The weight of product retained on the strip was 164 g.

In conducting the burning test, the specimen was suspended with its long edge vertical in a location free from drafts. An 11-in. flame produced by a Bunsen burner, having a 3/8-in. diameter tube, was used as the source of ignition. The Bunsen flame was applied vertically to the lower end of the test specimen so that the flame overlapped the specimen approximately 7 in.

RESULTS

The product, when disseminated on the vertically suspended asbestos strip, ignited in approximately 2 min. The burning did not spread beyond the area of the test flame, and the burning ceased within 1-1/2 min after the test flame was removed.

CORROSION TESTS:

METHOD

The metals used in the corrosion tests were copper, yellow brass, steel, tin-lead solder, copper and tin-lead solder, and copper and iron coupled. Test specimens, 1/2 in. wide and 6 in. long, were cut from sheets of the metals. The specimens were buffed, measured, cleansed with soap and water, washed with ethyl alcohol and ethyl ether, dried, and weighed.

Each metal specimen was immersed separately for half its length in a sample of the product contained in a glass tube provided with a cork stopper. The tubes and contents were maintained at a temperature of 90 C (194 F) in a thermostatically controlled electrically heated oven.

The metal specimens were examined visually at weekly intervals during the test for evidences of corrosion. At the conclusion of the test, the metal specimens were cleansed, dried, again weighed, and the change in weight per square centimeter of surface area calculated.

RESULTS

When heated in glass tubes containing the product at 90 C for 1464 hr, the specimens showed little visible evidence of corrosion except for a slight discoloration of the surfaces above the liquid. The change in weight of the specimens was very small (less than 1.0 mg per sq in.).

DIELECTRIC STRENGTH TEST:

METHOD

The dielectric breakdown voltage of the product was determined in accordance with ASTM Method D877-64 using the referee test procedure.

RESULTS

The dielectric breakdown voltage of the product at 25 C (77 F) was 43 kv.

SPONTANEOUS HEATING TESTS:

METHOD

The apparatus used for the spontaneous heating test consisted essentially of a vertical, cylindrical test chamber, 7 in. in height and 4 in. in diameter, surrounded at the side and bottom by a water bath heated electrically. The test chamber was provided with a cover having two air vent tubes and an opening for introduction of a thermocouple. The sample was contained within the test chamber by a cylinder of wire gauze, 6 in. in height and 1-1/2 in. in diameter. This cylinder was concentric with the axis of the test chamber, there being an annular space through air of 1-1/4 in. between the cylinder and the wall of the chamber.

In conducting the tests, 14 g of the product were evenly distributed over 7 g of cotton fiber (commercial absorbent cotton) and placed in the containing cylinder within the test chamber. A thermocouple connected to a recording potentiometer was inserted in the cotton bearing the test sample so as to measure the temperature at the approximate center of the mass. The cover was then placed on the test chamber and the water bath surrounding the chamber maintained at boiling for a period of 24 hr. A rise in the temperature of the sample above the temperature of the ambient water bath under the conditions of the test is an indication of spontaneous heating of the material.

RESULTS

The product showed no indication of spontaneous heating.

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C O N C L U S I O N S

FIRE HAZARD:

The fire hazard of this product is small. Nonflammable and nonexplosive at ordinary temperatures. It is capable of forming moderately combustible and explosive mixtures with air under laboratory test conditions at higher temperatures, beginning at a temperature of 147 C (296.6 F).

The fire hazard of this product is judged to be in a class considerably less hazardous than paraffin oil as determined by the Standard of Underwriters' Laboratories, Inc. for the classification of liquids, the rate of hazard being 2 to 3 in accordance with the following schedule in which:

Ether rates - 100
Gasoline rates - 90-100
Alcohol (ethyl) rates - 60-70
Kerosene (100 F flash) rates - 30-40
Paraffin oil rates - 10-20

The product showed a flash point in the closed tester of 179.4 C (355 F). The product showed no fire point to boiling when tested in the open cup tester. Intermittent flashes were obtained during the fire point test, but the product did not continue to burn. The flash point and fire point tests are of limited value as a measure of fire hazard in the case of chlorinated hydrocarbons. The practical significance of these tests, in the case of this product, is that the fire hazard is shown to be of a low order.

As shown by the tests for explosiveness of vapors in mixture with air, the product was capable of propagating flame with development of moderate pressure effects at temperatures at or above 147 C (296.6 F).

The ignition temperature of the product was found to be 662 C (1224 F).

The product, when applied to a hot steel surface (red heat, about 780 C, 1436 F), evaporated or decomposed without ignition of the vapors, or evidence of hazardous reaction with the heated steel.

The product, when disseminated on vertically suspended strips of asbestos cloth, ignited and burned in the vicinity of a test flame. The burning did not spread beyond the area subjected to the test flame, and the burning ceased when the test flame was removed.

TOXIC HAZARD:

The conclusions on toxic hazard given below are based on available data obtained at Underwriters' Laboratories, Inc. in tests where chlorinated aromatic hydrocarbons of similar composition were decomposed by hot metal surfaces (steel at 600 C) and by electric arcs, and the nature and amounts of the resulting decomposition products determined.

The gases or fumes produced by burning or decomposition by hot metal surfaces or electric arcs include hydrochloric acid, carbon monoxide, and a small amount of phosgene. This will ordinarily constitute a toxic hazard only where the conditions are such as to cause confinement of the fumes as in a closed room in which combustion or decomposition is maintained by fire, highly heated surfaces, or electric arcs.

It is to be noted in this connection that oils in common use at present as the dielectric medium for electrical apparatus are readily combustible and when burning under conditions of restricted air supply form carbon monoxide in dangerous concentrations.

While phosgene is poisonous, our data indicate that the concentrations likely to result in the failure of a transformer or other electrical apparatus containing the product are not liable to endanger life.

The resulting concentration of hydrochloric acid in air when failure of a transformer or other electrical apparatus containing the product occurs will depend largely upon the conditions. It will constitute a toxic hazard only where the conditions are such as to cause a high concentration of the fumes as in a closed room. In ordinary use the small quantities of gases evolved will be vented to some safe location.

The exceedingly unpleasant and irritating fumes from the decomposition of the product, even in concentrations of a very low order, act not only to give warning of their presence but to prevent dangerous exposure of persons. While carbon monoxide is odorless and toxic, its formation from the product is always accompanied by the simultaneous formation of hydrochloric acid gas which gives adequate warning of its presence as brought out above.

Available data obtained in tests of chlorinated aromatic hydrocarbons of similar composition indicate that the product would not be appreciably decomposed at temperatures below 300 C (572 F).

CORROSIVE ACTION:

The product does not corrode the metals commonly used in electrical apparatus.

No corrosion occurred in the tests conducted on representative metals and alloys as recorded under corrosion tests.

As noted in our conclusions concerning the toxicity of products of this nature, available data indicate that appreciable amounts of hydrochloric acid are formed when such products are decomposed in the presence of hot metal surfaces or electric arcs.

STABILITY:

The product is reasonably stable and in use is unlikely to undergo decomposition resulting in an increase in fire hazard.

The product showed no tendency to heat or ignite spontaneously under test conditions designed to start and accelerate the process.

PRACTICABILITY:

Based on considerations of the general nature of this product and the results of the dielectric strength test, it is considered practicable to use this product as a dielectric and cooling medium in electrical apparatus.

The product is not intended to replace other dielectric and cooling mediums unless the equipment is designed for such mediums or this product.

The product covered by this Report will be listed under Reexamination Service of Underwriters' Laboratories, Inc.

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