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8:mfo

January 27, 1989

Mr. Thomas E. Kotoske
540 University Avenue
Third Floor
Palo Alto, California 94301

Re: David Adams, et al. v. Kentucky Power, et al.

Dear Tom:

Pursuant to the instructions of the Court and my agreement with David McCrea, I am enclosing the documents outlined in the list of exhibits for Westinghouse. In line with my conversation with David, please note that we deleted item no. 15 from the original list.

Best regards.

Yours truly,

Charles S. Cassis

Enclosures

cc: Mr. David S. McCrea

PLAINTIFF'S EXHIBIT 486

Adams, et al. v. Kentucky Power Co., et al.

C.A. No. 85-CI-1724

AMENDED
LIST OF EXHIBITS

WESTINGHOUSE ELECTRIC CORPORATION

1. Inerteen Transformers Instruction Book
Dated: Pre-1938.

2. Inerteen Transformers Instruction Book
Dated: March, 1938.

3. Inerteen Transformers Instruction Book
Dated: January, 1942.

4. Inerteen Transformers Instruction Book
Dated: November, 1946

5. Inerteen Insulating Fluid for Electrical Paratus
Dated: February, 1952.

6. Instructions for Inerteen Insulating Fluid P.D.S. 54201 KA
Dated: July, 1965.

7. Instructions for Inerteen Insulating Fluid P.D.S. 54201 CM
Dated: April, 1968.

8. Instructions for Inerteen Insulating Fluid P.D.S. 54201 CM and Installation and Maintenance of Inerteen Transformers (including Supplement)
Dated: September, 1968.

9. Instructions for Handling Inerteen Insulating Fluid P.D.S. 54201 CM and Installation and Maintenance of Inerteen Transformers
Dated: August, 1971.

10. Instructions for Handling Inerteen Insulation Fluid P.D.S. 54201 CM and Installation and Maintenance of Interteen Transformers
Dated: February, 1976.

11. Instructions for Handling Inerteen Insulating Fluid P.D.S. 54201 CM and Installation and Maintenance of Inerteen Transformers
Dated: June, 1976.

12. Westinghouse schedules of transformer serial numbers and years of manufacture.

13. Summaries of serial numbers, years, KVA work order numbers and dates of Westinghouse transformers from Kentucky Power Co. retirement work orders.

14. Summaries of serial numbers and years of manufacture of transformers from Westinghouse records corresponding to serial numbers from Kentucky Power Co.

COMMONWEALTH OF KENTUCKY
PIKE CIRCUIT COURT
DIVISION I
CIVIL ACTION NO. 85 CI-1724

DAVID ADAMS, et al. PLAINTIFFS

v. SUBMISSION OF AMENDED EXHIBIT LIST
FOR
WESTINGHOUSE ELECTRIC CORPORATION

KENTUCKY POWER CO., et al. DEFENDANTS

* * * *

Defendant, Westinghouse Electric Corporation, submits herewith its Amended Exhibit List in compliance with the Court's instructions and order of November 28, 1988.

BROWN, TODD & HEYBURN
Charles S. Cassis
Mark R. Feather

Charles S. Cassis

1600 Citizens Plaza
Louisville, Kentucky 40202
(502) 589-5400

ATTORNEYS FOR DEFENDANT
WESTINGHOUSE ELECTRIC CORPORATION

CERTIFICATE OF SERVICE

This is to certify that on this 27th day of January, 1989, a true copy of the foregoing pleading and the attachment was mailed to all counsel of record.

Charles S. Cassis

Charles S. Cassis

Adams, et al. v. Kentucky Power Co., et al.

C.A. No. 85-CI-1724

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Westinghouse
INERTEEN TRANSFORMERS

Instruction Book

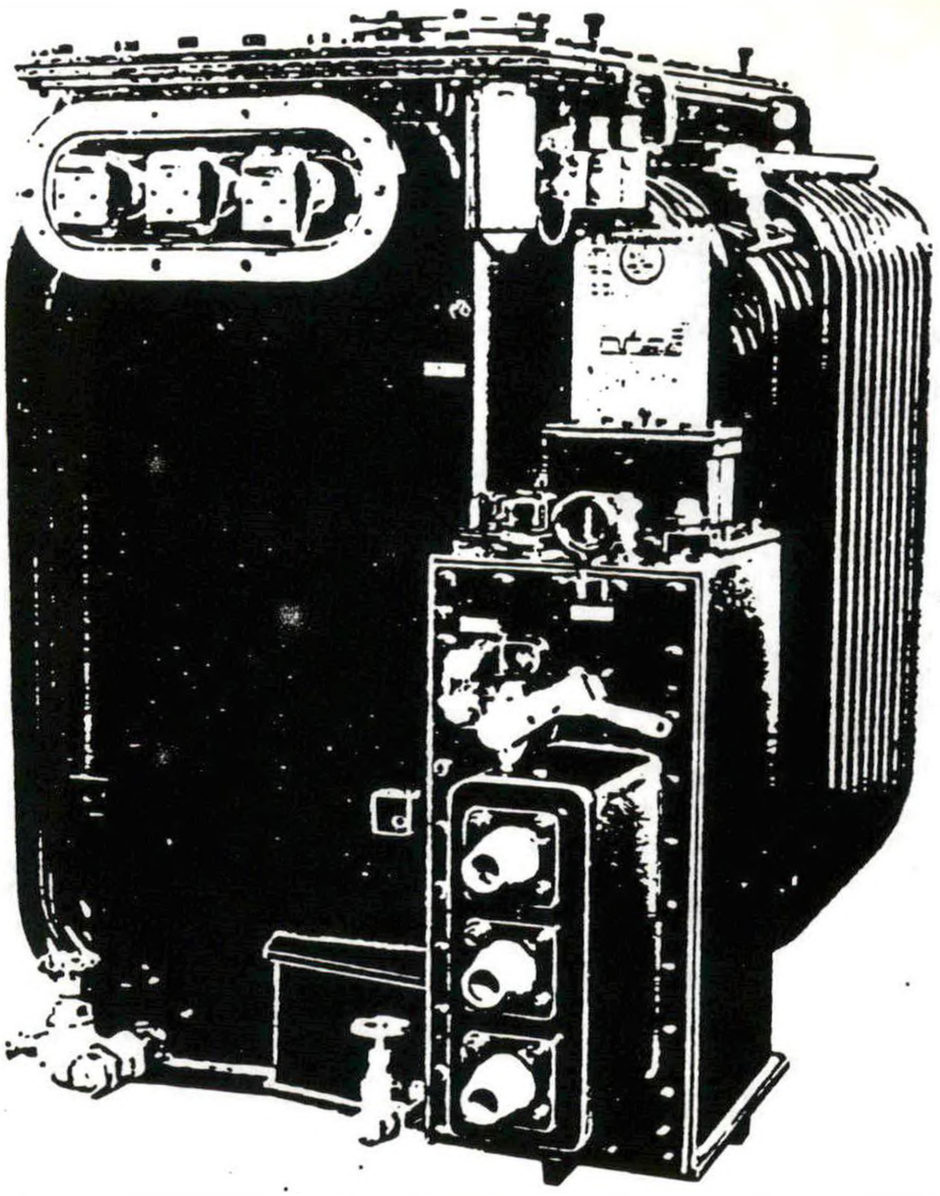

FIG. 1—800 KVA. INERTEEN TRANSFORMER

0854707

Westinghouse Electric & Manufacturing Company

Sharon Works

Sharon, Pa.

I. B. 5802
Filing No. 80-700

INDEX

INERTEEN

I N E R T E E N

Inerteen, developed by Westinghouse Engineers, is a synthetic non-inflammable and non-explosive insulating and cooling liquid used in Westinghouse Inerteen Transformers.

CHARACTERISTICS

Color	Straw-Yellow
Odor	Slightly Aromatic
Viscosity at 100°F. (Saybolt)	50 Seconds
Flash Point	None
Fire Point	None
Boiling Point	440°F.
Freezing Point	- 40°F.
Specific Gravity at 60°F.	1.555
Coefficient of Expansion per °C.	.00078
Specific Heat (Cal./cc)	.40
Dielectric Constant	4.42
Dielectric Strength	35 to 40 K.V.

Mineral oil is completely miscible with Inerteen. It is practically impossible to separate mineral oil and Inerteen; therefore, it is important to avoid contamination of Inerteen with any oil as the presence of such materials markedly changes the non-inflammable and non-explosive characteristics of Inerteen.

Inerteen is chemically stable. It is not affected by reaction with other materials used in the manufacture of Inerteen Transformers. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in transformers. Inerteen will not form sludge under any conditions.

Inerteen exerts a strong solvent action on most of the ordinary varnishes, gums and paints commonly used in oil-insulated transformers. Such materials, therefore, cannot be used in the design and construction of Inerteen Transformers. It is necessary to use such materials as pure cellulose, cotton, paper and porcelain. This requirement, coupled with the necessary use of tight-tank construction for Inerteen Transformers tends to give improved operating characteristics.

If Inerteen is decomposed by an electric arc, hydrogen chloride gas is evolved. In case of arcing, the products of arc decomposition are definitely harmful and the Inerteen will have to be reconditioned. Where severe arcing occurs, the solid insulation of the transformer would become saturated with the products of arc decomposition and the affected parts must be removed from the transformers.

With reference to the dielectric strength of Inerteen it compares favorably with and under average normal conditions will be found higher than that of transformer oil. The same precautions are necessary with Inerteen as are taken with transformer oil. Inerteen should be kept free of moisture, lint and dirt.

0854709

INERTEEN

Inerteen has an irritating effect upon the skin. This is more pronounced to some persons than to others. Especially the eyes, nose and lips are effected when coming in contact with Inerteen and certain safety precautions must be observed when handling it. When working with the hands in Inerteen, it will irritate skin abrasions or the tender parts between the fingers. Continued exposure may cause skin eruptions with certain individuals due to absorption of the Inerteen through the pores of the skin. Cleanliness among workmen handling Inerteen is essential and a very good safeguard against such effects. An application of castor oil is recommended for the eyes and castor oil or cold cream for the nose and lips. In case Inerteen comes in contact with the skin, the part should be thoroughly washed and cleaned. A supply of these materials should be kept available at all times where men are working with Inerteen.

Hot transformers should not be opened except in well ventilated places. Large quantities of Inerteen should be handled in a closed system. Workmen should be protected from frequent contact with any appreciable vapor concentration and from frequent skin contact with Inerteen.

In case Inerteen is spilled on one's clothing, it should be changed as soon as possible and the soiled clothing laundered before it is worn again. Special gloves, M-7530-6, which are resistant to Inerteen, should be worn where parts of transformers are handled wet.

SHIPMENT

Inerteen Transformers are always constructed in tight tanks which permit no breathing.

Inerteen Transformers are shipped properly filled with Inerteen and ready for installation. This prevents the entrance of moisture into the windings during transit and usually makes it unnecessary to dry the transformers prior to installation.

Transformers equipped with switch or terminal chamber which must be opened for installation, are always shipped with the Inerteen for these chambers in separate cans or steel drums.

Inerteen must always be kept in sealed containers to prevent the loss of its more volatile constituents by evaporation or possible contamination from dirt or moisture.

MOVING TRANSFORMERS

Lugs are provided for lifting the complete transformer, and when necessary, additional means are provided for lifting the different parts. The transformer should be lifted by the means provided and when necessary, spreaders should be used to obtain a balanced lift. Transformers should not be moved or lifted by placing jacks or other devices against or under cooling tubes, radiators, valves or other fittings. Skids should be used to distribute the stresses properly over the base when transformers are moved on rollers.

INSPECTION

Carefully inspect the transformers for possible damage during shipment.

This should include a check of the Inerteen level and at least the removal of the manhole to determine whether any parts have become loose or out of place and whether there is any evidence of moisture present. Insulation tests of the Inerteen should be made and if the dielectric strength is less than 22 K.V. or if there is any evidence of moisture, the transformer should be dried.

Inerteen Transformers are carefully tested at the Factory and in good condition when shipment is made but it is desirable to inspect every transformer carefully before placing it in service.

GROUNDING AND MAKING CONNECTIONS

No matter what the type of floor or foundation on which the transformer is to rest, the tank should be definitely and permanently grounded by connecting to the grounding connection provided for that purpose near the bottom of the tank.

Terminal board, tap changer and other connections should never be changed with voltage on the transformer. Do not make any connections except those indicated on the diagram or the diagram nameplate shipped with the transformer.

Any lead or connector not in use should be insulated from any other leads and connectors and from ground.

GASKETS

Gaskets used on Inerteen Transformers are made from a high grade cork and, it is recommended, in replacing any gaskets that they be made of cork. Before replacing a gasket, all gasket surfaces should be thoroughly cleaned free of rust, oil, grease, paint or other foreign materials. The cleaning may be done by scraping or wire-brushing and then wiping the gasket surface with denatured alcohol.

Gasket Cement, M-7386, especially developed for use with Inerteen, should always be used in applying gaskets to Inerteen Transformers. Thoroughly brush the cement on the tank surface, place the gasket in position and apply weights or other means to obtain good adhesion of the gasket to the metal surface. The gasket should be allowed to set approximately one-half hour before the weights are removed. Cement M-7386 should then be applied to the top surface of the gasket. The gasket surfaces must immediately be bolted together under a uniform pressure.

Some transformers are equipped with terminal or switch compartments into which cables enter by means of potheads. In such cases, it will be necessary to remove the switch-cover.

When transformers are designed for bayonet connections, it is only necessary to remove the bayonet pothead, make the cable connections and replace the pothead.

Extra gaskets with Cement M-7386, are furnished with all Inerteen Transformers where their installation requires the removal of any gaskets. Additional gaskets and cement should be ordered from the manufacturer.

PIPE FITTINGS

Care should be used to see that threads of pipe fittings are not damaged. Their threads should be thoroughly cleaned to remove all dirt, grease, etc. After cleaning, apply Cement M-7386 to the threads of each fitting. Immediately screw the proper fittings together tightly.

PRESSURE TESTING

Inerteen Transformers should be pressure tested before they are put into service. The tanks, including all compartments, should be subjected to a pressure of 7 lbs. per square inch for

at least six hours. Preferably, this test should be made after the transformer installation is complete and before voltage is applied to it. It is suggested that the air space above the Inerteen be blown out by using a nitrogen-cylinder, after which all vents should be closed and the pressure test applied. The test-pressure, in order to avoid subjecting the tank or compartment under test to excessive pressure, can best be limited by a regulating valve on the nitrogen-cylinder. A check for leaks above the Inerteen level can be made with a solution of soap and water applied to all gasketed joints, pipe fittings and wiping sleeve connections.

PAINT

Inerteen Transformers are finished with a special paint which is resistant to the solvent action of Inerteen. A sufficient quantity of this paint, M-7664-1, is furnished with each transformer to "touch up" any damage caused during the normal process of installation.

STORAGE

Inerteen Transformers must always be stored filled with Inerteen, otherwise a certain amount of moisture will most certainly accumulate on account of variations of air temperature. The Inerteen level should always be checked to see that it is at the proper point. Inerteen Transformers should be stored in a dry place, one where minimum temperature changes will occur.

If there is any reason to store coils, insulation or other parts for the complete core and coil assembly of an Inerteen Transformer, they should be immersed in Inerteen to prevent any moisture absorption. If such storage is necessary for a long period of time, the tank or storage container must be sealed to prevent the evaporation of Inerteen.

Inerteen Transformers which have been idle or stored for an appreciable length of time, should be put into service only after making certain that the transformer is dry and that the dielectric strength of the Inerteen tests 22,000 volts or higher.

MAINTENANCE

Inerteen Equipment

Care must be exercised in handling Inerteen to prevent contamination since impurities alter its non-inflammable and electrical characteristics. It must be handled in thoroughly clean containers free from oil. If there is any question concerning the cleanliness of the containers, they should be thoroughly washed with Trichlorbenzene, M-6872, and dried before any Inerteen is place in them. The transformer tank or any of its compartments in which Inerteen is used, must be free from oil.

Inerteen should not be mixed with vegetable oils since these materials affect the deterioration, D.C. resistance and otherwise contaminate it. Compounds of asphaltic nature, paraffin and ordinary soldering flux are particularly harmful to Inerteen.

For soldering, a solution of rosin in alcohol is recommended.

All-metal hose must be used in handling Inerteen since the lining used in most hose is soluble in Inerteen.

Filling Inerteen Transformers

When it is necessary to fill a transformer with Inerteen, one should make sure that all joints are tight; Cement M-7386 should be used for this purpose. Steel pipe or metal hose should be used, and preferably the transformer should be filled through the drain valve. This will keep aeration of the Inerteen to a minimum. See that air vents are open as the transformer is filled.

It is desirable to fill a transformer by passing the Inerteen through an Inerteen Conditioner. If this cannot be done and the Inerteen tests satisfactorily, fill the transformer by passing the Inerteen through three thicknesses of tightly woven white cloth, which has first been washed in Trichlorbenzene M-6872, and dried to remove any sizing. New cloths should be used for at least every two transformers.

When it is necessary to fill Inerteen Transformers out-of-doors and particularly on damp days due precaution must be taken to prevent the entrance of moisture into the transformer.

PERIODIC INSPECTIONS

Inerteen - It is desirable that top and bottom samples of Inerteen be taken from each transformer and tested after a short period of operation. When operating conditions permit, routine sampling of the Inerteen at intervals of six months is recommended. Accurate records should be kept of such inspections and tests, and if the Inerteen shows a dielectric strength of less than 16 K.V., the Inerteen Conditioner may be used. This depends somewhat on the transformer load cycle and climatic conditions. If no facilities are available for making dielectric tests on Inerteen, samples should be sent to the Westinghouse Electric & Manufacturing Company, Sharon Works, Sharon, Penna. Each sample of Inerteen should be properly identified by the transformer serial number and it should be recorded whether taken from the top or bottom of the tank or from a tank-compartment. Samples should be carefully packed to avoid breakage in transit. When any appreciable amount of Inerteen is removed from a transformer, it should be replaced with an equal amount of new Inerteen of proper dielectric strength so that the liquid level in the transformer is maintained.

Operation of Transformers - It is recommended that a periodic check be made of the operating temperatures of Inerteen transformers and that the temperature of the Inerteen be kept below 90°C. for a maximum-rated self-cooled transformer.

Paint - The external tank surfaces of Inerteen Transformers should be examined regularly for signs of corrosion. If appreciable corrosion is found, its cause should be determined and, if possible, remedied. Inerteen Transformer tanks are made from corrosion-resisting, copper-bearing steel, and they are finished with a high grade Inerteen-resisting paint which is baked on at high temperature. Any surface which is found corroded should be thoroughly cleaned to the bare metal and refinished with one coat of paint, M-6930, and two coats of paint, M-7664-1. Allow twelve hours drying time between each coat of paint.

TAKING SAMPLES OF INERTEEN

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for Inerteen Transformers be used for no other purpose. Care must be used in obtaining and sealing samples of Inerteen taken from a transformer.

Use only small tin containers with screw-metal gasket caps or small glass bottles with sealed glass stoppers for holding Inerteen samples.

If it becomes necessary to use other than Factory sampling containers, such containers should be thoroughly rinsed with clean gasoline, washed with strong soap suds and rinsed thoroughly in hot water, and then dried in an oven at approximately 110°C. for one hour. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

Inerteen sampling packages may be obtained from the Westinghouse Electric & Manufacturing Company, Sharon, Penna. This package consists of two 1-pint cans of Inerteen, packed and shipped in cardboard cartons. This Inerteen may be used to replace that removed from a transformer as a sample. If samples are not taken immediately after emptying the containers, the empty containers should be kept capped snugly to prevent admittance of moisture. The containers and carton should be used to return the samples of Inerteen to the Westinghouse Company.

It is desirable that samples of Inerteen be removed from a transformer tank or from a drum on clear days only and when the Inerteen is at least as warm as the surrounding air.

The sample of Inerteen should preferably be removed from the top of the tank and at a point 2 or 3" under the level of the Inerteen. It is recommended that a sample be taken also from the

bottom of the tank. If the sample is withdrawn through a valve connection, this connection should be flushed by allowing a small amount of Inerteen to run out before collecting the sample. The sample should be immediately placed in the container and the cap screwed on tightly. The sticker on each container should be marked to identify the sample of Inerteen with the transformer from which it was taken.

Before taking samples from a drum, the Inerteen should be allowed to settle for approximately twelve hours. Samples from the top of the drum should be removed by means of a clean glass sneak-thief.

The same precautions to prevent moisture contamination should be used in sampling Inerteen as are observed in taking transformer oil samples.

The samples of Inerteen properly identified and packed in cardboard cartons should be shipped to the Westinghouse Electric & Manufacturing Company, Sharon Works, Sharon, Penna.

DIELECTRIC TESTING OF INERTEEN

The same rules and precautions as normally followed in testing oil should be used in testing Inerteen, except as herein stated.

The test cup should be wiped clean with a clean, dry chamois and thoroughly rinsed with clean gasoline and allowed to dry before being used. The electrode spacing should be checked.

To determine whether the test cup is suitable for testing Inerteen, fill it with dry gasoline and test this under a standard voltage rise of 3 K.V. per second. If the dielectric strength of the gasoline is not less than 22 K.V., the test cup is suitable for testing Inerteen, after the cup has been dried in an oven to remove all traces of gasoline. Care should be exercised in handling gasoline. In testing, do not make but one "shot" per filling of the test cup. Five different fillings should be made and the average result used.

DRYING AND FILTERING INERTEEN

Inerteen may be dehydrated and filtered by means of an oil filter press but in order that it may not be contaminated, it is necessary that the filter press be used for Inerteen only.

A different procedure than that followed for oil is required to purify Inerteen. Contamination in Inerteen cannot be removed entirely by filter paper alone. To clean Inerteen thoroughly it must be filtered through "activated clay" which absorbs impurities. In practice, it is only necessary to pass the Inerteen through the clay and to separate the clay mechanically from the Inerteen to obtain clean Inerteen of proper dielectric strength.

THE INERTEEN CONDITIONER

The equipment recommended for conditioning Inerteen consists of a filter press with suitable inlet and outlet connections and the necessary fittings.

The clay is contained in five frames mounted in a yoke. Plates are used on both sides of these frames between which one piece of blotting paper is used to provide a gasket-seal and to remove fine particles of clay from the Inerteen.

The discharge in the plate incorporates a trap to avoid pumping into the transformer air which might result from a leak in the suction line. A strainer is provided on the suction side of the pump, so constructed that all dirt collected is removed with the screen. A by-pass connection fitted with a needle valve is used for testing the suction line from the transformer for leaks.

A pressure gage and a by-pass valve indicate the operation of the conditioner and they also serve as a check to avoid overloading and stalling the motor. The valve is set to by-pass the Inerteen at a pressure of 60 to 70 lbs. per square inch. Another pressure gage and by-pass valve are provided on the discharge side of the conditioner connecting to the transformer. This by-pass valve, releasing at a pressure of approximately 5 lbs. per square inch, will avoid breaking the transformer relief diaphragm when no other relief is provided.

TO PREPARE THE CONDITIONER FOR OPERATION

Release the pressure-screw and remove the frames. Fill each frame with activated clay, M-6934, to within 1/2" of the cover. Replace the frames in the conditioner, placing one sheet of "A" size blotting paper between the face of each frame and plate. Care should be used to see that the holes through the plates, frames and paper are in proper alignment before the pressure-screw is tightened. Close the discharge, suction and suction-test valves. Pour sufficient Inerteen into the drip pan to fill the conditioner and to wet the clay. This will require approximately 8 gallons of Inerteen. Start the motor and open the drip-pan valve so that not less than 5 minutes are required to fill the conditioner, saturating the clay with Inerteen. With the valve at the transformer closed, open the suction-test valve to check the suction line for leaks.

Since the density of Inerteen is considerably greater than that of water, moisture will float on the surface of the Inerteen. It is therefore considered advisable to condition Inerteen from the top and return it to the bottom of the tank. To begin conditioning Inerteen in a transformer, close the suction-test valve and stop the motor. Open the transformer valves. Open the conditioner discharge and suction valves. Close the drip-pan valve and start the motor.

One charge of clay will condition approximately 3000 gallons of Inerteen, depending upon the amount of contamination present. To change the clay, remove the frames and turn them over to allow any free Inerteen to drain out of the openings at the top. Dump the used clay and fill the frames with fresh clay as previously described.

When it is necessary to change the blotters or the clay, first close the valve in the suction line, then stop the motor and close the discharge valve before releasing the pressure-screw. Follow the procedure outlined above when starting up the conditioner again.

If the system-seal is not broken, it will only be necessary to open the discharge and suction valves and start the motor to again resume conditioning the Inerteen.

TO DRY INERTEEN TRANSFORMERS

Inerteen Transformers above 100 Kv-a. should be dried by the short-circuit method with the transformer in its tank immersed in the Inerteen. During the heating and drying process, the top of the tank should be vented to the air to prevent moisture condensation. The desired load current should be obtained by short-circuiting one winding and impressing the proper voltage on the other winding. If the full load impedance of the transformer is not known or not engraved on the transformer nameplate, it should be obtained from the Westinghouse Electric & Manufacturing Company by identifying the transformer with its serial number.

Transformer windings in Inerteen should first be heated under a partial load. A higher top Inerteen temperature can be obtained more quickly by blanketing the tank with the cover removed to prevent condensation.

If the transformer is at or lower than room temperature at the start of the drying process, from 125% to 150% full load current will hasten the heating. The temperature should be carefully watched and when the Inerteen reaches a temperature of 60°C., the load should be reduced to obtain an approximately constant Inerteen temperature based on the following table. These temperatures should not be exceeded for a given load.

Short Circuit Amperes in Percent of Load	Max. Temperature of Top Inerteen
50	80
75	75
85	70

The transformer may be dried more quickly if it is possible to filter the Inerteen during the drying process. If the

filtering is continuous, care should be taken to avoid letting the Inerteen temperature become too low. If any moisture condenses on the underside of the cover, the temperature should be decreased until it stops, and it should not be increased again until after a period of time of approximately four to eight hours, depending upon the size of the transformer.

The drying should be continued until dielectric tests of samples of the Inerteen taken from the top and bottom of the tank show 22 K.V. or higher. The tests should be made in a standard test cup and it is recommended that at least two consecutive tests of both the top and bottom Inerteen be made at least 24 hours apart while the Inerteen is near a maximum temperature. Tests of the Inerteen should not be made during the filtering process.

DRYING TRANSFORMERS BY HOT AIR

Inerteen transformers may be dried by blowing clean, dry hot air through them. The air should be at a temperature of approximately 90°C. and it should be blown through the core and coils from the bottom of the transformer and allowed to pass out at the top. The amount of air required to dry the transformer must be such that the temperatures of the ingoing and outgoing air are approximately alike.

IF INERTEEN TRANSFORMERS FAIL IN SERVICE

Should an Inerteen transformer fail in service, the nearest W. E. & M. Company District Office should be notified as soon as possible. Give the rating of the transformer and its serial number and, if possible, the conditions under which the failure took place. Samples of the Inerteen should be taken so that an analysis of it can be made. The transformer should be kept immersed in Inerteen and it is recommended that no work be done on the transformer except under advice from the District Office.

ACCESSORIES FOR INERTEEN TRANSFORMERS

Pressure Relief Diaphragms - All transformers of ratings larger than 25 Kv-a., are furnished with pressure relief diaphragms. This device is made in different sizes to provide ample venting for different ratings.

Relief diaphragms are regularly supplied with covers arranged for a pipe connection to carry the gases to the outside atmosphere in case of a transformer failure and after the diaphragm ruptures. It is recommended that this type of installation be used for indoor transformers. For outdoor transformers, the relief device is regularly provided with a perforated outlet which allows the gases to escape directly to the outside atmosphere. The outlet is covered by a hood which prevents the entrance of moisture and dirt. A screen under the diaphragm prevents broken pieces from falling into the transformer.

The relief diaphragm unit assembly, which is bolted to the transformer cover or other suitable place, consists of a supporting flange in which the glass diaphragm is mounted between two cork gaskets. A tight joint between gasket and diaphragm on the supporting flange is made by a pressure-ring against the lower gasket, all of which is clamped in place by stud bolts.

It is necessary to be very careful in bolting down the pressure-ring to avoid breakage of the glass diaphragm for its rupture strength depends largely upon having an even distribution of clamping pressure applied to the diaphragm.

Make sure that gasket seats are thoroughly clean. Apply Cement M-7386 to both sides of the upper gasket and put the glass diaphragm in place, being sure that both the gasket and the diaphragm are centrally located in the supporting flange. Lay the cushion or lower gasket in place over the glass diaphragm and assemble the pressure-ring over this gasket. Then tighten the assembly by means of the nuts and lock washers on the stud bolts.

An even distribution of pressure on the glass diaphragm can be obtained only by tightening the nuts uniformly. This should be done by tightening alternate nuts until the lock washers are nearly compressed. The other nuts should then be tightened in a similar manner. This alternate nut tightening should be continued until the face of the pressure-ring is against the metal gasket-stop.

Diaphragm relief devices are assembled on the transformer at the factory and they are then pressure-tested at 7 lbs. per square inch and shipped in place.

Two spare diaphragms and the necessary gaskets and cement are shipped with each transformer. Additional diaphragms, if needed, should be ordered from the W. E. & M. Company, Sharon, Pennsylvania, identified by the serial number of the transformer.

Gas Absorbers for Inerteen Transformers - When Inerteen transformers are equipped with gas absorbers, separate instructions are shipped with each transformer describing the device and its installation, operation and maintenance.

RENEWAL PARTS

When information is required concerning a transformer, always give its serial number, particularly whenever renewal or stock parts are ordered. The serial number will be found engraved on the nameplate attached to the transformer tank and on the small nameplate attached to the top or end of the core and coils assembly. Whenever possible, a sketch showing the part or parts and their exact locations, will materially help to assure that the proper parts are supplied by the Factory.. This sketch should always indicate the direction or side of the transformer from which the view is made.

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NOTE: Some transformers are ordered designed for Inerteen but are to be operated first as oil-insulated transformers. Consequently, they are shipped from the factory filled with oil. Whenever it is desired to operate these transformers with Inerteen, complete instructions for the removal of the oil, the cleaning of the transformer and filling it with Inerteen should be obtained from the W. E. & M. Company, Sharon, Pennsylvania.

Westinghouse

INERTEEN TRANSFORMERS

Instruction Book

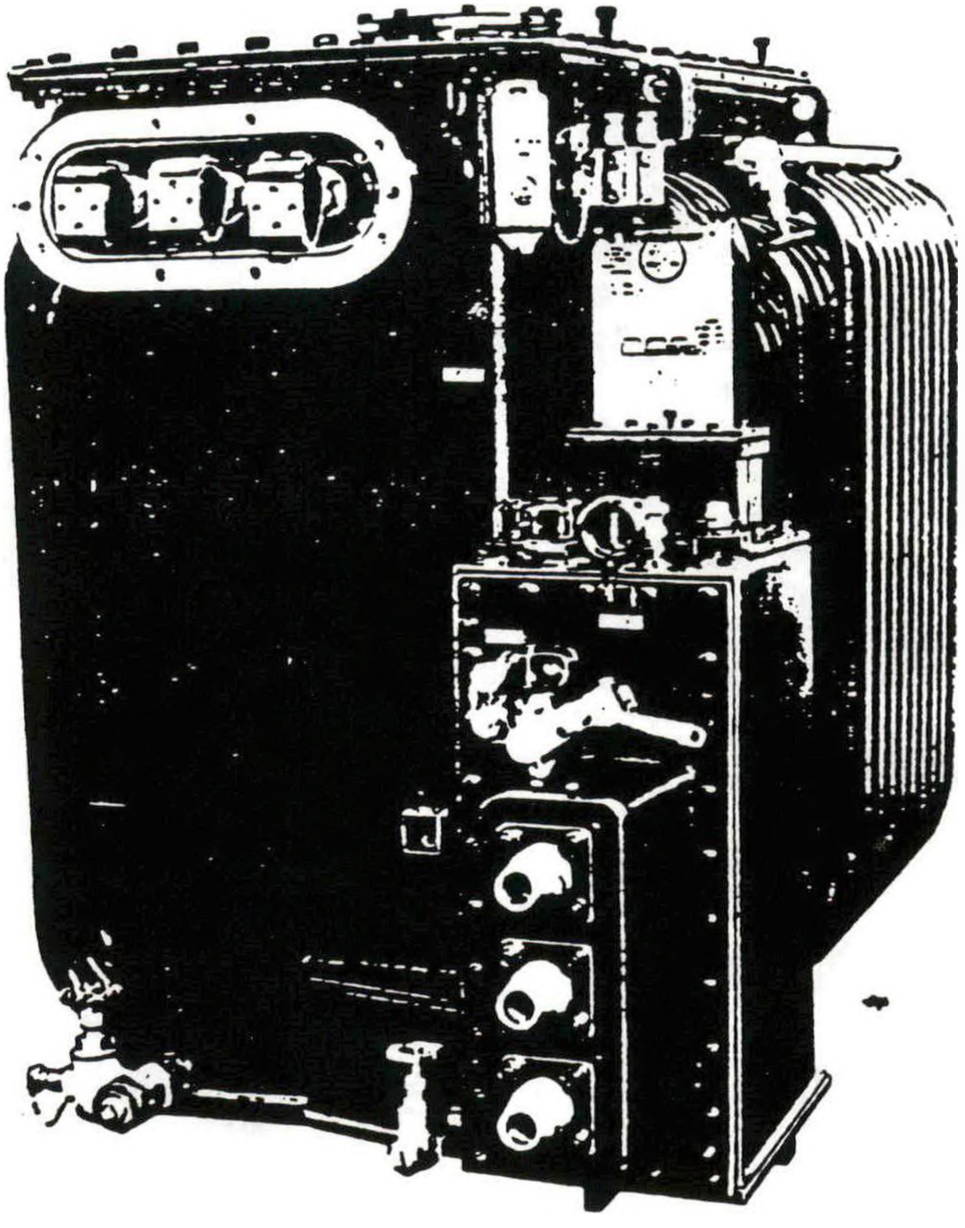

Fig. 1—500 KVA Inerteen Transformer

Westinghouse Electric & Manufacturing Company
Sharon Works, Sharon, Pa.

Printed in U.S.A. (Rep. 3-38)

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INERTEEN

INERTEEN TRANSFORMERS

INERTEEN

Inerteen, developed by Westinghouse Engineers, is a synthetic non-inflammable and non-explosive insulating and cooling liquid used in Westinghouse Inerteen Transformers.

Characteristics

Color	Straw-Yellow
Odor	Slightly Aromatic
Viscosity at 100°F. (Saybolt)	50 Seconds
Flash Point	None
Fire Point	None
Boiling Point	440°F.
Freezing Point	-40°F.
Specific Gravity at 60°F.	1.555
Coefficient of Expansion per °C.	.00078
Specific Heat (Cal./cc.	.40
Dielectric Constant	4.42
Dielectric Strength	35 to 40 K.V.

Mineral oil is completely miscible with Inerteen. It is practically impossible to separate mineral oil and Inerteen; therefore it is important to avoid contamination of Inerteen with any oil as the presence of such materials markedly changes the non-inflammable and non-explosive characteristics of Inerteen.

Inerteen is chemically stable. It is not affected by reaction with other materials used in the manufacture of Inerteen Transformers. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in transformers. Inerteen will not form sludge under any conditions.

Inerteen exerts a strong solvent action on most of the ordinary varnishes, gums and paints commonly used in oil-insulated transformers. Such materials, therefore, cannot be used in the design and construction of Inerteen transformers. It is necessary to use such materials as pure cellulose, cotton, paper and porcelain. This requirement, coupled with the necessary use of tight-tank construction for Inerteen Transformers tends to give improved operating characteristics.

If Inerteen is decomposed by an electric arc, hydrogen chloride gas is evolved. In case of arcing, the products of arc decomposition are definitely harmful and the Inerteen will have to be reconditioned. Where severe arcing occurs, the solid insulation of the transformer would become saturated with the products of arc decomposition and the affected parts must be removed from the transformer.

With reference to the dielectric strength of Inerteen it compares favorably with and under average normal conditions will be found higher than that of transformer oil. The same precautions are necessary with Inerteen as are taken with transformer oil. Inerteen should be kept free of moisture, lint and dirt.

Inerteen has an irritating effect upon the skin. This is more pronounced to some persons than to others. Especially the eyes, nose and lips are affected when coming in contact with Inerteen and certain safety precautions must be observed when handling it. When working with the material in Inerteen, it will irritate skin abrasions or tender parts between the fingers. Continued exposure may cause skin erruptions with certain individuals due to absorption of the Inerteen through the pores of the skin. Cleanliness among workmen handling Inerteen is essential and a very good safeguard against such effects. An application of castor oil is recommended for the eyes and castor oil or cold cream for the nose and lips. In case Inerteen comes in contact with the skin, the part should be thoroughly washed and cleaned. A supply of these materials should be kept available at all times where men are working with Inerteen.

Hot transformers should not be opened except in well ventilated places. Large quantities of Inerteen should be handled in a cooled system. Workmen should be protected from frequent contact with any appreciable vapor concentration and from frequent skin contact with Inerteen.

In case Inerteen is spilled on one's clothing, it should be changed as soon as possible and the soiled clothing laundered before it is worn again. Special gloves, M-7530-E which are resistant to Inerteen, should be worn where parts of transformers are handled wet.

INERTEEN TRANSFORMERS

Shipment

Inerteen Transformers are always constructed in tight tanks which permit no breathing.

Inerteen Transformers are shipped properly filled with Inerteen and ready for installation. This prevents the entrance of moisture into the windings during transit and usually makes it unnecessary to dry the transformers prior to installation.

Transformers equipped with switch or terminal chamber which must be opened for installation, are always shipped with the Inerteen for these chambers in separate cans or steel drums.

Inerteen must always be kept in sealed containers to prevent the loss of its more volatile constituents by evaporation or possible contamination from dirt or moisture.

Moving Transformers

Lugs are provided for lifting the complete transformer, and when necessary, additional means are provided for lifting the different parts. The transformer should be lifted by means provided and when

necessary, spreaders should be used to obtain a balanced lift. Transformers should not be moved or lifted by placing jacks or other devices against or under cooling tubes, radiators, valves or other fittings. Skids should be used to distribute the stresses properly over the base when transformers are moved on rollers.

INSPECTION

Carefully inspect the transformers for possible damage during shipment.

This should include a check of the Inerteen level and at least the removal of the manhole to determine whether any parts have become loose or out of place and whether there is any evidence of moisture present. Insulation tests of the Inerteen should be made and if the dielectric strength is less than 22 K.V. or if there is any evidence of moisture, the transformer should be dried.

Inerteen Transformers are carefully tested at the Factory and in good condition when shipment is made but it is desirable to inspect every transformer carefully before placing it in service.

Grounding and Making Connections

No matter what the type of floor or foundation on which the transformer is to rest, the tank should be definitely and permanently grounded by connecting to the grounding connection provided for that purpose near the bottom of the tank.

Terminal board, tap changer and other connections should never be changed with voltage on the transformer. Do not make any connections except those indicated on the diagram or the diagram nameplate shipped with the transformer.

Any lead or connector not in use should be insulated from any other leads and connectors and from ground.

Gaskets

Gaskets used on Inerteen Transformers are made from a high grade cork and, it is recommended, in replacing any gaskets that they be made of cork. Before replacing a gasket, all gasket surfaces should be thoroughly cleaned free of rust, oil, grease, paint or other foreign materials. The cleaning may be done by scraping or wire-brushing and then wiping the gasket surface with denatured alcohol.

Gasket Cement, M-7386, especially developed for use with Inerteen, should always be used in applying gaskets to Inerteen Transformers. Thoroughly brush the cement on the tank surface, place the gasket in position and apply weights or other means to obtain good adhesion of the gasket to the metal surface. The gasket should be allowed to set approximately one-half hour before the weights are removed. Cement M-7386 should then be applied to the top surface of the gasket. The gasket surfaces must immediately be bolted together under a uniform pressure.

Some transformers are equipped with terminal or switch compartments into which cables enter by means of potheads. In such cases, it will be necessary to remove the switch-cover.

When transformers are designed for bayonet connections, it is only necessary to remove the bayonet pothead, make the cable connections and replace the pothead.

Extra gaskets with Cement M-7386, are furnished with all Inerteen Transformers where their installation requires the removal of any gaskets. Additional gaskets and cement should be ordered from the manufacturer.

Pipe Fittings

Care should be used to see that threads of pipe fittings are not damaged. Their threads should be thoroughly cleaned to remove all dirt, grease, etc. After cleaning, apply Cement M-7386 to the threads of each fitting. Immediately screw the proper fittings together tightly.

Pressure Testing

Inerteen Transformers should be pressure tested before they are put into service. The tanks, including all compartments, should be subjected to a pressure of 7 lbs. per square inch for at least six hours. Preferably, this test should be made after the transformer installation is complete and before voltage is applied to it. It is suggested that the air space above the Inerteen be blown out by using a nitrogen-cylinder, after which all vents should be closed and the pressure test applied. The test-pressure, in order to avoid subjecting the tank or compartment under test to excessive pressure, can best be limited by a regulating valve on the nitrogen-cylinder. A check for leaks above the Inerteen level can be made with a solution of soap and water applied to all gasketed joints, pipe fittings and wiping sleeve connections.

Paint

Inerteen Transformers are finished with a special paint which is resistant to the solvent action of Inerteen. A sufficient quantity of this paint, M-7664-1, is furnished with each transformer to "touch up" any damage caused during the normal process of installation.

Storage

Inerteen Transformers must always

be stored filled with Inerteen, otherwise a certain amount of moisture will most certainly accumulate on account of variations of air temperature. The Inerteen level should always be checked to see that it is at the proper point. Inerteen Transformers should be stored in a dry place, one where minimum temperature changes will occur.

If there is any reason to store coils, insulation or other parts for the complete core and coil assembly of an Inerteen Transformer, they should be immersed in Inerteen to prevent any moisture absorption. If such storage is necessary for a long period of time, the tank or storage container must be sealed to prevent the evaporation of Inerteen.

Inerteen Transformers which have been idle or stored for an appreciable length of time, should be put into service only after making certain that the transformer is dry and that the dielectric strength of the Inerteen tests 22,000 volts or higher.

Maintenance

Inerteen Equipment - Care must be exercised in handling Inerteen to prevent contamination since impurities alter its non-inflammable and electrical characteristics. It must be handled in thoroughly clean containers free from oil. If there is any question concerning the cleanliness of the containers, they should be thoroughly washed with Trichlorbenzene, M-6872, and dried before any Inerteen is placed in them. The transformer tank or any of its compartments in which Inerteen is used, must be free from oil.

Inerteen should not be mixed with vegetable oils since these materials affect the deterioration, D.C. resistance and otherwise contaminate it. Compounds of asphaltic nature, paraffin and ordinary soldering flux are particularly harmful to Inerteen.

For soldering, a solution of rosin in alcohol is recommended.

All-metal hose must be used in handling Inerteen since the lining used in most hose is soluble in Inerteen.

Filling Inerteen Transformers - When it is necessary to fill a transformer with Inerteen one should make sure that all joints are tight; Cement M-7386 should be used for this purpose. Steel pipe or metal hose should be used, and preferably the transformer should be filled through the drain valve. This will keep aeration of the Inerteen to a minimum. See that air vents are open as the transformer is filled.

It is desirable to fill a transformer by passing the Inerteen through an Inerteen Conditioner. If this cannot be done and the Inerteen tests satisfactorily, fill the transformer by passing the Inerteen through three thicknesses of tightly woven white cloth, which has first been washed in Trichlorbenzene M-6872, and dried to remove any sizing. New cloths should be used for at least every two transformers.

When it is necessary to fill Inerteen transformers out-of-doors and particularly on damp days due precaution must be taken to prevent the entrance of moisture into the transformer.

Periodic Inspections

Inerteen - It is desirable that top and bottom samples of Inerteen be taken from each transformer and tested after a short period of operation. When operating conditions permit, routine sampling of the Inerteen at intervals of six months is recommended. Accurate records should be kept of such inspections and tests, and if the Inerteen shows a dielectric strength of less than 16 K.V., the Inerteen Conditioner may be used. This depends somewhat on the transformer load cycle and climatic conditions. If no facilities are available for making dielectric tests on Inerteen, samples should be sent to the Westinghouse Electric & Manufacturing Company, Sharon Works, Sharon, Penna. Each sample of Inerteen should be properly identified by the transformer serial number and it should be recorded whether taken from the top or bottom of the tank or from a tank-compartment. Samples should be carefully packed to avoid breakage in transit. When any appreciable amount of Inerteen is removed from a transformer, it should be replaced with an equal amount of new Inerteen of proper dielectric strength so that the liquid level in the transformer is maintained.

Operation of Transformers - It is recommended that a periodic check be made of the operating temperatures of Inerteen transformers and that the temperature of the Inerteen be kept below 90°C. for a maximum-rated self-cooled transformer.

Paint - The external tank surfaces of Inerteen Transformers should be examined regularly for signs of corrosion. If appreciable corrosion is found, its cause should be determined and, if possible, remedied. Inerteen Transformer tanks are made from corrosion-resisting, copper-bearing steel, and they are finished with a high grade Inerteen-resisting paint which is baked on at high temperature. Any surface which is found corroded should be thoroughly cleaned to the bare metal and refinished with one coat of paint, M-6930, and two coats of paint, M-7664-1. Allow twelve hours drying time between each coat of paint.

Taking Samples of Inerteen

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for Inerteen Transformers be used for no other purpose. Care must be used in obtain-

ing and sealing samples of Inerteen taken from a transformer.

Use only small tin containers with screw-metal gasket caps or small glass bottles with sealed glass stoppers for holding Inerteen samples.

If it becomes necessary to use other than factory sampling containers, such containers should be thoroughly rinsed with clean gasoline, washed with strong soap suds and rinsed thoroughly in hot water, and then dried in an oven at approximately 110°C. for one hour. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

Inerteen sampling packages S# 1065658 may be obtained from the Westinghouse Electric & Manufacturing Company, Sharon, Penna. This package consists of two 1-pint cans of Inerteen, packed and shipped in cardboard cartons. This Inerteen may be used to replace that removed from a transformer as a sample. If samples are not taken immediately after emptying the containers, the empty containers should be kept capped snugly to prevent admittance of moisture. The containers and carton should be used to return the samples of Inerteen to the Westinghouse Company.

It is desirable that samples of Inerteen be removed from a transformer tank or from a drum on clear days only and when the Inerteen is at least as warm as the surrounding air.

The sample of Inerteen should preferably be removed from the top of the tank and at a point 2 or 3" under the level of the Inerteen. It is recommended that a sample be taken also from the bottom of the tank. If the sample is withdrawn through a valve connection, this connection should be flushed by allowing a small amount of Inerteen to run out before collecting the sample. The sample should be immediately placed in the container and the cap screwed on tightly. The sticker on each container should be marked to identify the sample of Inerteen with the transformer from which it was taken.

Before taking samples from a drum, the Inerteen should be allowed to settle for approximately twelve hours. Samples from the top of the drum should be removed by means of a clean glass sneak-thief.

The same precautions to prevent moisture contamination should be used in sampling Inerteen as are observed in taking transformer oil samples.

The samples of Inerteen properly identified and packed in cardboard cartons should be shipped to the Westinghouse Electric & Manufacturing Company, Sharon Works, Sharon, Penna.

Dielectric Testing of Inerteen

The same rules and precautions as normally followed in testing oil should be used in testing Inerteen, except as herein stated.

The test cup should be wiped clean with a clean, dry chamois and thoroughly rinsed with clean gasoline and allowed to dry before being used. The electrode spacing should be checked.

To determine whether the test cup is suitable for testing Inerteen, fill it with dry gasoline and test this under a standard voltage rise of 3 K.V. per second. If the dielectric strength of the gasoline is not less than 22 K.V. the test cup is suitable for testing Inerteen, after the cup has been dried in an oven to remove all traces of gasoline. Care should be exercised in handling gasoline. In testing, do not make but one "shot" per filling of the test cup. Five different fillings should be made and the average result used.

Drying and Filtering Inerteen

Inerteen may be dehydrated and filtered by means of an oil filter press but in order that it may not be contaminated, it is necessary that the filter press be used for Inerteen only.

A different procedure than that followed for oil is required to purify Inerteen. Contamination in Inerteen cannot be removed entirely by filter paper alone. To clean Inerteen thoroughly it must be filtered through "activated clay" which absorbs impurities. In practice, it is only necessary to pass the Inerteen through the clay and to separate the clay mechanically from the Inerteen to obtain clean Inerteen of proper dielectric strength.

The Inerteen Conditioner

The equipment recommended for conditioning consists of a filter press with suitable inlet and outlet connections and the necessary fittings.

The clay is contained in five frames mounted in a yoke. Plates are used on both sides of these frames between which one piece of blotting paper is used to provide a gasket-seal and to remove fine particles of clay from the Inerteen.

The discharge in the plate incorporates a trap to avoid pumping into the transformer air which might result from a leak in the suction line. A strainer is provided on the suction side of the pump, so constructed that all dirt collected is removed with the screen. A by-pass connection fitted with a needle valve is used for testing the suction line from the transformer for leaks.

A pressure gage and a by-pass valve indicate the operation of the conditioner and

they also serve as a check to avoid overloading and stalling the motor. The valve is set to by-pass the Inerteen at a pressure of 60 to 70 lbs. per square inch. Another pressure gage and by-pass valve are provided on the discharge side of the conditioner connecting to the transformer. This by-pass valve, releasing at a pressure of approximately 5 lbs. per square inch, will avoid breaking the transformer relief diaphragm when no other relief is provided.

To Prepare The Conditioner For Operation

Release the pressure-screw and remove the frames. Fill each frame with activated clay, M-6935, to within 1/2" of the cover. Replace the frames in the conditioner, placing one sheet of "A" size blotting paper between the face of each frame and plate. Care should be used to see that the holes through the plates, frames and paper are in proper alignment before the pressure-screw is tightened. Close the discharge, suction and suction-test valves. Pour sufficient Inerteen into the drip pan to fill the conditioner and to wet the clay. This will require approximately 8 gallons of Inerteen. Start the motor and open the drip pan valve so that not less than 5 minutes are required to fill the conditioner, saturating the clay with Inerteen. With the valve at the transformer closed, open the suction-test valve to check the suction line for leaks.

Since the density of Inerteen is considerably greater than that of water, moisture will float on the surface of the Inerteen. It is therefore considered advisable to condition Inerteen from the top and return it to the bottom of the tank. To begin conditioning Inerteen in a transformer, close the suction test valve and stop the motor. Open the transformer valves. Open the conditioner discharge and suction valves. Close the drip pan valve and start the motor.

One charge of clay will condition approximately 3000 gallons of Inerteen, depending upon the amount of contamination present. To change the clay, remove the frames and turn them over to allow any free Inerteen to drain out of the openings at the top. Dump the used clay and fill the frames with fresh clay as previously described.

When it is necessary to change the blotters or the clay, first close the valve in the suction line, then stop the motor and close the discharge valve before releasing the pressure-screw. Follow the procedure outlined above when starting up the conditioner again.

If the system-seal is not broken, it will only be necessary to open the discharge and suction valves and start the motor to again resume conditioning the Inerteen.

To Dry Inerteen Transformers

Inerteen Transformers above 100 Kv-a. should be dried by the short-circuit method with the transformer in its tank immersed in the Inerteen. During the heating and drying process, the top of the tank should be vented to the air to prevent moisture condensation. The desired load current should be obtained by short-circuiting one winding and impressing the proper voltage on the other winding. If the full load impedance of the transformer is not known or not engraved on the transformer nameplate, it should be obtained from the Westinghouse Electric & Manufacturing Company by identifying the transformer with its serial number.

Transformer windings in Inerteen should first be heated under a partial load. A higher top Inerteen temperature can be obtained more quickly by blanketing the tank with the cover removed to prevent condensation.

If the transformer is at or lower than room temperature at the start of the drying process, from 125% to 150% full load current will hasten the heating. The temperature should be carefully watched and when the Inerteen reaches a temperature of 60°C., the load should be reduced to obtain an approximately constant Inerteen temperature based on the following table. These temperatures should not be exceeded for a given load

Short Circuit Amperes in Percent of Load	Max. Temperature of Top Inerteen
50	80
75	75
85	70

The transformer may be dried more quickly if it is possible to filter the Inerteen during the drying process. If the filtering is continuous, care should be taken to avoid letting the Inerteen temperature become too low. If any moisture condenses on the underside of the cover, the temperature should be decreased until it stops, and it should not be increased again until after a period of time of approximately four to eight hours, depending upon the size of the transformer.

The drying should be continued until dielectric tests of samples of the Inerteen taken from the top and bottom of the tank show 22 K.V. or higher. The tests should be made in a standard test cup and it is recommended that at least two consecutive tests of both the top and bottom Inerteen be made at least 24 house apart while the Inerteen is near a maximum temperature. Tests of the Inerteen should not be made during the filtering process.

Drying Transformers by Hot Air

Inerteen transformers may be dried by blowing clean, dry hot air through them. The air should be at a temperature of approximately 90°C.

and it should be blown through the core and coils from the bottom of the transformer and allowed to pass out at the top. The amount of air required to dry the transformer must be such that the temperatures of the ingoing and outgoing air are approximately alike.

If Inerteen Transformers Fail in Service

Should an Inerteen transformer fail in service, the nearest W. E. & M. Company District Office should be notified as soon as possible. Give the rating of the transformer and its serial number and, if possible, the conditions under which the failure took place. Samples of the Inerteen should be taken so that an analysis of it can be made. The transformer should be kept immersed in Inerteen and it is recommended that no work be done on the transformer except under advice from the District Office.

Accessories for Inerteen Transformers

Pressure Relief Diaphragms - All transformers of ratings larger than 25 Kv-a., are furnished with pressure relief diaphragm. This device is made in different sizes to provide ample venting for different ratings.

Relief diaphragms are regularly supplied with vers arranged for a pipe connection to carry the gases to the outside atmosphere in case of a transformer failure and after the diaphragm ruptures. It is recommended that this type of installation be used for indoor transformers. For outdoor transformers, the relief device is regularly provided with a perforated outlet which allows the gases to escape directly to the outsied atmosphere.. The outlet is covered by a hood which prevents the entrance of moisture and dirt. A screen under the diaphragm prevents broken pieces from falling into the transformer.

The relief diaphragm unit assembly, which is bolted to the transformer cover or other suitable place, consists of a supporting flange in which the glass diaphragm is mounted between two cork gaskets. A tight joint between gasket and diaphragm on the supporting flange is made by a pressure ring against the lower gasket, all of which is clamped in place by stud bolts.

It is necessary to be very careful bolting down the pressure-ring to avoid breakage of the glass diaphragm for rupture strength depends largely upon having an even distribution of clamping pressure applied to the diaphragm.

Make sure that gasket seats are thoroughly clean. Apply Cement M-7386 to both sides of the upper gasket and put the glass diaphragm in place, being sure that both the gasket and the diaphragm are centrally located in the supporting flange. Lay the cushion or lower gasket in place over the glass diaphragm and assemble the pressure ring over this gasket. Then tighten the assembly by means of the nuts and lock washers on the stud bolts.

An even distribution of pressure on the glass diaphragm can be obtained only by tightening the nuts uniformly. This should be done by tightening alternate nuts until the lock washers are nearly compressed. The other nuts should then be tightened in a similar manner. This alternate nut tightening should be continued until the face of the pressure-ring is against the metal gasket-stop.

Diaphragm relief devices are assembled on the transformer at the factory and they are then pressure-tested at 7 lbs. per square inch and shipped in place.

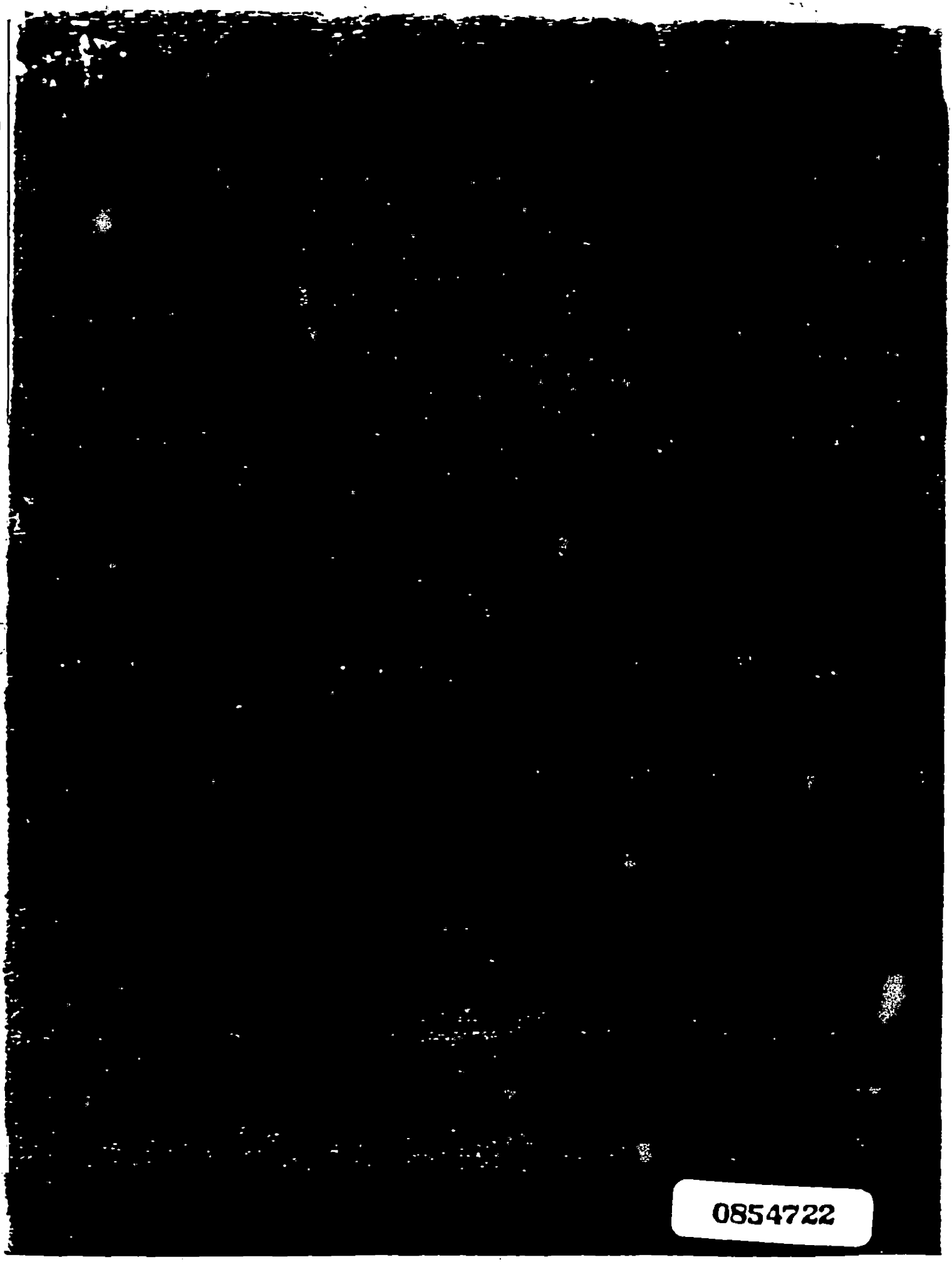
Two spare diaphragms and the necessary gaskets and cement are shipped with each transformer. Additional diaphragms, if needed, should be ordered from the W. E. & M. Company, Sharon, Pennsylvania, identified by the serial number of the transformer.

Gas Absorbers for Inerteen Transformers-- When Inerteen transformers are equipped with gas absorbers, separate instructions are shipped with each transformer describing the device and its installation, operation and maintenance.

Reneval Parts

When information is required concerning a transformer, always give its serial number particularly whenever reneval or stock parts are ordered. The serial number will be found engraved on the nameplate attached to the transformer tank and on the small nameplate attached to the top or end of the core and coils assembly. Whenever possible, a sketch showing the part or parts and their exact locations, will materially help to assure that the proper parts are supplied by the Factory. This sketch should always indicate the direction or side of the transformer from which the view is made.

NOTE: Some transformers are ordered designed for Inerteen but are to be operated first as oil-insulated transformers. Consequently, they are shipped from the factory filled with oil. Whenever it is desired to operate these transformers with Inerteen, complete instructions for the removal of the oil, the cleaning of the transformer and filling it with Inerteen should be obtained from the W. E. & M. Company, Sharon, Pennsylvania.



Westinghouse Exhibit 3

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INERTEEN

Inerteen is a synthetic non-inflammable and non-explosive insulating and cooling liquid used in Westinghouse Inerteen Transformers.

Characteristics

Color	Straw Yellow
Viscosity at 100°F. (Saybolt)	54 Seconds
Fire Point	None
Specific Gravity at 60°F.	1.564
Dielectric Constant	4.5

Mineral oil is completely miscible with transformer Inerteen. It is practically impossible to separate mineral oil and Inerteen; therefore it is important to avoid contamination of Inerteen with any oil as the presence of such materials markedly changes the non-inflammable and non-explosive characteristics of Inerteen.

Inerteen is chemically stable. It is not affected by reaction with other materials used in the manufacture of Inerteen Transformers. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in transformers. Inerteen will not form sludge under any conditions.

Inerteen exerts a strong solvent action on most of the ordinary varnishes, gums and paints commonly used in oil-insulated transformers. Such materials, therefore, are not used in the design and construction of Inerteen Transformers. It is necessary to use such materials as pure cellulose, cotton, paper and porcelain. This requirement, coupled with the necessary use of tight-tank construction for Inerteen Transformers tends to give improved operating characteristics. The operating experience with Inerteen Transformers indicates that Inerteen requires less maintenance than oil.

If Inerteen is decomposed by an electric arc, hydrogen chloride gas is evolved. The products of arc decomposition are harmful to the transformer structure. Where severe arcing occurs, the solid insulation of the transformer becomes saturated with hydrogen chloride and the affected parts must be removed in the repair of the transformer.

The dielectric strength of Inerteen compares favorably with and under average normal conditions will be found higher than that of transformer oil. The same precautions are necessary with Inerteen as are taken with transformer oil. Inerteen should be kept free of moisture, lint and dirt.

Inerteen has an irritating effect upon the skin. This is more pronounced to some persons than to others. Especially the eyes, nose and lips are affected when coming in contact with Inerteen and certain safety precautions must be observed when handling it. When working with the hands in Inerteen, it will irritate skin abrasions or the tender parts between the fingers. Continued exposure may cause skin eruptions with certain individuals due to absorption of the Inerteen through the pores of the skin. Cleanliness among workmen handling Inerteen is essential and a very good safeguard against such effects. An application of castor oil is recommended for the eyes and castor oil or cold cream for the nose and lips. In case Inerteen comes in contact with the skin, the part should be thoroughly washed and cleaned. A supply of these materials should be kept available at all times where men are working with Inerteen.

Hot transformers should not be opened except in well ventilated places. Large quantities of Inerteen should be handled in a closed system. Workmen should be protected from frequent contact with any appreciable vapor concentration and from frequent skin contact with Inerteen.

In case Inerteen is spilled on one's clothing, it should be changed as soon as possible and the soiled clothing laundered before it is worn again. Gloves, #1184650, which are resistant to Inerteen, should be worn where it is necessary to put one's hand in Inerteen or where parts of transformers are handled wet.

INERTEEN TRANSFORMERS

Shipment

Inerteen Transformers are always constructed in pressure-tight tanks.

Inerteen transformers are shipped properly filled with Inerteen and ready for installation. This prevents the entrance of moisture into the windings during transit and usually makes it unnecessary to dry the transformers prior to installation.

Transformers equipped with switch or terminal chambers which must be opened for installation, are shipped with the Inerteen for these chambers in separate containers.

A small amount of moisture will reduce the dielectric strength of Inerteen. It may be present in vapor form in the gas space above the Inerteen level or from minute leaks.

Activated clay has a high affinity for moisture and absorbs other materials which may contaminate Inerteen. To keep the Inerteen in the best condition, bonded tubes of activated clay are installed and shipped in place in switch and terminal chambers of new transformers. When the Inerteen is shipped in separate containers the tubes are also shipped separately, enclosed in air-tight containers.

Inerteen must always be kept in sealed containers to prevent the loss of its more volatile constituents by evaporation or possible contamination from dirt or moisture.

Moving Transformers

Lugs are provided for lifting the complete transformer, and when necessary, additional means are provided for lifting the different parts. The transformer should be lifted by the means provided and when necessary, spreaders should be used to obtain a balanced lift. Transformers should not be moved or lifted by placing jacks or other devices against or under cooling tubes, radiators, valves or other fittings. Skids should be used to distribute the stresses properly over the base when transformers are moved on rollers.

Inspection

Carefully inspect the transformers for possible damage during shipment.

This should include a check of the Inerteen level and at least the removal of the manhole cover to determine whether any parts have become loose or out of place and whether there is any evidence of moisture present. Insulation tests of the Inerteen should be made and if the dielectric strength is less than 22 KV or if there is any evidence of moisture, the transformer should be dried.

Where transformers are to be used at high altitude (more than 3000 ft. above sea level) a fitting above the liquid level should be opened to equalize the internal and external pressures at a temperature of approximately 25°C. before placing the transformer in service. Be sure that the fitting is closed after equalizing the pressure.

All transformers are carefully tested at the Factory and in good condition when shipment is made but it is desirable to inspect each transformer thoroughly before placing it in service.

Grounding and Making Connections

No matter what the type of floor or foundation on which the transformer is to rest, the tank should be definitely and permanently grounded by connecting a lead to the grounding connection provided for that purpose near the bottom of the tank.

Terminal board, tap changer and other connections should never be changed with voltage on the transformer. Do not make any connections except those indicated on the diagram or the diagram nameplate shipped with the transformer.

Any lead or connector not in use should be insulated from all other leads and connectors and from ground.

Gaskets

Gaskets used on Inerteen Transformers are made from a high grade of cork and, it is recommended, in replacing any gaskets that they be made of cork. Before replacing a gasket, all gasket surfaces should be thoroughly cleaned free of rust, oil, grease, paint or other foreign materials. The cleaning may be done by scraping or wire-brushing and then wiping the gasket surface with denatured alcohol.

Gasket Cement S#471880* especially developed for use with Inerteen, should always be used in applying gaskets. Thoroughly brush the cement on the tank surface and on the bottom side of the gasket. Place the gasket in position and apply weights or other means to obtain good adhesion of the gasket to the metal surface. The gasket should be allowed to set approximately one-half hour before the weights are removed. Cement should then be applied to the top surface of the gasket. The gasket surfaces must immediately be bolted together under a uniform pressure.

Transformers are frequently equipped with terminal or switch compartments into which cables enter by means of potheads. In some cases, it will be necessary to remove the switch-cover to make the cable connections.

When transformers are designed for bayonet connections, it is only necessary to remove the bayonet pothead, make the cable connections and replace the pothead.

Extra gaskets and Cement S#471880 are furnished with all Inerteen Transformers where their installation requires the removal of any gaskets. Additional gaskets and cement should be ordered from the manufacturer.

Pipe Fittings

Care should be taken to see that threads of pipe fittings are not damaged. All threads should be thoroughly cleaned to remove dirt, grease, etc. After cleaning, apply Cement S# 471880 to the threads of each fitting. Immediately screw the proper fittings together tightly.

Pressure Testing

All Inerteen transformers are pressure tested at the factory and shipped free of leaks. After installation and before voltage is applied, it is desirable to pressure test each transformer especially if any fittings or covers have been removed and replaced during the installation. Dry compressed nitrogen or air should be used at a test pressure of 7 lbs. per square inch for a period of six hours. It is suggested that the air space above the Inerteen be blown out with nitrogen, all vents closed and the pressure test applied. The test pressure can best be limited by the use of a regulating valve on the nitrogen cylinder. A check for leaks above the Inerteen level may be made with a solution of soap and water applied to all gasketed-joints, screwed-fittings and wiping-sleeve connections.

Paint

Inerteen Transformers are finished with a special paint, which is resistant to the solvent action of Inerteen. A sufficient quantity of this paint S#302509 is furnished with each transformer to "touch up" any places damaged during the process of installation.

Storage

Inerteen Transformers must always be stored filled to the proper level with Inerteen, otherwise a certain amount of moisture may accumulate on account of variations of air temperature. Inerteen Transformers should be stored in a dry place, and where minimum temperature changes will occur.

Where it is necessary to temporarily store coils, insulation or other parts for the complete core and coil assembly of an Inerteen Transformer, they should be immersed in Inerteen to prevent moisture absorption. If such storage is necessary for a long period of time, the tank or storage container must be sealed to prevent the entrance of moisture and the evaporation of Inerteen.

Inerteen Transformers which have been idle or stored for an appreciable length of time, should be put into service only after making cer-

*Quart Can.

tain that the transformer is dry and that the dielectric strength of the Inerteen tests 22,000 volts or higher. The inspection instructions should also be followed.

Maintenance

Inerteen Equipment - Care must be exercised in handling Inerteen to prevent contamination since impurities alter its non-inflammable and electrical characteristics. It must be handled in thoroughly clean containers free from oil. If there is any question concerning the cleanliness of the containers, they should be thoroughly washed with Trichlorbenzene M-6872 and dried before any Inerteen is placed in them. The transformer tank or any of its compartments in which Inerteen is used, must be free from oil and other contaminating materials.

Inerteen should not be mixed with vegetable oils since these materials affect the deterioration, D.C. resistance and otherwise contaminate it. Compounds of asphaltic nature, paraffin and ordinary soldering flux are particularly harmful to Inerteen.

For soldering, a solution of rosin in alcohol is recommended.

All-metal hose must be used in handling Inerteen since the lining used in most hose is soluble in Inerteen.

Filling Transformers - When it is necessary to fill a transformer with Inerteen one should make sure that all joints are tight; Cement Sp471880 should be used for this purpose. Steel pipe or metal hose should be used, and preferably the transformer should be filled through the drain valve. This will keep aeration of the Inerteen to a minimum. See that air vents are open as the transformer is filled.

It is desirable to fill a transformer by passing the Inerteen through an Inerteen Conditioner. If this cannot be done and the Inerteen tests satisfactorily, fill the transformer by passing the Inerteen through three thicknesses of tightly woven white cloth, which has first been washed in Trichlorbenzene and dried to remove any sizing. New cloths should be used for at least every two transformers.

When it is necessary to fill Inerteen transformers out-of-doors and particularly on damp days due precaution must be taken to prevent the entrance of moisture into the transformer.

Filling Switch and Terminal Chambers - Care should be exercised when filling switch and terminal chambers with Inerteen, and during servicing to avoid contamination by moisture or dirt, which may lower the dielectric strength of the Inerteen. The moisture may be present during the filling operation due to condensation and absorption on the inside of the chamber walls, or may appear as vapor in the gas space above the Inerteen or from any minute leaks.

The use of bonded tubes of activated clay in Inerteen-filled chambers of transformers in service is recommended where routine tests show the Inerteen to have unsatisfactory dielectric strength.

The tubes should not be removed from their containers until the terminal chamber is ready for their installation. The tubes should not be exposed to air more than approximately thirty minutes before closing up the chamber preparatory to filling it with Inerteen unless they are first dried for two hours at a temperature of approximately 250°C. or for twelve hours at 135 to 150°C.

If it becomes necessary to drain the Inerteen or to open the chamber after a period of service, it is recommended that new tubes be installed. To do this, it is only necessary to remove the bolts holding the spring clips, remove the old and insert the new tubes, and replace the clips and bolts.

When an Inerteen Conditioner is not available for use in filling chambers with Inerteen, it is recommended that the Inerteen be strained through two or three layers of tightly woven white cloth and poured through a container in which three or four clay tubes have been broken into small pieces. This will materially reduce the possibility of contamination of the Inerteen from dirt and moisture.

Bonded clay tubes should be ordered as Style #1150140 from the Westinghouse Electric & Manufacturing Company, Sharon, Penna. It is also desirable when ordering new tubes to identify the transformer for which they are required by including the serial number of the transformer.

Periodic Inspections

Inerteen - It is desirable that top and bottom samples of Inerteen be taken from each transformer and tested after a short period of operation. When operating conditions permit, routine sampling of the Inerteen at intervals of six months is recommended. Accurate records should be kept of such inspections and tests, and if the Inerteen shows a dielectric strength of less than 16 KV the Inerteen Conditioner may be used. This depends somewhat on the transformer load cycle and climatic conditions. If no facilities are available for making dielectric tests on Inerteen, samples should be sent to the Westinghouse Electric & Manufacturing Company, Sharon, Penna. Each sample of Inerteen should be properly identified by the transformer serial number and it should be recorded whether taken from the top or bottom of the tank or from a tank-compartment. Samples should be carefully packed to avoid breakage in transit. When any appreciable amount of Inerteen is removed from a transformer, it should be replaced with an equal amount of new Inerteen of proper dielectric strength so that the liquid level in the transformer is maintained.

Operation of Transformers - It is recommended that a periodic check be made of the operating temperatures of Inerteen transformers and that the temperature of the Inerteen be kept below 90°C. for a maximum-rated self-cooled transformer.

Paint - The external tank surfaces of Inerteen Transformers should be examined regularly for signs of corrosion. If appreciable corrosion is found, its cause should be determined and, if possible, remedied. Inerteen Transformer tanks are made from corrosion-resis-

ting, copper-bearing steel, and they are finished with a high grade Inerteen-resisting paint which is baked on at high temperature. Any surface which is found corroded should be thoroughly cleaned to the bare metal and refinished with one coat of primer, and two coats of finish paint S#302509. Allow twelve hours drying time between each coat of paint.

Taking Samples of Inerteen

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for Inerteen Transformers be used for no other purpose. Care must be used in obtaining and sealing samples of Inerteen taken from a transformer.

Use only small tin containers with screwed metal-gasket caps or small glass bottles with glass stoppers for holding Inerteen samples.

If it becomes necessary to use other than Factory sampling containers, such containers should be thoroughly rinsed with clean gasoline, washed with strong soap suds and rinsed thoroughly in hot water, and then dried in an oven at approximately 110°C. for one hour. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

Inerteen sampling package S# 1065658 may be obtained from the Westinghouse Electric & Manufacturing Company, Sharon, Penna. This package consists of four 1-pint cans of Inerteen, packed and shipped in cardboard cartons. This Inerteen may be used to replace that removed from a transformer as a sample. If samples are not taken immediately after emptying the containers, the empty containers should be tightly capped to prevent admittance of moisture.

It is desirable that samples of Inerteen be removed from a transformer tank or from a drum on clear days only and when the Inerteen is at least as warm as the surrounding air.

The sample of Inerteen should be removed near the surface of the fluid. This can be done readily through the rotary sampling device and valve. It is also recommended that a sample be taken from the bottom of the tank, particularly from the bottom of switch or terminal-chambers. If the sample is withdrawn through a valve connection, this connection should be flushed by allowing a small amount of Inerteen to run out before collecting the sample. The sample should be immediately placed in the container and the cap screwed on tightly. The sticker on each container should be marked to identify the sample of Inerteen with the transformer from which it was taken and whether taken from the top or bottom.

Before taking samples from a drum, the Inerteen should be allowed to settle for approximately twelve hours. Samples from the top of the drum should be removed by means of a clean glass sneak-thief.

The same precautions to prevent moisture contamination should be used in sampling Inerteen as are observed in taking transformer oil samples. Sampling equipment should be used only for Inerteen.

Dielectric Testing of Inerteen

The same rules and precautions as normally followed in testing oil should be used in testing Inerteen, except as herein stated.

The test cup should be wiped with a clean, dry chamois and thoroughly rinsed with clean gasoline and allowed to dry before being used. The electrode spacing should be checked.

To determine whether the test cup is suitable for testing Inerteen, fill it with dry gasoline and test this under a standard voltage rise of 3 KV per second. If the dielectric strength of the gasoline is not less than 22 KV, the test cup is suitable for testing Inerteen, after the cup has been dried in an oven where the temperature does not exceed 50°C. to remove all traces of gasoline. Care should be exercised in handling gasoline as it is highly inflammable. In testing Inerteen, make only one "shot" per filling of the test cup. Five different fillings should be made and the average result used.

Drying and Filtering Inerteen

Inerteen may be dehydrated and filtered by means of an oil filter press but in order that it may not be contaminated, it is necessary that the filter press be used for Inerteen only.

A different procedure than that followed for oil is required to purify Inerteen. Contamination in Inerteen cannot be removed entirely by filter paper alone. To clean Inerteen thoroughly it must be filtered through "activated clay" which absorbs impurities. In practice, it is only necessary to pass the Inerteen through the clay and to separate the clay mechanically from the Inerteen to obtain clean Inerteen of proper dielectric strength.

The Inerteen Conditioner

The equipment recommended for conditioning Inerteen consists of an activated clay chamber and filter press with suitable inlet and outlet connections and other necessary fittings.

The activated clay is contained in a tank mounted on one end of the filter press. The Inerteen is pumped up through the clay insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through a wire screen prior to entering the filter press to remove practically all of the clay.

The cover of the tank incorporates an air-trap and vent to avoid pumping air into the transformer which might result from a leak in the suction line. A strainer is provided on the suction side of the pump, so constructed that all dirt collected is removed with the screen. A by-pass connection fitted with a needle valve is used for testing the suction line from the transformer for leaks.

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The filter press consists of 15 frames and 16 plates alternately spaced mounted in a yoke. One sheet of blotting paper is used between each plate and frame to provide a gasket-seal and to remove all traces of clay from the Inerteen.

A pressure gage indicates the operation and two by-pass valves assure safe operation of the Conditioner by preventing excessive pressures and serve as a check to overloading and stalling the motor. One valve, connected across the pump, is set to by-pass the Inerteen at a pressure of 60 to 70 lbs. per square inch. The other valve is provided on the discharge side of the Conditioner connecting to the transformer. This by-pass valve, releasing at a pressure of approximately 5 lbs. per square inch, will avoid breaking the transformer relief diaphragm when no other relief is provided.

To Prepare the Conditioner for Operation

Remove the cover and screen from the clay tank and fill the tank with activated clay, M-6934 to within four inches of the bottom edge on the inner flange. Replace screen and cover. Release the pressure-screw of the filter press and loosen plates and frames. Place one sheet of "B" size blotting paper between the face of each frame and plate. Care should be used to see that the holes through the plates, frames and paper are in proper alignment before the pressure-screw is tightened. Close the discharge, tank by-pass, tank drain, suction and suction-test valves. Pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons of Inerteen. Start the motor and open the drip pan valve so that not less than 5 minutes are required to fill the clay tank, saturating the clay with Inerteen. With the valve at the transformer closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks.

Since the density of Inerteen is considerably greater than that of water, moisture will float on the surface of the Inerteen. It is therefore considered advisable to condition Inerteen from the top and return it to the bottom of the tank. To begin conditioning Inerteen in a transformer, close the suction test valve and stop the motor. Open the transformer valves. Open the Conditioner discharge and suction valves. Close the drip pan valve and start the motor.

One charge of clay will condition approximately 3000 gallons of Inerteen, depending upon the amount of contamination present.

When it is necessary to change the clay, first close the valve in the suction line, close the tank inlet and outlet valves, open the tank by-pass valve and tank drain valve to permit the free Inerteen in the tank to drain into the lower drip pan. Open the drip pan valve and pump the Inerteen from the drip pan through the filter press. Additional Inerteen may be forced out of the clay by applying air pressure to the air vent. Shut down the motor and remove the clay from the tank and refill with fresh clay as previously described.

To change the filter or blotting papers, stop the motor, close the tank by-pass valve, the tank inlet valve and the tank drain valve, if these valves are open. Open the tank outlet valve and apply air pressure to the air vent until the free Inerteen has been driven out of the blotting papers. Then release the pressure-screw and remove the papers.

If the system-seal is not broken, it will only be necessary to open the discharge and suction valves and start the motor to again resume conditioning the Inerteen.

To Dry Inerteen Transformers

Inerteen Transformers should be dried by the short-circuit method with the transformer in its tank immersed in the Inerteen. During the heating and drying process, the top of the tank should be vented to the air to prevent moisture condensation. The desired load current should be obtained by short-circuiting one winding and impressing the proper voltage on the other winding. If the full load impedance of the transformer is not known or not engraved on the transformer nameplate, it should be obtained from the Westinghouse Electric & Manufacturing Company by identifying the transformer with its serial number.

Transformer windings in Inerteen should first be heated under a partial load. A higher top Inerteen temperature can be obtained more quickly by blanketing the tank with the cover removed to prevent condensation.

If the transformer is at or lower than room temperature at the start of the drying process, from 125% to 150% full load current will hasten the heating. The temperature should be carefully watched and when the Inerteen reaches a temperature of 60°C., the load should be reduced to obtain an approximately constant Inerteen temperature based on the following table. These temperatures should not be exceeded for a given load.

Short Circuit Amperes in Percent of Load	Max. Temperature of Top Inerteen
50	80
75	75
85	70

The transformer may be dried more quickly if it is possible to filter the Inerteen during the drying process. If the filtering is continuous, care should be taken to keep the Inerteen temperature above 60°C. If moisture condenses on the underside of the cover, the rate of temperature rise should be decreased until condensation ceases. To prevent condensation the tank temperature may be raised by blanketing the tank.

The drying should be continued until dielectric tests of samples of the Inerteen taken from the top and bottom of the tank show 22 KV or higher. The tests should be made in a standard test cup and it is recommended that at least two consecutive tests of both the top and bottom Inerteen be made at least 24 hours apart while the Inerteen is near a maximum temperature. Tests of the Inerteen should not be made during the filtering process.

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If Transformers Fail in Service

Should an Inerteen Transformer fail in service, the nearest Westinghouse Electric & Manufacturing Company District Office should be notified as soon as possible. Give the rating of the transformer and its serial number and, if possible, the conditions under which the failure took place. Samples of the Inerteen should be taken so that an analysis of it can be made. The transformer should be kept immersed in Inerteen and it is recommended that no work be done on the transformer except under advice from the District Office.

Accessories for Inerteen Transformers

Pressure Relief Diaphragms - All transformers above 25 KVA are furnished with a pressure relief diaphragm. Fig. #1 shows a sectional view. This device is made in different sizes to provide ample venting for different ratings.

Relief diaphragms are regularly supplied, arranged so that a flange with the necessary piping may be applied to carry the gases to the outside atmosphere in case of transformer failure, and after the diaphragm ruptures. This type of installation should be made where possible on transformers installed indoors. For outdoor transformers, the relief device is regularly provided with a vented outlet which allows gases to escape directly to the outside atmosphere. A screen under the diaphragm prevents broken pieces from falling into the transformer.

The relief diaphragm unit-assembly, which is bolted to the transformer cover or other suitable place, consists of a supporting flange in which the glass diaphragm is mounted between two cork gaskets. A tight joint between gasket and diaphragm on the supporting flange is made by a pressure ring against the lower gasket, all of which is clamped in place by stud bolts.

It is necessary to be very careful bolting down the pressure-ring to avoid breakage of the glass diaphragm for its rupture strength depends largely upon having an even distribution of clamping pressure applied to the diaphragm.

Make sure that gasket seats are thoroughly clean. Apply Cement 3#471880 to both sides of the upper gasket and put the glass diaphragm in place, being sure that both the gasket and the diaphragm are centrally located in the supporting flange. Lay the cushion or lower gasket in place over the glass diaphragm and assemble the pressure ring over this gasket. Then tighten the assembly by means of the nuts and lock washers on the stud bolts.

An even distribution of pressure on the glass diaphragm can be obtained only by tightening the nuts uniformly. This should be done by tightening alternate nuts until the lock washers are nearly compressed. The other nuts should then be tightened in a similar manner. This alternate nut tightening should be continued until the face of the pressure-ring is against the metal gasket-stop. Thread a wire through the holes in the studs and fasten its ends securely.

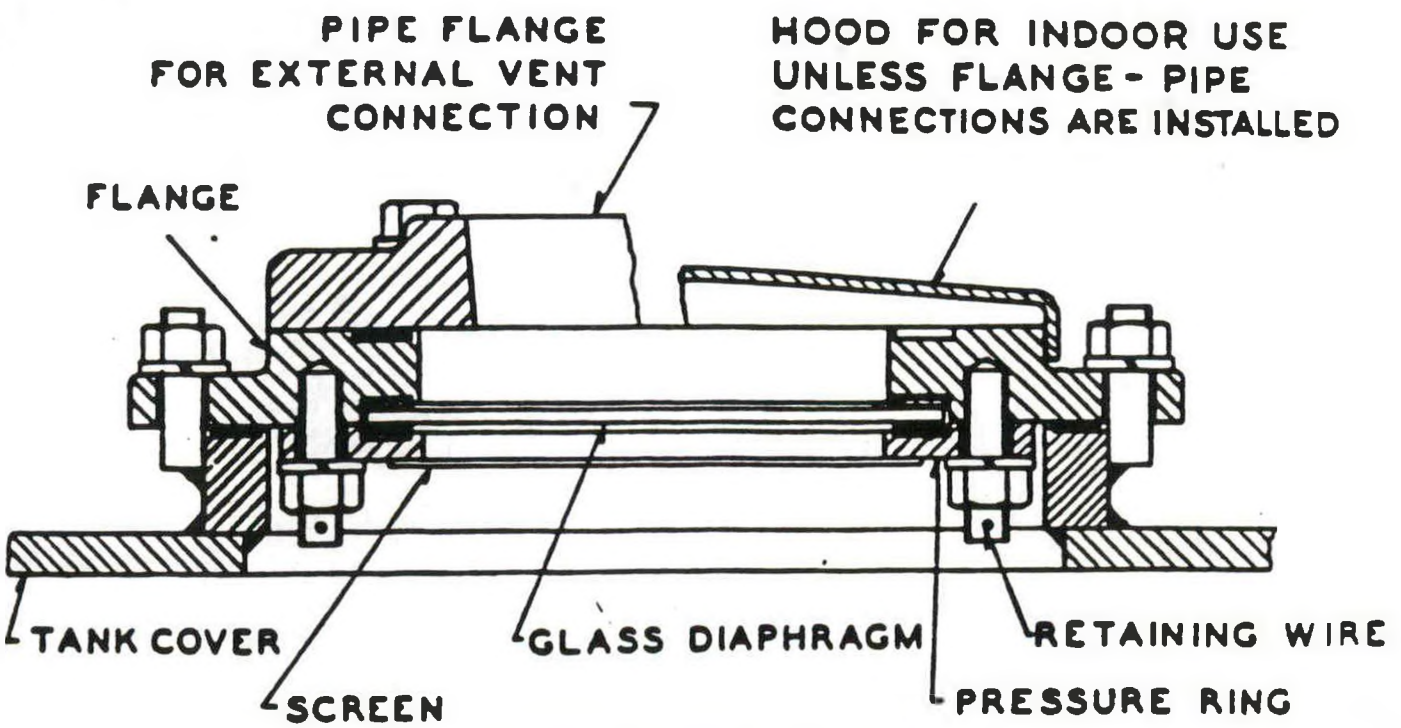

Fig. 1 - Westinghouse Pressure Relief Device
Sectional View

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Diaphragm relief devices are assembled on the transformer at the factory and they are then pressure-tested at 7 lbs. per square inch and shipped in place.

Two spare diaphragms and the necessary gaskets and cement are shipped with each transformer. Additional diaphragms, if needed, should be ordered from the Westinghouse Electric & Manufacturing Company, Sharon, Pennsylvania, identified by the serial number of the transformer.

Rotary Type Sampling Device - The rotary type sampling device supplied on Inerteen Transformers provides a convenient means of draining a sample of Inerteen for test purposes. Due to the high specific gravity of Inerteen, water tends to collect on the surface of the Inerteen. Therefore, in order to obtain a sample that will be representative of the surface Inerteen in the transformer, the sampling valve is located near the Inerteen level.

This device is designed to skim a sample from the surface, and may also be used in applying pressure tests.

Fig. #2 shows a sectional view of the rotary type valve. The tube should be left in a vertical position as shown. A sample is taken by turning the operating knob to the right. The travel is limited to 90 degs. by position-stops on the body of the device. A position indicator is made a part of the operating knob, attached to the shaft in the same plane as the tube. A packing gland prevents the leakage of Inerteen along the operating shaft.

When the knob is turned, the end of the tube passes under the Inerteen level, allowing the Inerteen to enter the tube and flow to the sampling-plug. The device may be equipped with a plug type Belknap sampling valve, Figs. 990-A or 992, a spring-closing Belknap valve, Figs. 995 or 994, or spring-closing Waterbury valve #108.

The sampling device is easily removed as a unit from the tank. A 1-1/8" hex is provided for this purpose.

If the device is equipped with a spring-closing valve, remove the dust cap from the valve. Remove the inner dust cap from the proper operating device and screw the operating device tightly onto the valve. This releases the ball-check in the valve. Rotate the operating knob slowly, using a wrench to fit the 1-1/8" hex on this knob, until the Inerteen begins to flow. At this point the rotation should be stopped to insure obtaining a true sample of the top liquid.

A screw driver or coin may be used to open and close the plug type valve, Belknap Fig. 990-A. The Belknap 992 valve is operated by turning the knurled knob.

When pressure tests are required, they should be made before withdrawing samples of Inerteen. To make a pressure test, the indicator arm should be in the vertical position. If a spring-closing valve is used, remove dust caps

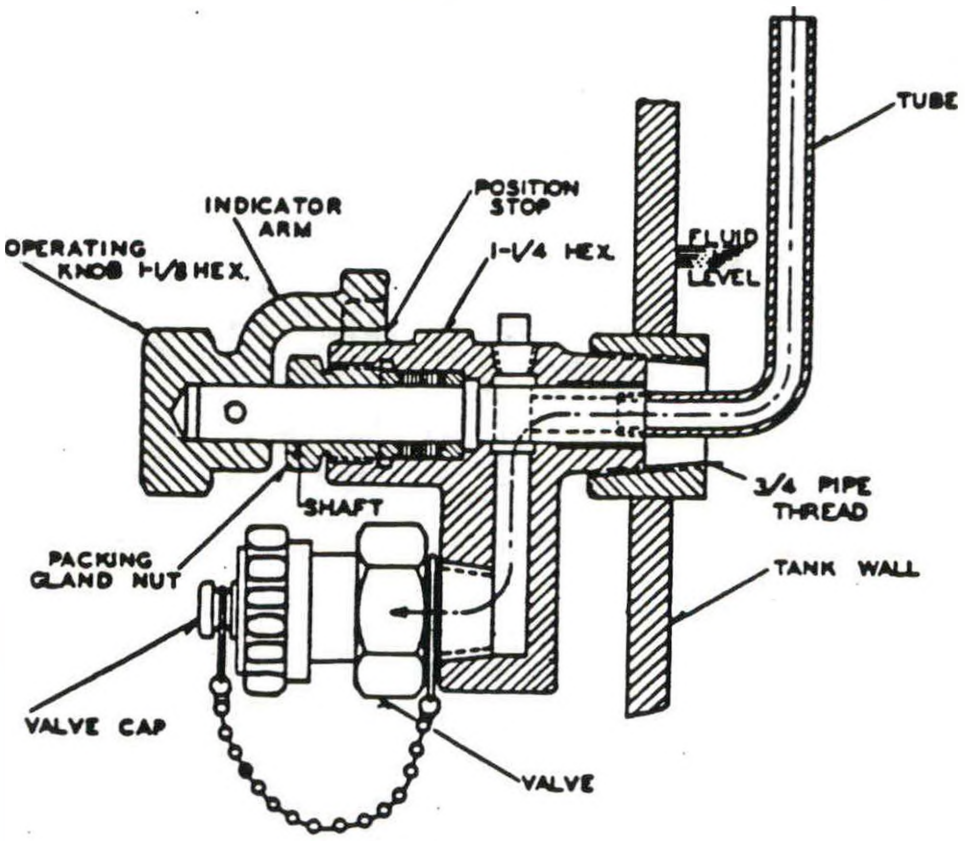

Fig. 2 - Westinghouse Rotary Type Sampling Valve Sectional View

from pressure-testing device and attach the device to the spring closing valve. To apply pressure, attach operating device to pressure-testing device. Any pressure in the transformer tank may be released by removing the operating-device and releasing the check valve in the pressure-testing device. If a plug type valve is used, connect the pressure gage to the valve by means of a metal tube or hose. Open valve, using a screw driver or coin and note pressure on gage. If sample of gas is desired, connect hose to a suitable container.

If the Inerteen is above the 25°C. level, the pressure will be somewhat above atmospheric while if the Inerteen is below the 25°C. level there will be a partial vacuum in the tank. It is therefore advisable to take the sample when the gage shows the Inerteen to be at, or slightly above the 25°C. level. If the sample is taken at a higher or lower Inerteen level, provision should be made to relieve any pressure or vacuum which may be created. This may be done by restoring the pressure to the proper point by forcing air into or pumping air out of the tank. This should be done with the tube of the sampling device in a vertical position.

The rotary type sampling device is ruggedly constructed and requires very little servicing or maintenance. If there is a slight leakage through the packing gland the gland nut should be tightened. In case this does not stop the leakage the gland should be repacked. Packing Style #1066507 may be obtained from Westinghouse Electric & Manufacturing Company, Sharon, Penna. In ordering, include the transformer serial number.

Gas Absorbers for Inerteen Transformers - When Inerteen transformers are equipped with gas absorbers, separate instructions are shipped with each transformer describing the device and its installation, operation and maintenance.

Renewal Parts

When information is required concerning a transformer, always give its serial number, particularly whenever renewal or stock parts are ordered. The serial number will be found engraved on the nameplate attached to the transformer tank and on the small nameplate attached to the top or end of the core and coils assembly. Whenever possible, a sketch showing the part or parts and their exact locations will materially help to assure that the proper parts are supplied by the Factory. This sketch should always indicate the direction or side of the transformer from which the view is made.

NOTE: Some transformers are ordered designed for Inerteen but are to be operated first as oil-insulated transformers. Consequently, they are shipped from the factory filled with oil. Whenever it is desired to operate these transformers with Inerteen, complete instructions for the removal of the oil, the cleaning of the transformer and filling it with Inerteen should be obtained from the Westinghouse Electric & Manufacturing Company, Sharon, Pennsylvania.

Revised: January, 1942

INERTEEN

Inerteen is a synthetic non-inflammable and non-explosive insulating and cooling liquid used in Westinghouse Inerteen Transformers.

Characteristics

Color	Straw Yellow
Viscosity at 100°F. (Saybolt).	54 Seconds
Fire Point	None
Specific Gravity at 60°F.	1.564
Dielectric Constant	4.5

Mineral oil is completely miscible with transformer Inerteen. It is practically impossible to separate mineral oil and Inerteen; therefore, it is important to avoid contamination of Inerteen with any oil as the presence of such materials changes the non-inflammable and non-explosive characteristics of Inerteen.

Inerteen is chemically stable. It is not affected by reaction with other materials used in the manufacture of Inerteen Transformers. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in transformers. Inerteen will not form sludge under any conditions.

Inerteen exerts a strong solvent action on most of the ordinary varnishes, gums and paints commonly used in oil-insulated transformers. Such materials, therefore, are not used in the design and construction of Inerteen Transformers. It is necessary to use such material as pure cellulose, cotton, paper and porcelain. This requirement, coupled with the necessary use of tight-tank construction for Inerteen Transformers tends to give improved operating characteristics.

If Inerteen is decomposed by an electric arc, hydrogen chloride gas is evolved. The products of arc decomposition are harmful to the transformer structure. Where severe arcing occurs, the solid insulation of the transformer becomes saturated with hydrogen chloride and the affected parts must be removed in the repair of the transformer.

The dielectric strength of Inerteen compares favorably with and under average normal conditions will be found higher than that of transformer oil. The same precautions are necessary with Inerteen as are taken with transformer oil. Inerteen should be kept free of moisture, lint and dirt.

Inerteen has an irritating effect upon the skin. This is more pronounced to some persons than to others. Especially the eyes, nose and lips are affected when coming in contact with Inerteen and certain safety precautions must be observed when handling it. When working with the hands in Inerteen, it will irritate skin abrasions or the tender parts between the fingers. Continued exposure may cause skin eruptions with certain individuals due to absorption of the Inerteen through the pores of the skin. Cleanliness among workmen handling Inerteen is essential and a very good safeguard against such effects. An application of castor oil is recommended for the eyes and castor oil or cold cream for the nose and lips. In case Inerteen comes in contact with the skin, the parts should be thoroughly washed and cleaned. A supply of these materials should be kept available at all times where men are working with Inerteen.

Hot transformers should not be opened except in well ventilated places. Large quantities of Inerteen should be handled in a closed system. Workmen should be protected from frequent contact with any appreciable vapor concentration and from frequent skin contact with Inerteen.

In case Inerteen is spilled on one's clothing, it should be changed as soon as possible and the soiled clothing laundered before it is worn again. Gloves, S#1184690, which are resistant to Inerteen, should be worn where it is necessary to put one's hand in Inerteen or when parts of transformers are handled wet.

INERTEEN TRANSFORMERS

Shipment

Inerteen Transformers are always constructed in pressure-tight tanks.

Inerteen transformers are shipped properly filled with Inerteen and ready for installation. This prevents the entrance of moisture into the windings during transit and usually makes it unnecessary to dry the transformers prior to installation. A small amount of moisture will reduce the dielectric strength of Inerteen. It may be present in vapor form in the gas space above the Inerteen level or from minute leaks.

Transformers equipped with switch or terminal chambers which must be opened for installation, are shipped with the Inerteen for these chambers in separate containers.

Activated clay has a high affinity for moisture and absorbs other materials which may contaminate Inerteen. To keep the Inerteen in the best condition, bonded tubes of activated clay are installed and shipped in place in switch and terminal chambers of new transformers. When the Inerteen is shipped in separate containers the tubes are also shipped separately, enclosed in air-tight containers.

Inerteen must always be kept in sealed containers to prevent the loss of its more volatile constituents by evaporation or possible contamination from dirt or moisture.

Moving Transformers

Lugs are provided for lifting the complete transformer, and when necessary, additional means are provided for lifting the different parts. The transformer should be lifted by the means provided and when necessary, spreaders should be used to obtain a balanced lift. Transformers should not be moved or lifted by placing jacks or other devices against or under cooling tubes, radiators, valves or other fittings. Skids should be used to distribute the stresses properly over the base when transformers are moved on rollers.

Carefully inspect the transformers for damage during shipment.

This should include a check of the In- level and the tightening of any parts ave become loose or out of place and there is any evidence of moisture having the transformer. Inerteen used for fill- sformers should have a dielectric strength 7 or higher. When the dielectric strength teen in transformers in service reaches r lower, it should be filtered. If the ric strength is very low or if there is e of free water, the core and coils should d.

Where transformers are to be used at ltitude (more than 3000 ft. above sea level) ing above the liquid level should be open- equalize the internal and external pres- at a temperature of approximately 25°C. be- lacing the transformer in service. Be sure the fitting is closed after equalizing the ure.

All transformers are carefully tested e Factory and in good condition when ship- is made but it is desirable to inspect each former thoroughly before placing it in ser-

nding and Making Connections

No matter what the type of floor or dation on which the transformer is to rest, tank should be definitely and permanently nded by connecting a lead to the grounding nection provided for that purpose near the tom of the tank.

Terminal board, tap changer and other nections should never be changed with voltage the transformer. Do not make any connections ept those indicated on the diagram or the dia- m nameplate shipped with the transformer.

Any lead or connector not in use should insulated from all other leads and connectors l from ground.

skets

Gaskets used on Inerteen Transformers e made from a high grade of cork and, it is commended, in replacing any gaskets that they e made of cork. Before replacing a gasket, all sket surfaces should be thoroughly cleaned free f rust, oil, grease, paint or other foreign ma- erials. The cleaning may be done by scraping or ire-brushing and then wiping the gasket surface ith denatured alcohol.

Gasket Cement S#471880 especially de- veloped for use with Inerteen, should always be used in applying gaskets. Thoroughly brush the cement on the tank surface and on the bottom side of the gasket. Place the gasket in position and apply weights or other means to obtain good ad- hesion of the gasket to the metal surface. The gasket should be allowed to set approximately one-half hour before the weights are removed. Cement should then be applied to the top surface of the gasket. The gasket surfaces must immedi- ately be bolted together under a uniform pressure.

Transformers are frequently equipped with terminal or switch compartments into which cables enter by means of potheads. In some cases, it will be necessary to remove the switch-cover to make the cable connections.

When transformers are designed for bayo- net connections, it is only necessary to remove the bayonet pothead, make the cable connections and replace the pothead.

Extra gaskets and Cement S#471880 are furnished with all Inerteen Transformers where their installation requires the removal of any gaskets. Additional gaskets and cement should be ordered from the manufacturer.

Pipe Fittings

Care should be taken to see that threads of pipe fittings are not damaged. All threads should be thoroughly cleaned to remove dirt, grease, etc. After cleaning, apply Cement S# 471880 to the threads of each fitting. Immedi- ately screw the proper fittings together tightly.

Pressure Testing

All Inerteen transformers are pressure tested at the factory and shipped free of leaks. After installation and before voltage is applied, it is desirable to pressure test each transformer especially if any fittings or covers have been removed and replaced during the installation. Dry compressed nitrogen or air should be used at a test pressure of 7 lbs. per square inch for a period of six hours. It is suggested that the air space above the Inerteen be blown out with nitrogen, all vents closed and the pressure test applied. The test pressure can best be limited by the use of a regulating valve on the nitrogen cylinder. A check for leaks above the Inerteen level may be made with a solution of soap and water applied to all gasketed-joints, screwed- fittings and wiping-sleeve connections.

Paint

Inerteen Transformers are finished with a special paint, which is resistant to the sol- vent action of Inerteen. A sufficient quantity of this paint S#302509 is furnished with each transformer to "touch up" any places damaged during the process of installation.

Storage

Inerteen Transformers must always be stored filled to the proper level with Inerteen, otherwise a certain amount of moisture may accu- mulate on account of variations of air tempera- ture. Inerteen Transformers should be stored in a dry place, and where minimum temperature changes will occur.

Where it is necessary to temporarily store coils, insulation or other parts for the complete core and coil assembly of an Inerteen Transformer, they should be immersed in Inerteen to prevent moisture absorption. If such storage is necessary for a long period of time, the tank or storage container must be sealed to prevent the entrance of moisture and the evaporation of Inerteen.

Inerteen Transformers which have been idle or stored for an appreciable length of time, should be put into service only after making care-

tain that the transformer is dry and that the dielectric strength of the Inerteen tests 22,000 volts or higher. The inspection instructions should also be followed.

Maintenance

Inerteen Equipment - Care must be exercised in handling Inerteen to prevent contamination since impurities alter its non-inflammable and electrical characteristics. It must be handled in thoroughly clean containers free from oil. If there is any question concerning the cleanliness of the containers, they should be thoroughly washed with Trichlorbenzene M-6872 and dried before any Inerteen is placed in them. The transformer tank or any of its compartments in which Inerteen is used, must be free from oil and other contaminating materials.

Inerteen should not be mixed with vegetable oils since these materials affect the deterioration, D.C. resistance and otherwise contaminate it. Compounds of asphaltic nature, paraffin and ordinary soldering flux are particularly harmful to Inerteen.

For soldering, a solution of rosin in alcohol is recommended.

All-metal hose must be used in handling Inerteen since the lining used in most hose is soluble in Inerteen.

Filling Transformers - When it is necessary to fill a transformer with Inerteen one should make sure that all joints are tight; Cement S#471880 should be used for this purpose. Steel pipe or metal hose should be used, and preferably the transformer should be filled through the drain valve. This will keep aeration of the Inerteen to a minimum. See that air vents are open as the transformer is filled.

It is desirable to fill a transformer by passing the Inerteen through an Inerteen Conditioner. If this cannot be done and the Inerteen tests satisfactorily, fill the transformer by passing the Inerteen through three thicknesses of tightly woven white cloth, which has first been washed in Trichlorbenzene and dried to remove any sizing. New cloths should be used for at least every two transformers.

When it is necessary to fill Inerteen transformers out-of-doors and particularly on damp days due precaution must be taken to prevent the entrance of moisture into the transformer.

Filling Switch and Terminal Chambers - Care should be exercised when filling switch and terminal chambers with Inerteen, and during servicing to avoid contamination by moisture or dirt, which may lower the dielectric strength of the Inerteen. The moisture may be present during the filling operation due to condensation and absorption on the inside of the chamber walls, or may appear as vapor in the gas space above the Inerteen or from any minute leaks.

The use of bonded tubes of activated clay in Inerteen-filled chambers of transformers in service is recommended where routine tests show the Inerteen to have unsatisfactory dielectric strength.

The tubes should not be removed from their containers until the terminal chamber is ready for their installation. The tubes should not be exposed to air more than [illegible] thirty minutes before closing up the chamber preparatory to filling it with Inerteen unless they are first dried for two hours at a temperature of approximately 250°C. or for twelve hours at 135 to 150°C.

If it becomes necessary to drain the Inerteen or to open the chamber after a period of service, it is recommended that new tubes be installed. To do this, it is only necessary to remove the bolts holding the spring clips, remove the old and insert the new tubes, and replace the clips and bolts.

When an Inerteen Conditioner is not available for use in filling chambers with Inerteen, it is recommended that the Inerteen be strained through two or three layers of tightly woven white cloth and poured through a container in which three or four clay tubes have been broken into small pieces. This will materially reduce the possibility of contamination of the Inerteen from dirt and moisture.

Bonded clay tubes should be ordered as Style #1150140 from the Westinghouse Electric & Manufacturing Company, Sharon, Penna. It is also desirable when ordering new tubes to identify the transformer for which they are required by including the serial number of the transformer.

Periodic Inspections

Inerteen - It is desirable that top and bottom samples of Inerteen be taken from each transformer and tested after a short period of operation. When operating conditions permit, routine sampling of the Inerteen at intervals of six months is recommended. Accurate records should be kept of such inspections and tests and if the Inerteen shows a dielectric strength of less than 22 KV the Inerteen should be conditioned. This depends somewhat on the transformer load cycle and climatic conditions. If no facilities are available for making dielectric tests on Inerteen, samples should be sent to the Westinghouse Electric & Manufacturing Company, Sharon, Penna. Each sample should be properly identified by the transformer serial number and it should be specified that taken from the top or bottom of the tank or of a tank-compartment. Samples should be carefully packed to avoid breakage in transit. When any appreciable amount of Inerteen is removed from a transformer, it should be replaced with an equal amount of new Inerteen of proper dielectric strength so that the liquid level in the transformer is maintained.

Operation of Transformers - It is recommended that a periodic check be made of the operating temperatures of Inerteen transformers and that the temperature of the Inerteen be kept below 90°C. for a maximum-rated load of the transformer.

Paint - The external tank surfaces of Inerteen Transformers should be examined particularly for signs of corrosion. If any external corrosion is found, its cause should be determined and, if possible, [illegible] Transformer tanks are [illegible]

ting, copper-bearing steel, and they are finished with a high grade Inerteen-resisting paint which is baked on at high temperature. Any surface which is found corroded should be thoroughly cleaned to the bare metal and refinished with one coat of primer, and two coats of finish paint S#302509. Allow twelve hours drying time between each coat of paint.

Taking Samples of Inerteen

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for Inerteen Transformers be used for no other purpose. Care must be used in obtaining and sealing samples of Inerteen taken from a transformer.

Use only small tin containers with screwed metal-gasket caps or small glass bottles with glass stoppers for holding Inerteen samples.

If it becomes necessary to use other than Factory sampling containers, such containers should be thoroughly rinsed with clean gasoline, washed with strong soap suds and rinsed thoroughly in hot water, and then dried in an oven at approximately 110°C. for one hour. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

Inerteen sampling package S# 1065658 may be obtained from the Westinghouse Electric & Manufacturing Company, Sharon, Penna. This package consists of four 1-pint cans of Inerteen, packed and shipped in cardboard cartons. This Inerteen may be used to replace that removed from a transformer as a sample. If samples are not taken immediately after emptying the containers, the empty containers should be tightly capped to prevent admittance of moisture.

It is desirable that samples of Inerteen be removed from a transformer tank or from a drum on clear days only and when the Inerteen is at least as warm as the surrounding air.

The sample of Inerteen should be removed near the surface of the fluid. This can be done readily through the rotary sampling device and valve. It is also recommended that a sample be taken from the bottom of the tank, particularly from the bottom of switch or terminal-chambers. If the sample is withdrawn through a valve connection, this connection should be flushed by allowing a small amount of Inerteen to run out before collecting the sample. The sample should be immediately placed in the container and the cap screwed on tightly. The sticker on each container should be marked to identify the sample of Inerteen with the transformer from which it was taken and whether taken from the top or bottom.

Before taking samples from a drum, the Inerteen should be allowed to settle for approximately twelve hours. Samples from the top of the drum should be removed by means of a clean glass sneak-thief.

The same precautions to prevent moisture contamination should be used in sampling Inerteen as are observed in taking transformer oil samples. Sampling equipment should be used only for Inerteen.

Dielectric Testing of Inerteen

The same rules and precautions as normally followed in testing oil should be used in testing Inerteen, except as herein stated.

The test cup should be wiped with a clean, dry chamois and thoroughly rinsed with clean gasoline and allowed to dry before being used. The electrode spacing should be checked.

To determine whether the test cup is suitable for testing Inerteen, fill it with dry gasoline and test this under a standard voltage rise of 3 KV per second. If the dielectric strength of the gasoline is not less than 22 KV, the test cup is suitable for testing Inerteen, after the cup has been dried in an oven where the temperature does not exceed 50°C. to remove all traces of gasoline. Care should be exercised in handling gasoline as it is highly inflammable. In testing Inerteen, make only one "shot" per filling of the test cup. Five different fillings should be made and the average result used.

Drying and Filtering Inerteen

Inerteen may be dehydrated and filtered by means of an oil filter press but in order that it may not be contaminated, it is necessary that the filter press be used for Inerteen only.

A different procedure than that followed for oil is required to purify Inerteen. Contamination in Inerteen cannot be removed entirely by filter paper alone. To clean Inerteen thoroughly it must be filtered through "activated clay" which absorbs impurities. In practice, it is only necessary to pass the Inerteen through the clay and to separate the clay mechanically from the Inerteen to obtain clean Inerteen of proper dielectric strength.

The Inerteen Conditioner

The equipment recommended for conditioning Inerteen consists of an activated clay chamber and filter press with suitable inlet and outlet connections and other necessary fittings.

The activated clay is contained in a tank mounted on one end of the filter press. The Inerteen is pumped up through the clay insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through a wire screen prior to entering the filter press to remove practically all of the clay.

The cover of the tank incorporates an air-trap and vent to avoid pumping air into the transformer which might result from a leak in the suction line. A strainer is provided on the suction side of the pump, so constructed that all dirt collected is removed with the screen. A by-pass connection fitted with a needle valve is used for testing the suction line from the transformer for leaks.

The filter press consists of 15 frames and 16 plates alternately spaced mounted in a yoke. One sheet of blotting paper is used between each plate and frame to provide a gasket-seal and to remove all traces of clay from the Inerteen.

A pressure gage indicates the operation and two by-pass valves assure safe operation of the Conditioner by preventing excessive pressures and serve as a check to overloading and stalling the motor. One valve, connected across the pump, is set to by-pass the Inerteen at a pressure of 60 to 70 lbs. per square inch. The other valve is provided on the discharge side of the Conditioner connecting to the transformer. This by-pass valve, releasing at a pressure of approximately 5 lbs. per square inch, will avoid breaking the transformer relief diaphragm when no other relief is provided.

To Prepare the Conditioner for Operation

Remove the cover and screen from the clay tank and fill the tank with activated clay, M-6934-F to within four inches of the bottom edge on the inner flange. Replace screen and cover. Release the pressure-screw of the filter press and loosen plates and frames. Place one sheet of "B" size blotting paper between the face of each frame and plate. Care should be used to see that the holes through the plates, frames and paper are in proper alignment before the pressure-screw is tightened. Close the discharge, tank by-pass, tank drain, suction and suction-test valves. Pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons of Inerteen. Start the motor and open the drip pan valve so that not less than 5 minutes are required to fill the clay tank, saturating the clay with Inerteen. With the valve at the transformer closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks.

Since the density of Inerteen is considerably greater than that of water, moisture will float on the surface of the Inerteen. It is therefore considered advisable to condition Inerteen from the top and return it to the bottom of the tank. To begin conditioning Inerteen in a transformer, close the suction test valve and stop the motor. Open the transformer valves. Open the Conditioner discharge and suction valves. Close the drip pan valve and start the motor.

One charge of clay will condition approximately 3000 gallons of Inerteen, depending upon the amount of contamination present.

When it is necessary to change the clay, first close the valve in the suction line, close the tank inlet and outlet valves, open the tank by-pass valve and tank drain valve to permit the free Inerteen in the tank to drain into the lower drip pan. Open the drip pan valve and pump the Inerteen from the drip pan through the filter press. Additional Inerteen may be forced out of the clay by applying air pressure to the air vent. Shut down the motor and remove the clay from the tank and refill with fresh clay as previously described.

To change the filter or blotting papers, stop the motor, close the tank by-pass valve, the tank inlet valve and the tank drain valve, if these valves are open. Open the tank outlet valve and apply air pressure to the air vent until the free Inerteen has been driven out of the blotting papers. Then release the pressure-screw and remove the papers.

If the system-seal is not broken, it will only be necessary to open the discharge and suction valves and start the motor to again resume conditioning the Inerteen.

To Dry Inerteen Transformers

Inerteen Transformers should be dried by the short-circuit method with the transformer in its tank immersed in the Inerteen. During the heating and drying process, the top of the tank should be vented to the air to prevent moisture condensation. The desired load current should be obtained by short-circuiting one winding and impressing the proper voltage on the other winding. If the full load impedance of the transformer is not known or not engraved on the transformer nameplate, it should be obtained from the Westinghouse Electric & Manufacturing Company by identifying the transformer with its serial number.

Transformer windings in Inerteen should first be heated under a partial load. A higher top Inerteen temperature can be obtained more quickly by blanketing the tank with the cover removed to prevent condensation.

If the transformer is at or lower than room temperature at the start of the drying process, from 125% to 150% full load current will hasten the heating. The temperature should be carefully watched and when the Inerteen reaches a temperature of 60°C., the load should be reduced to obtain an approximately constant Inerteen temperature based on the following table. These temperatures should not be exceeded for a given load.

Short Circuit Amperes in Percent of Load	Max. Temperature of Top Inerteen
50	85
75	75
95	70

The transformer may be dried more quickly if it is possible to filter the Inerteen during the drying process. If the filtering is continuous, care should be taken to keep the Inerteen temperature above 60°C. If moisture condenses on the underside of the cover, the rate of temperature rise should be decreased until condensation ceases. To prevent condensation the tank temperature may be raised by blanketing the tank.

The drying should be continued until dielectric tests of samples of the Inerteen taken from the top and bottom of the tank show 30 KV or higher. The tests should be made in a standard test cup and it is recommended that at least two consecutive tests of both the top and bottom Inerteen be made at least 24 hours apart while the Inerteen is near a maximum temperature. Tests of the Inerteen should not be made during the filtering process.

If Transformers Fail in Service

Should an Inerteen Transformer fail in service, the nearest Westinghouse Electric & Manufacturing Company District Office should be notified as soon as possible. Give the rating of the transformer and its serial number and, if possible, the conditions under which the failure took place. Samples of the Inerteen should be taken so that an analysis of it can be made. The transformer should be kept immersed in Inerteen and it is recommended that no work be done on the transformer except under advice from the District Office.

Accessories for Inerteen Transformers

Pressure Relief Diaphragms - All transformers above 25 KVA are furnished with a pressure relief diaphragm. Fig. #1 shows a sectional view. This device is made in different sizes to provide ample venting for different ratings.

Relief diaphragms are regularly supplied, arranged so that a flange with the necessary piping may be applied to carry the gases to the outside atmosphere in case of transformer failure, and after the diaphragm ruptures. This type of installation should be made where possible on transformers installed indoors. For outdoor transformers, the relief device is regularly provided with a vented outlet which allows gases to escape directly to the outside atmosphere. A screen under the diaphragm prevents broken pieces from falling into the transformer.

The relief diaphragm unit-assembly, which is bolted to the transformer cover or other suitable place, consists of a supporting flange in which the glass diaphragm is mounted between two cork gaskets. A tight joint between gasket and diaphragm on the supporting flange is made by a pressure ring against the lower gasket, all of which is clamped in place by stud bolts.

It is necessary to be very careful bolting down the pressure-ring to avoid breakage of the glass diaphragm for its rupture strength depends largely upon having an even distribution of clamping pressure applied to the diaphragm.

Make sure that gasket seats are thoroughly clean. Apply Cement S#471880 to both sides of the upper gasket and put the glass diaphragm in place, being sure that both the gasket and the diaphragm are centrally located in the supporting flange. Lay the cushion or lower gasket in place over the glass diaphragm and assemble the pressure ring over this gasket. Then tighten the assembly by means of the nuts and lock washers on the stud bolts.

An even distribution of pressure on the glass diaphragm can be obtained only by tightening the nuts uniformly. This should be done by tightening alternate nuts until the lock washers are nearly compressed. The other nuts should then be tightened in a similar manner. This alternate nut tightening should be continued until the face of the pressure-ring is against the metal gasket-stop. Thread a wire through the holes in the studs and fasten its ends securely.

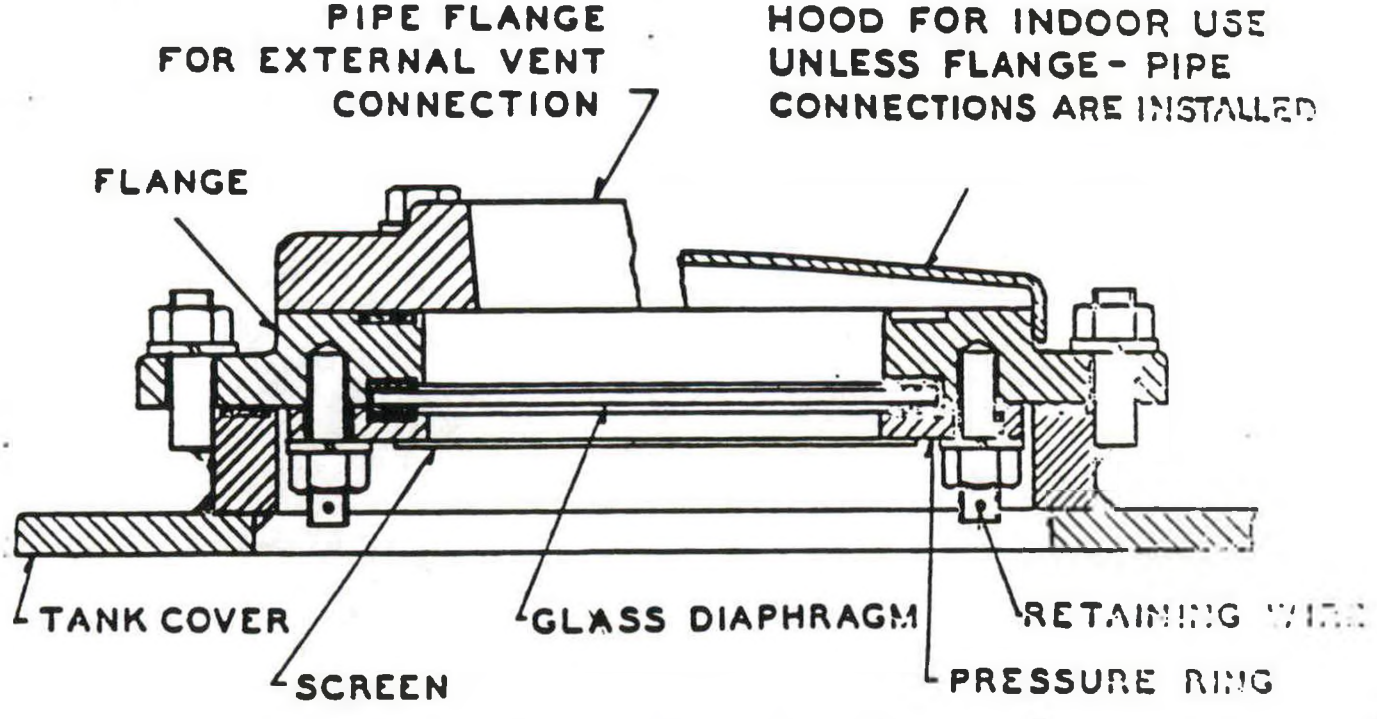

Fig. 1 - Westinghouse Pressure Relief Device
Sectional View

Diaphragm relief devices are assembled on the transformer at the factory and they are then pressure-tested at 7 lbs. per square inch and shipped in place.

Two spare diaphragms and the necessary gaskets and cement are shipped with each transformer. Additional diaphragms, if needed, should be ordered from the Westinghouse Electric & Manufacturing Company, Sharon, Pennsylvania, identified by the serial number of the transformer.

Rotary Type Sampling Device - The rotary type sampling device supplied on Inerteen Transformers provides a convenient means of draining a sample of Inerteen for test purposes. Due to the high specific gravity of Inerteen, water tends to collect on the surface of the Inerteen. Therefore, in order to obtain a sample that will be representative of the surface Inerteen in the transformer, the sampling valve is located near the Inerteen level.

This device is designed to skim a sample from the surface, and may also be used in applying pressure tests.

Fig. #2 shows a sectional view of the rotary type valve. The tube should be left in a vertical position as shown. A sample is taken by turning the operating knob to the right. The travel is limited to 90 degs. by position-stops on the body of the device. A position indicator is made a part of the operating knob, attached to the shaft in the same plane as the tube. A packing gland prevents the leakage of Inerteen along the operating shaft.

When the knob is turned, the end of the tube passes under the Inerteen level, allowing the Inerteen to enter the tube and flow to the sampling-plug. The device may be equipped with a plug type Belknap sampling valve, Figs. 990-A or 992, a spring-closing Belknap valve, Figs. 993 or 994, or spring-closing Waterbury valve #108.

The sampling device is easily removed as a unit from the tank. A 1-1/4" hex is provided for this purpose.

If the device is equipped with a spring-closing valve, remove the dust cap from the valve. Remove the inner dust cap from the proper operating device and screw the operating device tightly onto the valve. This releases the ball-check in the valve. Rotate the operating knob slowly, using a wrench to fit the 1-1/2" hex on this knob, until the Inerteen begins to flow. At this point the rotation should be stopped to insure obtaining a true sample of the top liquid.

A screw driver or coin may be used to open and close the plug type valve, Belknap Fig. 990-A. The Belknap 992 valve is operated by turning the knurled knob.

When pressure tests are required, they should be made before withdrawing samples of Inerteen. To make a pressure test, the indicator arm should be in the vertical position. If a spring-closing valve is used, remove dust caps

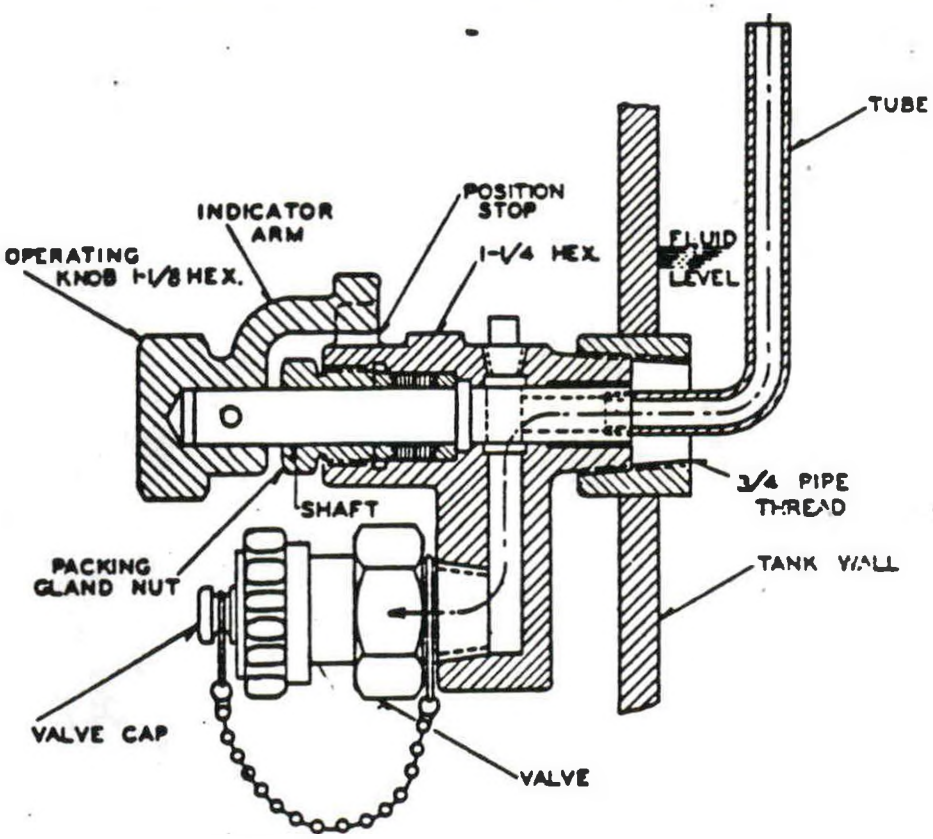

Fig. 2 - Westinghouse Rotary Type Sampling Valve
Sectional View

from pressure-testing device and attach the device to the spring closing valve. To apply pressure, attach operating device to pressure-testing device. Any pressure in the transformer tank may be released by removing the operating-device and releasing the check valve in the pressure-testing device. If a plug type valve is used, connect the pressure gage to the valve by means of a metal tube or hose. Open valve, using a screw driver or coin, and note pressure on gage. If sample of gas is desired, connect hose to a suitable container.

If the Inerteen is above the 25°C. level, the pressure will be somewhat above atmospheric while if the Inerteen is below the 25°C. level there will be a partial vacuum in the tank. It is therefore advisable to take the sample when the gage shows the Inerteen to be at, or slightly above the 25°C. level. If the sample is taken at a higher or lower Inerteen level, provision should be made to relieve any pressure or vacuum which may be created. This may be done by restoring the pressure to the proper point by forcing air into or pumping air out of the tank. This should be done with the tube of the sampling device in a vertical position.

The rotary type sampling device is ruggedly constructed and requires very little servicing or maintenance. If there is a slight leakage through the packing gland the gland nut should be tightened. In case this does not stop the leakage the gland should be repacked. Packing Style #1066507 may be obtained from Westinghouse Electric & Manufacturing Company, Sharon, Penna. In ordering, include the transformer serial number.

Gas Absorbers for Inerteen Transformers - When Inerteen transformers are equipped with gas absorbers, separate instructions are shipped with each transformer describing the device and its installation, operation and maintenance.

Renewal Parts

When information is required concerning a transformer, always give its serial number, particularly whenever renewal or stock parts are ordered. The serial number will be found engraved on the nameplate attached to the transformer tank and on the small nameplate attached to the top end of the core and coils assembly. Whenever possible, a sketch showing the part or parts and their exact locations will materially help to assure that the proper parts are supplied by the Factory. This sketch should always indicate the direction or side of the transformer from which the view is made.

NOTE: Some transformers are ordered designed for Inerteen but are to be operated first as oil-insulated transformers. Consequently, they are shipped from the factory filled with oil. Whenever it is desired to operate these transformers with Inerteen, complete instructions for the removal of the oil, the cleaning of the transformer and filling it with Inerteen should be obtained from the Westinghouse Electric & Manufacturing Company, Sharon, Pennsylvania.

NOTE: "Inerteen 7336-8 is regularly used in all new Westinghouse Inerteen transformers. Inerteen 7336-8 supersedes Inerteen 7336-7. Inerteen 7336-8 has improved characteristics so that if arcing occurs in an Inerteen transformer the insulating materials are not so quickly or so greatly impaired as a result of the formation of hydrogen chloride. This improved characteristic of 7336-8 Inerteen may be obtained from 7336-7 Inerteen by adding a certain concentrate to 7336-7 Inerteen. If it is desired to make this conversion, complete instructions for doing it should be obtained from the Westinghouse Electric & Manufacturing Company, Sharon, Pennsylvania."

Revised: November, 1946

INSTRUCTION BOOK

INERTEEN
INSULATING FLUID

for

Electrical Apparatus

CC200318

Westinghouse Electric Corporation

3

I.B. 44-860.3

Westinghouse Exhibit 5

SPECIAL INQUIRIES

When communicating with Westinghouse regarding the product covered by this Instruction Book, include all data contained on the nameplate attached to the equipment.* Also, to facilitate replies when particular information is desired, be sure to state fully and clearly the problem and attendant conditions.

Address all communications to the nearest Westinghouse representative as listed in the back of this book.

*For a permanent record, it is suggested that all nameplate data be duplicated and retained in a convenient location.

RECEIVING • TESTING • RECONDITIONING

INSTRUCTIONS

INERTEEN®

INSULATING FLUID

P.D.S. 7336-9

for

Electrical Apparatus

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.

NEW INFORMATION
Printed in U.S.A.

FEBRUARY, 1952
C0230229 Rep. 7-54

INERTEEN* INSULATING FLUID

P.D.S. 7336-9

Inerteen is a synthetic non-inflammable and non-explosive insulating and cooling liquid. It has proved its suitability for use in all Westinghouse Inerteen insulated apparatus. In order to insure the proper performance of the apparatus, only Westinghouse Inerteen should be used.

This publication gives the instructions for handling, inspection, and maintenance which experience has shown are important in obtaining the best service from the Inerteen.

* Registered trade-mark for Westinghouse Askarel

RECEIVING, HANDLING, STORING

SHIPMENT

Inerteen is shipped in tank cars, drums, or cans. The modern tank cars are usually lagged to prevent rapid fluctuations in temperature during transit and thus reduce the amount of expansion and contraction of Inerteen. Changes in the volume of the Inerteen due to temperature changes tend to cause breathing in of moist air resulting in condensation of moisture inside the container, and lowering of the dielectric strength of the Inerteen.

When shipped in drums, the Inerteen and the drums are both heated above room temperature while the drums are being filled, and the bungs are tightened immediately after filling. After cooling to normal temperature, the bungs are again tightened. The drums are provided with screw bungs having gaskets to prevent admission of water.

When shipped in cans, the cans as well as the Inerteen are heated above room temperature while being filled and are hermetically sealed immediately after filling.

STORING

Drums. As soon as a drum of Inerteen has been unloaded, the bung should be examined and tightened if it is loose. It is possible for bungs to become loosened by change in temperature or rough handling in transit. If loosened, be sure Inerteen is tested before using, or combining it with good Inerteen.

It is very desirable that Inerteen in drums be stored in a closed room. Outdoor storage of Inerteen is always hazardous to the Inerteen and should be avoided if at all possible. If it is necessary to store Inerteen outside, protection against direct contact of rain and snow should be provided. Drums stored outdoors should be placed so that bungs will be protected from moisture. It is desirable to cover the drums with a tarpaulin.

Cans. Cans containing Inerteen must not be exposed to the weather. Seals should be kept intact until the Inerteen is actually needed.

Screw caps are provided on the cans to use when the Inerteen is only partially removed after hermetic seal has been broken. By replacing the screw caps, contamination by moisture and dirt will be retarded, but the Inerteen must be tested just before using.

Storage Tank. The storage tank should be mounted on piers so that it will not touch the ground, and will be accessible to all points for inspection for leakage.

It is desirable to maintain the temperature of the Inerteen and tank a little above the temperature of the surrounding air as this prevents condensation of moisture in the tank which would affect the dielectric strength of the Inerteen.

The tank should preferably have a convex bottom, allowing for the installation of a drain cock at the lowest point for removing dirt or tank scale which might settle out. As Inerteen is heavier than water, most all of any water present will, in time, rise to the top of the Inerteen. A valve somewhere near the normal top level of the Inerteen should be provided for drawing off water-contaminated Inerteen. Provision for drawing off the Inerteen should also be made near the bottom of the tank.

HANDLING

Caution: Inerteen is a skin irritant. Unnecessary contact with this liquid or its vapor, particularly when it is hot, should be avoided. Especially the eyes, nose, and lips are affected when Inerteen comes in contact with them. Certain safety precautions must be observed when handling Inerteen.

In case Inerteen comes in contact with the skin, the parts affected should be thoroughly washed in soapy water and followed by an application of cold cream. A supply of these materials should be kept available at all times where personnel are working with Inerteen. Continued exposure may cause eruptions on certain individuals due to the absorption of Inerteen through the pores

of the skin. Cleanliness among workmen handling Inerteen is a very good safeguard against such effects. Application of castor oil is recommended for the eyes, castor oil or cold cream for the nose and lips.

Hot apparatus should not be opened except in well-ventilated places. Large quantities of Inerteen should be handled in a closed system. Workmen should be protected from frequent contact with any appreciable vapor concentration and from frequent skin contact with Inerteen.

In case Inerteen is spilled on one's clothing, the clothing should be changed as soon as possible and the soiled clothing laundered before it is worn again. Gloves such as Westinghouse S ♦ 1389 974 should be worn when it is necessary to put one's hand into Inerteen or when parts of apparatus must be handled wet.

Mineral oil is completely miscible with Inerteen and it is practically impossible to separate them. Therefore, it is important to avoid contaminating Inerteen with any kind of oil, since its presence changes the non-inflammable and non-explosive characteristics of Inerteen.

Note: The Inerteen should be sampled and tested before being transferred from the container to the apparatus, particularly in cases where the wire lock-seal has been broken. In cases where the apparatus is received with the Inerteen installed, the Inerteen should be sampled and tested before the apparatus is put into service, as described later in this book.

When putting new apparatus into service, see that the apparatus tank is free from moisture and foreign material.

Although the drums and tank cars are thoroughly washed and dried at the refinery before filling, a certain amount of scale is sometimes loosened from the inside in transit. Therefore, Inerteen which has not been filtered should be strained through three or more thicknesses of muslin, or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. The straining cloths may be stretched across a funnel of large size and should be renewed at frequent intervals.

Important: Extreme precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with Inerteen, and to prevent the entrance of water and dirt during the transfer of the Inerteen to the apparatus.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not possible, protection against moisture must be provided.

All vessels used for transferring the Inerteen should be carefully inspected to see that they are absolutely dry and free from contamination.

Important: Always use all-metal hose or pipe when handling the Inerteen. A hose made of natural rubber should not be used. Inerteen can easily become contaminated from the sulphur in the natural rubber, and should not be allowed to come in contact with it.

When it is necessary to transfer Inerteen from warm surroundings to apparatus exposed to extremely cold weather, even when the dielectric strength at room temperature is high, it is desirable to circulate the Inerteen through an Inerteen conditioner at room temperature. A similar procedure is also advisable in the case of apparatus erected inside and later exposed to cold weather, the reason being that Inerteen will absorb more water at higher temperatures which will be thrown out of solution at lower temperatures. The remainder will be in suspension in the Inerteen and will lower the dielectric strength.

A drum of cold Inerteen when taken into a warm room will "sweat", and the resulting moisture on the surface may mix with the Inerteen as it flows from the drum. Before breaking the seal, the drum should therefore be allowed to stand long enough to reach room temperature, which may require eight hours, or even longer under extreme temperature conditions.

Cleaning Contaminated Drums. The cleaning of drums which have contained used Inerteen requires great care in order to insure a thoroughly clean drum.

It is preferable to return such drums to the supplier where adequate cleaning facilities are available, rather than to attempt to clean them.

If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or benzine, using about one gallon each time, until the solvent shows no discoloration after using. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at the lower end to explore the corners of the drum.

Caution: Do not use a steel pipe because of the danger of a spark igniting the gasoline or benzine vapor.

Next, heat the drum with bunghole down, in a ventilated oven at a temperature of at least 88°C. (190°F.) for sixteen hours. (A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.) Blow out the drum with dry nitrogen or dry air to remove any lingering explosive vapors. Screw the bung on tightly before removing the drum from the oven. Use a new washer with the bung to insure a tight seal.

Caution: Open flames must always be kept away from the oven to prevent igniting inflammable gases which might be remaining in drum when placed in the oven.

Refilling Drums. The practice of refilling drums with Inerteen is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the Inerteen is likely to become contaminated.

If it is necessary to refill them for storage, drums which have been used only for clean, dry Inerteen should be reserved for this purpose. They should be closed immediately after being emptied, to exclude dirt and water. After refilling, they should be examined to see that they do not leak.

Whenever a drum is to be filled with Inerteen, the temperature of the drum and of the Inerteen should be at least 5.5°C. (10°F.) higher than the air, but the temperature of the drum need not be the same as that of the Inerteen.

A new washer should be used with the bung each time the drum is refilled, to insure a tight seal. These washers may be obtained from the nearest Westinghouse Office and it is recommended that a supply be kept on hand. Natural rubber composition washers should never be used as they would be attacked by the Inerteen.

Drums to be refilled with Inerteen for storage should be plainly marked with paint for identification.

SAMPLING AND INSPECTION

A good fireproof insulating liquid is one that will act as an insulating liquid, will carry the heat away from the apparatus, and is fireproof. Westinghouse Inerteen meets these requirements with the following characteristics:

1. High dielectric strength.
2. Freedom from inorganic acid, alkali, and corrosive sulphur. (To prevent injury to insulation and conductors)
3. Low viscosity. (To provide good heat transfer)
4. Low pour point.
5. Fireproof.

CAUSES OF DETERIORATION

The principal causes of deterioration of Inerteen are:

1. Presence of water.
2. Arcing.

Condensation from moist air due to breathing of the apparatus, especially when the apparatus is not continuously in service, may injure the Inerteen. (The moist air drawn into the apparatus condenses moisture on the surface of the Inerteen and inside of the tank.) The Inerteen may also be contaminated with water through leakage such as from leaky cooling coils or covers.

Arcing or burning in Inerteen produces finely divided carbon and gases which are mostly hydrogen chloride. Hydrogen chloride in the presence of moisture forms hydrochloric acid which may soon damage the insulation in the apparatus and cause rusting of ferrous materials.

Since hydrogen chloride is formed quickly after the arcing occurs, neither the Inerteen nor the apparatus should be exposed to the atmosphere (which always contains more or less moisture) until an attempt has been made to remove the hydrogen chloride. See Reconditioning, Page 7, for the method of purification.

SAMPLING INERTEEN

The dielectric strength of Inerteen is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. There have been low dielectric test results reported from the field which, upon investigation, have been found to be largely a matter of carelessness in handling.

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for handling Inerteen and servicing Inerteen be used for no other purpose. Care must be used in taking samples of Inerteen and sealing them prior to testing. It is

desirable that samples of Inerteen be removed from any container on clear days only, and when the temperature of the Inerteen is at least as high as the temperature of the surrounding air.

Use only tin containers with screwed metal caps or glass bottles with Inerteen-resistant stoppers to hold Inerteen samples. If it becomes necessary to use other than factory sampling containers, they should be rinsed with clean naphtha, washed with strong soap suds, and rinsed thoroughly in hot water, and then dried at approximately 110°C. for four hours with neck down in a circulating air oven. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

Provision is made on all Inerteen transformers to obtain a top sample of the Inerteen, however on a transformer that is in operation, a sample may be taken from either the top or bottom since any moisture present will be mixed in, due to circulation of the Inerteen. In sampling, allow a small amount of Inerteen to run out to flush the sampling connection clean before collecting the sample. The Inerteen should be put into the sample containers immediately and the caps screwed on tightly. The label for each container should be marked clearly with the serial number of the transformer or compartment from which the Inerteen was taken.

Before taking samples from a storage tank, the Inerteen should be allowed to settle for approximately twelve hours so that if there is any moisture present, it, having a lower specific gravity, will rise to the top where the sample is to be taken. A clean sneak-thief should be used to obtain the samples. Essentially, the same precautions to prevent moisture and dirt contamination should be used as outlined above.

Quantity of Sample. It is recommended that one 16 oz. bottle of Inerteen be taken as a sample for testing. At least one sample should be taken from a tank car of Inerteen. One sample may be taken from each drum, or if desired, a composite sample may be made from Inerteen from five drums, provided all of the drums are airtight. When the bung is first loosened, a hissing sound should be heard, which indicates that the drum has been airtight. If the test of the composite sample is not satisfactory, a sample from each of the drums represented should be tested.

When drums have been stored exposed to the weather, a sample from each drum must be tested to determine if it is suitable for use.

PERIODIC INSPECTION

It is desirable that periodic inspections of Inerteen apparatus be made and that samples of Inerteen be taken from each and from all compartments of any apparatus and tested after a short period of service (approximately three months for transformers). Following this, when operating conditions permit, routine sampling and testing of the Inerteen at intervals of six months to one year are suggested. Accurate records should be kept of such inspections and tests and if the Inerteen shows a dielectric strength of less than 22 kv, it should be conditioned. If facilities are not available for testing Inerteen, see "Westinghouse Inerteen Testing Service" below, and also P.L. 44-860. When an appreciable amount of Inerteen is removed from any apparatus, it should be replaced with an equal amount of new Inerteen so that the liquid level in the apparatus is maintained The Inerteen used for replacement purposes should have a dielectric strength of not less than 30 kv.

INERTEEN TESTING SERVICE

Many users of Inerteen do not have the necessary facilities for testing it. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an Inerteen testing service to provide a careful test by experienced engineers, and a prompt report of test results.

Two special 16 oz. sample bottles per mailing container (W) S#1608 629, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse Office. (The bottle and the container will not be returned to the customer.)

After drawing the sample of Inerteen, the customer should seal the bottle and mail it to the Westinghouse Electric Corporation, Plant Laboratory, Sharon, Pa. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. *The order sheet must be sent to the nearest Westinghouse Office.*

When samples of Inerteen are received for testing, they are sent to the Plant Laboratory and tested in accordance with methods described under "Testing Methods," which follows and is part of this Instruction Book.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination if so requested. (The customer should plainly indicate the type of service desired.)

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The physical and chemical examination consists of an examination of the Inerteen by a competent chemist. Recommendations will be made as to the suitability of the Inerteen for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the Inerteen represented should be given as completely as possible.

Power factor test of Inerteen at 60 cycles can be made.

(For details refer to the nearest Westinghouse Office.)

CHARACTERISTICS AND RECONDITIONING

CHARACTERISTICS

Inerteen is chemically stable. It is straw-yellow in color. It is not affected by reaction with other materials regularly used in the manufacture of Inerteen apparatus. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in Inerteen apparatus. Inerteen will not sludge under any operating condition.

The dielectric strength of Inerteen will compare favorably with that of insulating oil when tested under the same conditions. Quality samples of Inerteen tested under laboratory conditions may show a dielectric strength in excess of 40 kv. Care must be exercised in handling and testing Inerteen. Inerteen must be kept in clean, sealed containers to prevent loss by evaporation or contamination by moisture or dirt.

Inerteen exerts a strong solvent action on most varnishes, gums, and paints. Such materials are not used in the construction of Inerteen apparatus. No materials should be used in Inerteen apparatus except those approved by the Westinghouse Electric Corporation.

Inerteen has an irritating effect upon the skin. If it is necessary to handle it, see the caution note under Receiving, Storing, and Handling. (See Page 3.) It should be remembered that mineral oil is completely miscible with Inerteen; in fact, it is practically impossible to separate mineral oil and Inerteen.

Inerteen P.D.S. 7336-9 has an improved characteristic so that, when arcing occurs, the insulating materials are not so quickly or so greatly impaired as a result of the liberation of hydrogen chloride. Inerteen 7336-7, which was supplied in Inerteen transformers previous to September 1, 1945, can easily be converted to 7336-9 Inerteen. For complete information on this conversion, request Engineering Data Letter No. 1337-A from any Westinghouse Electric Corporation Office.

Specific Characteristics of Inerteen. As outlined in "Method of Testing Askarels A.S.T.M. D901-49T", the specific characteristics of Inerteen are:

1. Burn point: None
2. Chemical stability: No generation of free chlorides under normal operating conditions
3. Color: (Maximum) 150 A.P.H.
4. Condition: Clear
5. Dielectric constant:
   At 1000 cycles 77°F (25°C), 4.0 to 4.3
   At 1000 cycles 212°F (100°C), 3.5 to 3.8
6. Dielectric strength: (Minimum) 77°F (25°C)
   At point of shipment, 35 kv
   At point of receipt, 30 kv
7. Electrical resistivity: (Minimum)
   100×10^9 ohms/cm^3 (212°F (100°C) at 500 volts d-c)
8. Fixed chlorine content: (Minimum) 59.1 percent
9. Free chlorides: Less than 0.10 ppm
10. Neutralization number: Less than 0.010 mg. of NaOH/gram.
11. Pour point: (Maximum) minus 25.6°F (minus 32°C)
12. Refractive index
    At 77°F (25°C), 1.6137 to 1.6157
13. Specific gravity: (Minimum)
    At 60°F/60°F (15.5°C/15.5°C), 1.560
14. Viscosity: (Maximum)
    At 100°F (37.8°C), 54 seconds

RECONDITIONING

Reconditioning will be necessary to remove water, dirt, and hydrogen chloride which may be present and contaminating the Inerteen.

The blotter filter press and the Inerteen conditioner (both of which will be explained later in this book under "Apparatus for Reconditioning") will remove water and dirt deposits which may be present. Of the two methods, the Inerteen conditioner is the most effective in removing these two contaminating agents. Any equipment used for filtering

Inerteen should first be thoroughly cleaned with benzine or naptha. Every trace of any material foreign to Inerteen must be removed. If at all possible separate equipment should be used for filtering Inerteen only.

Hydrogen chloride, caused by arcing, may be eliminated by vigorously bubbling dry nitrogen through the Inerteen. The nitrogen should be passed through the drain valve at the bottom of the apparatus and allowed to escape through a vent at the top. The nitrogen should be discharged through a pressure regulator attached to a stand pipe above the level of the Inerteen in the apparatus to prevent the Inerteen from flowing into the regulator. The nitrogen should be bubbled through the Inerteen at a rate of one to three cubic feet per minute for a period of four to six hours. This will require from two to eight cylinders (220 cu. ft. each) of dry nitrogen, based on apparatus containing 150 to 2000 gallons of Inerteen.

Immediate application of the bubbling process will reduce the destructive action of the hydrochloric acid on the working parts and insulation, thereby making it likely that the materials not damaged by arcing may be used in repairing the apparatus. Also, use of the process will in most cases make it possible to satisfactorily reclaim the arced Inerteen.

After the hydrogen chloride has been removed by the bubbling process, the Inerteen should be reclaimed by use of an Inerteen conditioner.

There is no commercially suitable method for separating transformer oil from Inerteen.

TESTING METHODS

Instructions for all tests listed correspond in general to the recommendations of the American Society for Testing Materials.

DIELECTRIC STRENGTH TEST

Apparatus. The testing transformer and the source of supply of energy shall not be less than ½ kva, and the frequency shall not exceed 100 cycles per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by an approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the Inerteen takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 kva or less, as the current is limited by the impedance of the transformer.

The standard test cup for holding the sample of Inerteen shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by Inerteen or gasoline, and non-absorbent as far as moisture, Inerteen, or gasoline are concerned.

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, 1 in. in diameter, with square (90°) edges. The electrodes shall be mounted in the test cup with their axes horizontal and coincident, with a gap of 0.100 in. between their adjacent faces, and with tops of electrodes about 1¼ in. below the top of the cup. (A suitable test cup is shown in Fig. 1, and portable testing outfits in Figs. 2, 3, and 4.)

PROCEDURE

The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100 in., and the electrodes then locked in position.

The electrodes and the test cup shall be wiped clean with dry, calendered tissue paper or with a clean, dry chamois skin and thoroughly rinsed with Inerteen-free, dry gasoline or benzine until they are entirely free from fibers.

The test cup shall be filled with dry, lead-free gasoline or benzine, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms) per second until breakdown occurs. If the dielectric strength is not less than 25 kv, the cup shall be considered in suitable condition for testing the Inerteen. If a lower test value is obtained the cup shall be cleaned with gasoline and the test repeated.

Note: Evaporation of gasoline from the electrodes may chill them sufficiently to cause moisture to condense on their surface. For this reason, after the final rinsing with gasoline, the test cup should be immediately filled with the Inerteen which is being tested, and the test made at once, or the electrodes should be thoroughly dried before using.

The temperature of the test cup and of the Inerteen when tested shall be the same as that of the room, which should be between 68°F and 86°F. (20°C and 30°C.) Testing at lower temperatures is likely to give variable results which may be misleading.

The sample in the container shall be agitated with a swirling motion (to avoid introducing air) so as to mix the Inerteen thoroughly before filling the test cup. This is even more important with used Inerteen than with new Inerteen as the impurities may be precipitated and the test may be misleading.

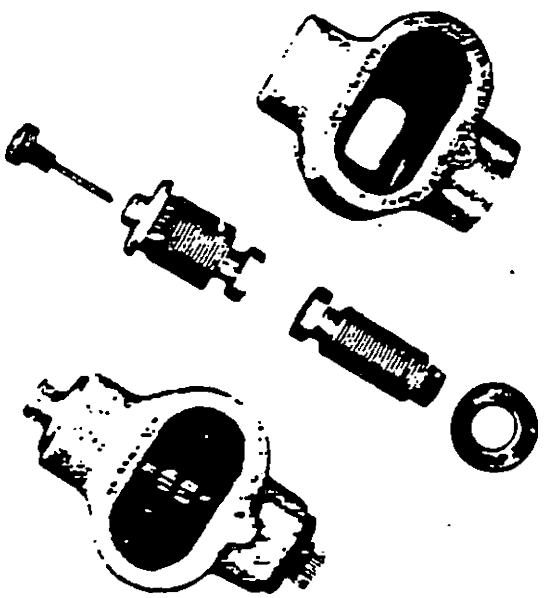

FIG. 1. Fluid Test Cup for Dielectric Test

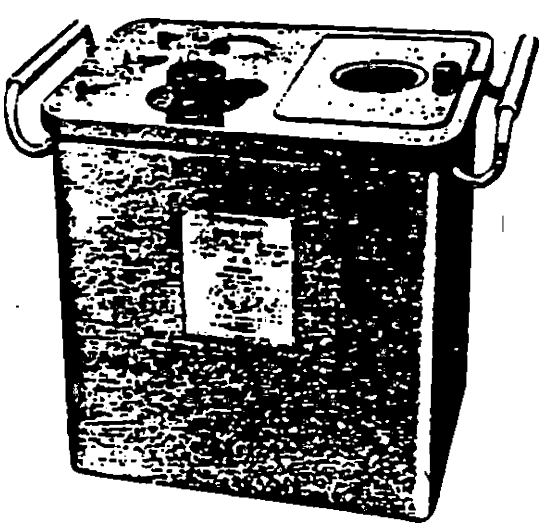

FIG. 2. Portable Oil Testing Set, ½ Kva, 35,000 Volts

The cup shall be filled with Inerteen to a height of no less than 0.79 in. (20 mm) above the top of the electrodes.

The Inerteen shall be gently agitated by rocking the cup and allowing it to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

Voltages shall be applied and increased uniformly at a rate of approximately 3000 volts (rms) per second until breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded.)

TESTS

a. Except as specified in (b) one breakdown test shall be made on each of five fillings of the test cup. If the average deviation from the mean exceeds 10 percent or if any individual test deviates more than 25 percent from the average, additional tests shall be made. The dielectric strength shall be determined by averaging the first five tests that conform to the allowable variations.

b. When Inerteen is tested in considerable quantity, so that the time required for testing is excessive and when it is merely desired to determine whether the breakdown safely exceeds the limit specified, or in those cases where the amount of Inerteen available for test may be very limited, one breakdown test shall be made on each of two fillings of the test cup. If neither breakdown is below this value, the Inerteen may be considered satisfactory and no further tests shall be required. If either of the breakdowns is less than the specified value a breakdown shall be made on each of three additional fillings and test results analyzed in accordance with (a).

Report. The report shall include the volts (rms value) at each breakdown and the average of the two or five breakdowns and the temperature of the Inerteen at the time of the test.

POUR TEST

Note: The procedures covered by the following instructions for the pour test, and especially the neutralization test, require spec-

ial equipment. The neutralization test must be made by a competent chemist, preferably one specializing in this particular field. Customers who do not possess these facilities are offered, at nominal cost, the use of the Westinghouse Inerteen Testing Service. Contact the nearest Westinghouse Office for details.

The pour point of Inerteen is the lowest temperature at which it will pour or flow when it is chilled without disturbance under certain definite specified conditions.

Apparatus. The test jar (see Fig. 4) shall be clear glass, of cylindrical shape, approximately 1¼ in. inside diameter and 4½ to 5 in. high, with a flat bottom. An ordinary 4 oz. Inerteen sample bottle may be used if the test jar is not available.

The cork shall fit the test jar, and shall be bored centrally to accommodate the test thermometer.

The thermometer shall conform to A.S.T.M. specifications for pour test. It may be ordered as: A.S.T.M. thermometer low cloud and pour, -70°F (—56.7°C) to 70°F (+21.1°C).

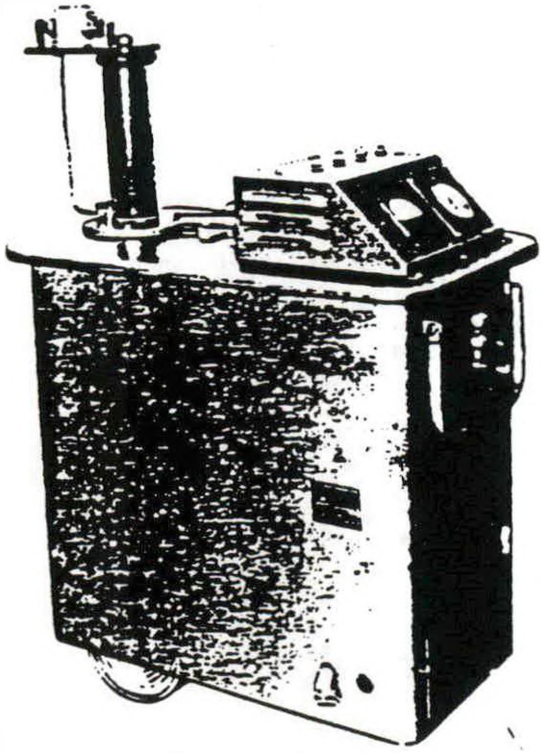

FIG. 3. Portable Trunk Type Insulating Liquid and Insulating Testing Set, 5 Kva. 30,000/60,000 Volts

The jacket shall be of glass or metal and shall be watertight, of cylindrical form, flat bottomed, about 4½ in. deep, with inside diameter ½ in. greater than outside diameter of the test jar.

A disc of cork or felt ¼ in. thick and of the same diameter as the inside of the jacket shall be placed in the bottom of the jacket.

The ring gasket shall be about ¾ in. thick, made to fit snugly around the outside of the test jar and loosely inside the jacket. This gasket may be made of cork, felt, or other suitable material, elastic enough to cling to the test jar and hard enough to hold its shape. The purpose of the ring gasket is to prevent the test jar from touching the jacket.

The cooling bath shall be of a type suitable for obtaining the required temperature. The size and shape of the bath are optional but a support suitable for holding the jacket firmly in a vertical position is essential. For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it. The required bath temperature may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

Procedure. The Inerteen to be tested shall be brought to a temperature at least 25°F. (14°C.), above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the Inerteen is perfectly clear. (Such filtration shall be made at a temperature at least 25°F. (14°C.), above the approximate cloud point.) The Inerteen shall be poured into the test jar, to a height of not less than 2 in. or more than 2¼ in. When necessary, the Inerteen shall be heated in a water bath just enough so it will pour into the test jar.

The test jar shall be tightly closed by the cork carrying the test thermometer in a vertical position in the center of the jar; the thermometer bulb should be immersed so that the beginning of the capillary shall be ⅛ in. below the surface of the Inerteen.

Heat without stirring to a temperature of 115°F. (46.1°C.) in a bath maintained at not higher than 118°F. (47.8°C.). The Inerteen shall then be cooled to 90°F. (32.2°C.) in air or in a water bath approximately 77°F. (25°C.) in temperature.

The cork or felt disc shall be placed in the bottom of the jacket and the test jar, with the ring gasket, 1 in. above the bottom, shall be inserted into the jacket. The disc, gasket, and inside of jacket shall be clean and dry.

During the cooling of the Inerteen, care shall be taken not to disturb the mass of the Inerteen nor to permit the thermometer to shift in the Inerteen.

The temperature of the cooling bath shall be adjusted so that it is below the pour point—approximately -25.6°F (-32°C)—of the Inerteen by not less than 15°F. (8.3°C) nor more than 30°F. (16.7°C), and the cooling bath shall be maintained at this temperature throughout the test. The jacket containing the test jar shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

Beginning at a temperature 20°F. (11.1°C.) above the expected pour point, at each lower test-thermometer reading which is a multiple of 5°F. (2.8°C), the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether there is a movement of the Inerteen in the test jar. The complete operation of removal and replacement shall require not more than three seconds. As soon as the Inerteen in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly five seconds as noted by a stop watch or other accurate timing device, and observed carefully. If the Inerteen shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure repeated at the next temperature reading 5°F. (2.8°C.) below the previous reading.

The test shall be continued in this manner until a point is reached at which the Inerteen in the test jar shows no movement when the test jar is held in a horizontal position for exactly five seconds. The reading of the test thermometer at this temperature corrected for error if necessary, shall be recorded. The pour point shall be taken as the temperature 5°F. (2.8°C.) above this solid point.

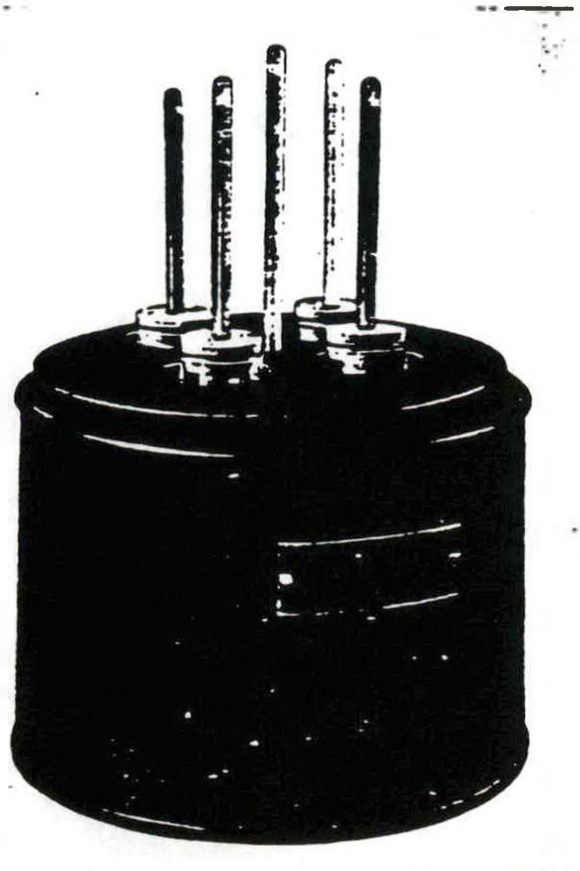

FIG. 4. Apparatus for Pour Test

NEUTRALIZATION TEST

The Neutralization Number is the number of milligrams of potassium hydroxide required to neutralize the acid in one gram of Inerteen.

Solutions Required.

a. Standard Potassium Hydroxide Solution (alcoholic, 0.1 N)—add 6 g. of c.p. solid KOH to 1 liter of c.p. anhydrous isopropyl alcohol. Boil, add 2 g. of c.p. Ba $(OH)_2$ and boil again. Cool, filter and store in a chemically resistant bottle protected by a guard tube containing soda lime and soda asbestos (Ascarite). Standardize against pure potassium acid phthalate using phenolphthalein as an indicator.

b. Titration Solvent—Add 500 ml. of c.p. benzene and 5 ml of water to 495 ml of c.p. anhydrous isopropyl alcohol.

c. Alpha-Naphtholbenzein Indicator Solution—Prepare a solution containing 10 g. of alpha-napthol-benzein per liter of c.p. anhydrous isopropyl alcohol.

Procedure. Into a 250 ml Erlenmeyer flask introduce 40 g. of Inerteen weighed accurately. Add 100 ml of the titration solvent and 3 ml of the indicator solution. Titrate immediately at a temperature below 30°C. Consider the end point definite if the color change to green persists for 15 seconds. A blank shall be determined on the solvent.

Calculations. The neutralization number or mg. KOH per g. of Inerteen = $\frac{(A-B)\,(N) \times 56.1}{W}$

A = ml KOH solution required for sample.
B = ml KOH solution required for blank.
N = normality of KOH solution.
W = grams of sample used.

APPARATUS FOR RECONDITIONING

There are several types of reconditioning apparatus available, the relative advantages of each of which are as follows:

1. The Inerteen Conditioner is the most effective method of removing moisture, dirt, and other contaminating materials from Inerteen.

2. The filter press is suitable for treating Inerteen containing only small quantities of water and dirt.

INERTEEN CONDITIONER

The Inerteen Conditioner consists of a clay container, clay filter, a motor-driven positive pressure pump, attendant valves, gauges, and relief devices, all mounted on a common base.

The motor and pump are combined as a unit and a strainer is provided on input to the pump to prevent entrance of large particles. The units are designed to operate under working pressures up to 60 psi. However, the usual operating pressure is 30 psi to 40 psi. Excessive pressures are prevented by two automatic by-pass valves. One by-pass valve connected across the pump is set to by-pass the Inerteen at a pressure of 60 psi to 70 psi. The other by-pass valve is connected on the discharge side of the conditioner. This latter by-pass valve, releasing at a pressure of approximately 5 psi, will avoid breaking the transformer relief diaphragm when no other relief is provided. Pump pressures are indicated by a pressure gauge.

Seven GPM Unit. The activated clay is contained in a tank mounted on one end of the filter frame. This tank is provided with a cover which incorporates an air-trap and vent to remove air which might be present in the tank and piping. The Inerteen is pumped up through the clay, insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through a wire screen prior to entering the paper filter to remove practically all of the clay. The paper filter consists of 18 frames and 17 plates, alternately spaced, mounted in a yoke. One sheet of filter paper is used between each plate and frame to provide a gasket seal and remove all traces of clay from the Inerteen. (See Fig. 8)

Three GPM Unit. This unit utilizes two tanks, one within the other. The activated clay is held in the inner tank by suitable screens at top and bottom. The space below the inner tank is completely sealed off from the rest of the space between the two tanks. The cover is of double-deck construction, incorporating the top screen for the inner tank and the solid cover for the outer tank. The Inerteen is pumped into the lower space and is forced up through the activated clay, insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through the fine mesh upper screen and out into the space between the two tanks. The discharge pipe is at the lower end of the outside tank and any air in the Inerteen is trapped in the upper space of the outside tank where it may be drawn off.

Since the density of Inerteen is considerably greater than that of water, moisture will float on the surface of the Inerteen. It is, therefore, considered advisable to condition Inerteen from the top and return it to the bottom of the Inerteen filled apparatus.

One charge of clay is composed of approximately 40 pounds of 15-30 mesh activated clay.* This relatively large volume of clay makes only occasional changes of clay necessary, depending of course on the amount and condition of the Inerteen filtered. Normally one charge will condition approximately 3000 gallons of Inerteen. The coarse granulated clay used gives maximum surface contact between clay and liquid and makes possible a rapid and thorough mixing of the clay and Inerteen to accomplish complete reconditioning of the Inerteen as it passes through the clay tank. The clay granules are removed from the Inerteen by means of fine screen in the 3 GPM filter and by screen and paper in the 7 GPM filter.

The clay never passes through the pump to cause wear on pump parts and consequent loss of pumping capacity. As soon as the charge of activated clay is placed in the tank and the cover clamped in place, the unit is ready for immediate use.

Neither clay nor filter paper can be effectively dried of water after they have once become saturated with Inerteen. Therefore, extreme care should be taken to see that both clay and filter paper are thoroughly dried when placed in the filter.

The clay may be dried in a high temperature oven at 200 deg. C. for six hours and shallow pans are preferred as containers for the clay while drying. A paper drying oven may be used if a high temperature oven is not available, with a drying time extended to approximately twenty-four hours at the oven's highest temperature. The filter paper should be dried six to twelve hours at 85°C. to 100°C.,

* Filter paper and activated clay may be obtained from the Westinghouse Sharon Plant.

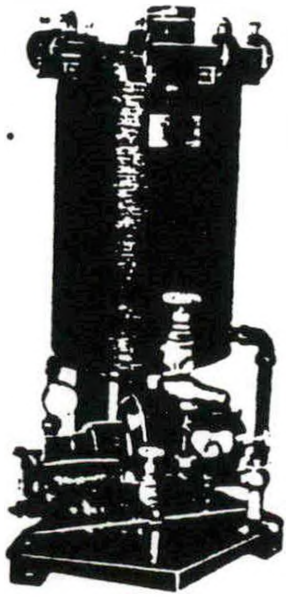

FIG. 5. Three Gallon-per-Minute Conditioner

depending on the condition of the paper and the spacing of the sheets in the oven. Both paper and clay should be placed directly in the filter after the drying process as either, if exposed, will absorb considerable moisture from the atmosphere in a very short time.

Each fresh charge of clay will absorb about three gallons of Inerteen. This should be provided for to prevent depleting the supply in the apparatus, but most of this Inerteen may be recovered when changing clay.

This can be accomplished most effectively by removing the used clay from the filter and placing it in a tank of approximately 30 gallons capacity containing about 5 gallons of water. The tank should have a drain valve at its bottom edge and should be tilted somewhat toward this valve. The clay thus placed in water, having a greater affinity for water, will give up the Inerteen it has absorbed and become saturated with water. The Inerteen being heavier than water will sink to the bottom; the clay and water will float on top. After settling for several hours, most of the Inerteen may be drawn off through the valve. This Inerteen may be reconditioned and used again in recharging the conditioner. The used clay should be discarded.

To Prepare the 7 GPM Conditioner for Operation. Remove the cover and screen from the clay tank and fill the tank with activated clay, 4440-3, to within four inches of the bottom edge of the inner flange. Replace screen and cover. Release the pressure-screw of the filter press and loosen plates and frames. Place one sheet of "B" size blotting paper between the face of each frame and plate. Care should be used to see that the holes thru the plates, frames and paper are in proper alignment before the pressure screw is tightened. Close the discharge, tank by-pass, tank drain, suction and suction-test valves. Open the air discharge valve. Pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons of Inerteen. Start the motor and open the drip pan valve a small amount so that not less than 5 minutes are required to fill the clay tank, saturating the clay with Inerteen. (If Inerteen is admitted too rapidly, it will tend to pack the clay into the top of the tank.) With the valve at the apparatus closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks. Stop motor and close suction-test, air discharge, and drip pan valves.

To begin conditioning Inerteen in Inerteen filled apparatus, open the apparatus valves. Open the conditioner discharge and suction valves. At intervals open air discharge valve to allow trapped air to escape and close when Inerteen starts to flow through valve. Open drip pan valve at intervals too, to remove Inerteen which may have dripped into the drip pan.

When it is necessary to change the clay, first close the valve in the suction line, close the tank

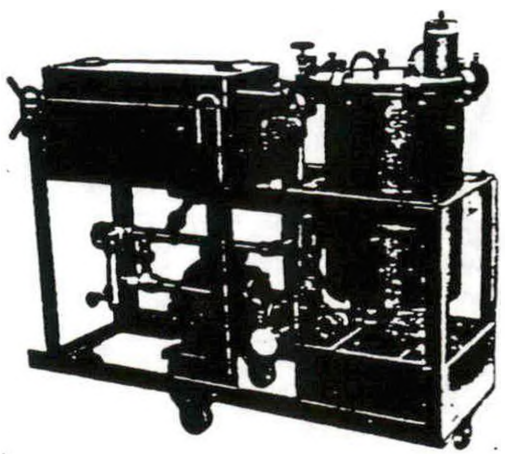

FIG. 6. Seven Gallon-per-Minute Conditioner

inlet and outlet valves, open the tank by-pass valve, the tank drain valve and the air vent valve to permit the free Inerteen in the tank to drain into the lower drip pan. Open the drip pan valve and pump the Inerteen from the drip pan through the filter press. Shut down the motor and remove the clay from the tank and refill with fresh clay as previously described.

To change the filter or blotting papers, stop the motor and close suction and discharge valves. Slowly back off the pressure screw, permitting the Inerteen trapped in the frames to be released gradually. Then back off the pressure screw completely, open up the press and let the surplus Inerteen drain from the papers. Replace the saturated papers with clean dry paper and retighten the press.

If the system-seal is not broken, it will only be necessary to open the discharge and suction valves and start the motor to resume conditioning the Inerteen.

To Prepare the 3 GPM Conditioner for Operation. Remove the cover and screen from the clay tank and fill the inner tank with activated clay, 4440-3, to within four inches of the top. Replace screen and cover. Close the discharge and suction valves and open air discharge and drip pan valves about ⅓ open. Start motor and pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons. Not less than five minutes should be required to fill the clay tank and saturate the clay with Inerteen. With the valve at the apparatus closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks. Stop motor and close suction-test, air discharge and drip pan valves.

To begin conditioning Inerteen, open apparatus valves, open the conditioner discharge and suction valves and start motor.

At intervals open air discharge valve to let trapped air escape and close as soon as Inerteen flows from the valve.

When it is necessary to change the clay, first stop motor and close the valves in the suction and discharge lines. Remove discharge hose and open the discharge valve and tank drain valve to permit the Inerteen in the tank and discharge hose to drain into a container. After draining is complete, remove inner tank and dump the clay from the inner tank and refill with fresh clay as previously described. The used clay should be discarded.

BLOTTER FILTER PRESS

The blotter filter press (See Fig. 7) is essentially a number of sets of blotter filter papers in parallel, each set containing several thicknesses. The Inerteen is pumped through filter paper which absorbs the water and strains out the sediment.

Other Classes of Service. Although there are other uses, such as cleaning of low-viscosity insulating compounds, benzine, etc., it is recommended that a cleaning device intended for Inerteen reconditioning should not be used for other classes of work, due to danger of subsequent contamination of the Inerteen.

Capacity. The capacity of these machines, with Inerteen pressure and filtering area fixed, depends on the viscosity of the Inerteen and its freedom from dirt. With fairly clean Inerteen at ordinary room temperature, the capacity of the machines will vary from normal to about 15 percent above normal, depending on the viscosity (which varies with the temperature). It has been found that the best results are obtained when the Inerteen temperature is about 50°C. The average working pressure of these machines is less than 40 psi and the pressure relief valve is set at the factory to by-pass the full flow at from 60 psi to 80 psi.

Apparatus. There are three standard sizes of Westinghouse filter presses: B-5, B-10, and A-30. The letter designates the size of filter paper; the number indicates the relative capacity in gallons per minute.

The complete outfit consists of filterpress, motor, strainer, pump, gas trap, pressure gauge, drip pan, wheels, and piping. The piping is arranged so the line can be tested for leaks under pressure. All machines are mounted on a fabricated structural steel frame. The drip pan can be removed by disconnecting one pipe coupling and four bolts. The strainer can be cleaned by disconnecting three bolts. The pumps are of the helical-gear type to insure quietness and smooth flow of Inerteen. The A-30 pump is connected to the motor through flexible couplings. The B-5 and B-10 pumps are mounted directly on the rear motor bracket and driven through a helical reduction gear.

The filter press proper is made up of a series of cast iron plates and frames assembled alternately, with the filter papers between them. By means of a screw and cast-iron end block, the plates, frames, and papers are forced tightly together. Except for a machined rim which serves as a joint to prevent

the escape of Inerteen, the plates are cast with small pyramids on both surfaces.

The plates and frames have holes in two corners and supporting lugs at the sides. The plates have handles cast on the top edge. When the plates and frames are assembled with the filter papers between, the holes form the inlet and outlet. The frames have the holes in the upper corner connected by small ducts to the middle of the frame. The plates have ducts leading from the surface of the plate to the hole in the lower corner. (See Fig. 8)

The Inerteen enters under pressure at the top corner through the inlet formed by the holes in the frames, plates, and filter papers, flows into the frames through the same ducts, and completely fills the chamber formed by the frame and two sets of filter paper. As there are no outlet ducts in the frame, the Inerteen is forced through the paper and flows along the grooves between the rows of pyramids and out through the ducts provided at the lower corner of the plates. The dry filter paper takes up the moisture and removes the sediment from the Inerteen.

Operation. The filter press is made ready for operation by placing a set of five sheets of filter paper (that have been thoroughly dried in an electric oven) between each filter plate and frame. The holes in the filter paper must line up with the holes in the plates and frames. The sediment is strained out by the first layer of paper and the moisture is taken up by the capillary action of the paper.

If any moisture remains, it indicates that the filter papers are saturated with moisture and should be renewed. No rule can be given as to how often the papers must be changed, as this depends entirely on the condition of the Inerteen. The usual procedure is to run the machine for about half an hour (if the Inerteen is not in very bad condition) and then shut down; remove one sheet from the inlet side of each set and put in a new sheet on the outlet side of each set. (The frame is the inlet side and the plate is the outlet side.) Frequent dielectric tests should be made during this procedure as wet Inerteen may necessitate recharging the filter press with a full set of papers before the five sheets have been removed in succession.

The quickest method of filtering a quantity of Inerteen is to pump all the Inerteen through the filter and into another tank which is clean and dry. If care is taken to change the filter papers before they become saturated, the Inerteen will be clean and dry. If a second tank for holding the Inerteen

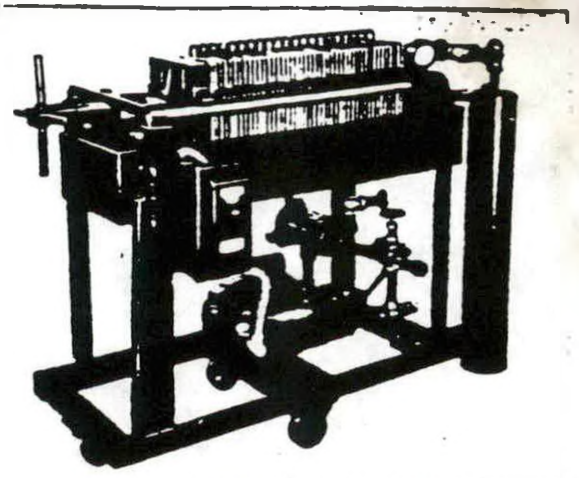

FIG. 7. B-10 Blotter Filter Press

is not available, or if it is desired to filter the Inerteen of apparatus while it is in service, the Inerteen may be pumped from the top of the apparatus tank through the filter and returned to the bottom of the same tank under the surface of the Inerteen. This operation should be continued until the Inerteen in the apparatus tank shows a sufficiently high dielectric strength.

When a large quantity of Inerteen is to be filtered, time may be saved by using two filter presses, one of which may be operated while the other is being recharged.

Filtering through blotter filter papers does not materially reduce organic acidity or improve resistance to emulsification, although the dielectric strength may be restored to a satisfactory value.

The capacity of the filter press is much reduced when operating at low temperatures.

When the Inerteen has to be filtered at low temperatures, an additional pump in the pipe line is desirable.

Inerteen in apparatus contaminated by only a small amount of moisture may be reconditioned by drawing the Inerteen from the top of the apparatus tank, passing it through the filter press, and pumping it back into the bottom of the apparatus. The Inerteen should be put through the system until a sample drawn from the top of the apparatus gives satisfactory dielectric values.

Blotter Filter Paper. The filter paper used is a special grade of blotting paper about .025 in. thick; it contains no coloring matter or chemicals which might injure the Inerteen. Five sheets cut to

the proper size, 12⅞ in. square for the A sizes and 7¾ in. square for the B sizes, and with holes punched to correspond with the holes in the plates and frames, are used between each plate and the adjacent frames.

To obtain the best results in reconditioning Inerteen, the paper must be perfectly dry when first placed in the press. Filter paper always takes up moisture if exposed to the air for any length of time and for this reason care must be used in handling. The standard paper is carried in packages containing one ream, carefully wrapped in waxed paper and covered with heavy wrapping paper.

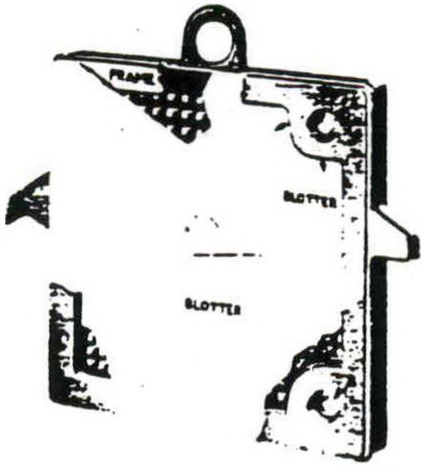

FIG. 8. Blotter Filter Press Frame Showing Blotter Filter Papers in Place

Electric Drying Ovens. Electric drying ovens for use with Type A and Type B filter presses require 2000 watts and 1400 watts respectively. The interior of the ovens is provided with rods for supporting the filter paper to facilitate rapid and thorough drying. An automatic thermostat having a range of 65°C to 120°C is provided for maintaining uniform oven temperature. The thermostat is adjusted at the factory for 100°C, the recommended value, and the setting marked so that the operator may conveniently reset thermostat to 100°C if adjustment is changed.

The standard thermostat-equipped oven is suitable for alternating current only. Ovens to operate on direct current are special and are equipped with a thermometer and a manually operated three-heat switch.

By moving one rod, the Type A oven can be used for drying Type B paper.

The normal capacity of the Type A oven is 240 sheets and the Type B oven is 180 sheets when spaced ¼ inch apart.

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DETROIT 32, MICH., 5757 Trumbull Ave., P.O. Box 902
DULUTH 2, MINN., 408 Bradley Bldg., 10 East Superior St.
EL PASO, TEXAS, 718 Mills Bldg.
FRESNO 1, CALIF., 2608 California Ave.
GRAND RAPIDS 2, MICH., 148 Monroe Ave., N. W.
HARTFORD 3, CONN., 119 Ann St.
HOUSTON 2, TEXAS, 907 Dallas Ave.
HUNTINGTON 1, W. VA., 1029 Seventh Ave., P.O. Box 1190
INDIANAPOLIS 9, IND., 137 S. Pennsylvania St.
JACKSON, MICH., 120 W. Michigan Ave.
KANSAS CITY 6, MO., 101 W. Eleventh St.
LOS ANGELES 17, CALIF., 600 St. Paul Ave.
LOUISVILLE 2, KY., 332 West Broadway
MEMPHIS 3, TENN., 825 Exchange Bldg., 130 Madison Ave.
MILWAUKEE 2, WIS., 538 N. Broadway
MINNEAPOLIS 13, MINN., 2303 Kennedy St., N. E.
NEWARK 2, N. J., 1180 Raymond Blvd.
NEW ORLEANS 12, LA., 1226 Whitney Bldg., 288 St. Charles St.
NEW YORK 5, N. Y., 40 Wall St.
NORFOLK 10, VA., 915 W. 21st St.
OMAHA 2, NEBR., 117 N. 13th St.
PHILADELPHIA 4, PA., 3001 Walnut St.
PHOENIX, ARIZ., 1102 N. 21st Ave., P.O. Box 6144
PITTSBURGH 30, PA., 306 4th Ave., P.O. Box 1017
PORTLAND 4, ORE., 309 S.W. 6th Ave.
RICHMOND 19, VA., 1110 East Main St.
ROANOKE 4, VA., 303 1st St. S.W.
ST. LOUIS, MO., 411 North Seventh St.
SALT LAKE CITY 1, UTAH, 235 W. South Temple St.
SAN DIEGO 1, CALIF., 525 "F" St.
SAN FRANCISCO 8, CALIF., 410 Bush St.
SEATTLE 4, WASH., 3451 East Marginal Way
SPOKANE 1, WASH., N. 1023 Monroe St.
SYRACUSE 4, N. Y., 700 W. Genesee St.
TOLEDO 4, OHIO, 245 Summit St.
UTICA 2, N. Y., 255-257 Genesee St.
WASHINGTON 6, D. C., 1625 "K" Street, N.W.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.
YOUNGSTOWN 3, OHIO, 25 E. Boardman St.

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Instructions for INERTEEN® Insulating Fluid P.D.S. 54201 KA

500537

Westinghouse Exhibit 6

Westinghouse Electric Corporation
Power Transformer Division, Sharon, Pa.
I.B. 44.063.00 5[illegible] July 1965 Supersedes I.B. [illegible]

INERTEEN* INSULATING FLUID

P.D.S. 54201KA

Inerteen is a synthetic non-inflammable and non-explosive insulating and cooling liquid. It has proved its suitability for use in all Westinghouse Inerteen insulated apparatus. In order to insure the proper performance of the apparatus, only Westinghouse Inerteen should be used.

This publication gives the instructions for handling, inspection, and maintenance which experience has shown are important in obtaining the best service from the Inerteen.

* Registered trade-mark for Westinghouse Askarel.

500538

RECEIVING, HANDLING, STORING

SHIPMENT

Inerteen is shipped in tank cars, drums, or cans. The modern tank cars are usually lagged to prevent rapid fluctuations in temperature during transit and thus reduce the amount of expansion and contraction of Inerteen. Changes in the volume of the Inerteen due to temperature changes tend to cause breathing in of moist air resulting in condensation of moisture inside the container, and lowering of the dielectric strength of the Inerteen.

When shipped in drums, the Inerteen and the drums are both heated above room temperature while the drums are being filled, and the bungs are tightened immediately after filling. After cooling to normal temperature, the bungs are again tightened. The drums are provided with screw bungs having gaskets to prevent admission of water.

When shipped in cans, the cans as well as the Inerteen are heated above room temperature while being filled and are hermetically sealed immediately after filling.

STORING

Drums. As soon as a drum of Inerteen has been unloaded, the bung should be examined and tightened if it is loose. It is possible for bungs to become loosened by change in temperature or rough handling in transit. If loosened, be sure Inerteen is tested before using, or combining it with good Inerteen.

It is very desirable that Inerteen in drums be stored in a closed room. Outdoor storage of Inerteen is always hazardous to the Inerteen and should be avoided if at all possible. If it is necessary to store Inerteen outside, protection against direct contact of rain and snow should be provided. Drums stored outdoors should be placed so that bungs will be protected from moisture. It is desirable to cover the drums with a tarpaulin.

Cans. Cans containing Inerteen must not be exposed to the weather. Seals should be kept intact until the Inerteen is actually needed.

Screw caps are provided on the cans to use when the Inerteen is only partially removed after hermetic-seal has been broken. By replacing the screw caps, contamination by moisture and dirt will be retarded, but the Inerteen must be tested just before using.

Storage Tank. The storage tank should be mounted on piers so that it will not touch the ground and will be accessible to all points for inspection for leakage.

It is desirable to maintain the temperature of the Inerteen and tank a little above the temperature of the surrounding air as this prevents condensation of moisture in the tank which would affect the dielectric strength of the Inerteen.

The tank should preferably have a conver bottom, allowing for the installation of a drain cock at the lowest point for removing dirt or tank scale which might settle out. As Inerteen is heavier than water most all of any water present will, in time rise to the top of the Inerteen. A valve somewhere near the normal top level of the Inerteen should be provided for drawing off water-contaminated Inerteen. Provision for drawing off the Inerteen should also be made near the bottom of the tank.

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HANDLING

Caution: Inerteen is a skin irritant. Unnecessary contact with the liquid or its vapor particularly when it is hot, should be avoided. Especially the eyes, nose, and lips are effected when Inerteen comes in contact with them. Certain safety precautions must be observed when handling Inerteen.

In case Inerteen comes in contact with the skin the parts affected should be thoroughly washed in soapy water and followed by an application of cold cream. A supply of these materials should be kept available at all times where persons are working with Inerteen. Continued exposure may cause eruptions on certain individuals due to the absorption of Inerteen through the pores

of the skin. Cleanliness among workmen handling Inerteen is a very good safeguard against such effects. Application of castor oil is recommended for the eyes, castor oil or cold cream for the nose and lips.

Hot apparatus should not be opened except in well-ventilated places. Large quantities of Inerteen should be handled in a closed system. Workmen should be protected from frequent contact with any appreciable vapor concentration and from frequent skin contact with Inerteen.

In case Inerteen is spilled on one's clothing, the clothing should be changed as soon as possible and the soiled clothing laundered before it is worn again. Gloves such as Westinghouse S#1309 974 should be worn when it is necessary to put one's hand into Inerteen or when parts of apparatus must be handled wet.

Mineral oil is completely miscible with Inerteen and it is practically impossible to separate them. Therefore, it is important to avoid contaminating Inerteen with any kind of oil, since its presence changes the non-inflammable and non-explosive characteristics of Inerteen.

Note: The Inerteen should be sampled and tested before being transferred from the container to the apparatus, particularly in cases where the wire lock-seal has been broken. In cases where the apparatus is received with the Inerteen installed, the Inerteen should be sampled and tested before the apparatus is put into service, as described later in this book.

When putting new apparatus into service, see that the apparatus tank is free from moisture and foreign material.

Although the drums and tank cars are thoroughly washed and dried at the refinery before filling, a certain amount of scale is sometimes loosened from the inside in transit. Therefore, Inerteen which has not been filtered should be strained through three or more thicknesses of muslin, or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. The straining cloths may be stretched across a funnel of large size and should be renewed at frequent intervals.

Important: Extreme precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with Inerteen, and to prevent the entrance of water and dirt during the transfer of the Inerteen to the apparatus.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not possible, protection against moisture must be provided.

All vessels used for transferring the Inerteen should be carefully inspected to see that they are absolutely dry and free from contamination.

Important: Always use all-metal hose or pipe when handling the Inerteen. A hose made of natural rubber should not be used. Inerteen can easily become contaminated from the sulphur in the natural rubber, and should not be allowed to come in contact with it.

When it is necessary to transfer Inerteen from warm surroundings to apparatus exposed to extremely cold weather, even when the dielectric strength at room temperature is high, it is desirable to circulate the Inerteen through an Inerteen conditioner at room temperature. A similar procedure is also advisable in the case of apparatus erected inside and later exposed to cold weather, the reason being that Inerteen will absorb more water at higher temperatures which will be thrown out of solution at lower temperatures. The remainder will be in suspension in the Inerteen and will lower the dielectric strength.

A drum of cold Inerteen when taken into a warm room will "sweat", and the resulting moisture on the surface may mix with the Inerteen as it flows from the drum. Before breaking the seal, the drum should therefore be allowed to stand long enough to reach room temperature, which may require eight hours, or even longer under extreme temperature conditions.

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Cleaning Contaminated Drums. The cleaning of drums which have contained used Inerteen requires great care in order to insure a thoroughly clean drum.

It is preferable to return such drums to the supplier where adequate cleaning facilities are available, rather than to attempt to clean them.

If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or benzine, using about one gallon each time, until the solvent shows no discoloration after using. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at the lower end to explore the corners of the drum.

Caution: Do not use a steel pipe because of the danger of a spark igniting the gasoline or benzine vapor.

Next, heat the drum with bunghole down, in a ventilated oven at a temperature of at least 88°C. (190°F.) for sixteen hours. (A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.) Blow out the drum with dry nitrogen or dry air to remove any lingering explosive vapors. Screw the bung on tightly before removing the drum from the oven. Use a new washer with the bung to insure a tight seal.

Caution: Open flames must always be kept away from the oven to prevent igniting inflammable gases which might be remaining in drum when placed in the oven.

Refilling Drums. The practice of refilling drums with Inerteen is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the Inerteen is likely to become contaminated.

If it is necessary to refill them for storage, drums which have been used only for clean, dry Inerteen should be reserved for this purpose. They should be closed immediately after being emptied, to exclude dirt and water. After refilling, they should be examined to see that they do not leak.

Whenever a drum is to be filled with Inerteen, the temperature of the drum and of the Inerteen should be at least 5.5°C. (10°F.) higher than the air, but the temperature of the drum need not be the same as that of the Inerteen.

A new washer should be used with the bung each time the drum is refilled, to insure a tight seal. These washers may be obtained from the nearest Westinghouse Office and it is recommended that a supply be kept on hand. Natural rubber composition washers should never be used as they would be attacked by the Inerteen.

Drums to be refilled with Inerteen for storage should be plainly marked with paint for identification.

SAMPLING AND INSPECTION

A good fireproof insulating liquid is one that will act as an insulating liquid, will carry the heat away from the apparatus, and is fireproof. Westinghouse Inerteen meets these requirements with the following characteristics:

1. High dielectric strength.
2. Freedom from inorganic acid, alkali, and corrosive sulphur. (To prevent injury to insulation and conductors)
3. Low viscosity. (To provide good heat transfer)
4. Low pour point.
5. Fireproof.

CAUSES OF DETERIORATION

The principal causes of deterioration of Inerteen are:

1. Presence of water.
2. Arcing.

Condensation from moist air due to breathing of the apparatus, especially when the apparatus is not continuously in service, may injure the Inerteen. (The moist air drawn into the apparatus condenses moisture on the surface of the Inerteen and inside of the tank.) The Inerteen may also be contaminated with water through leakage such as from leaky cooling coils or covers.

Arcing or burning in Inerteen produces finely divided carbon and gases which are mostly hydrogen chloride. Hydrogen chloride in the presence of moisture forms hydrochloric acid which may soon damage the insulation in the apparatus and cause rusting of ferrous materials.

Since hydrogen chloride is formed quickly after the arcing occurs, neither the Inerteen nor the apparatus should be exposed to the atmosphere (which always contains more or less moisture) until an attempt has been made to remove the hydrogen chloride. See Reconditioning, Page 7, for the method of purification.

SAMPLING INERTEEN

The dielectric strength of Inerteen is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. There have been low dielectric test results reported from the field which, upon investigation, have been found to be largely a matter of carelessness in handling.

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for handling Inerteen and servicing Inerteen be used for no other purpose. Care must be used in taking samples of Inerteen and sealing them prior to testing. It is

esirable that samples of Inerteen be removed from container on clear days only, and when the perature of the Inerteen is at least as high as the emperature of the surrounding air.

Use only tin containers with screwed metal caps or glass bottles with Inerteen-resistant stoppers to old Inerteen samples. If it becomes necessary to se other than factory sampling containers, they should be rinsed with clean naptha, washed with trong soap suds, and rinsed thoroughly in hot water, and then dried at approximately 110°C. for our hours with neck down in a circulating air oven. f the containers are not used immediately after leaning, they should be sealed tightly and stored n a dry, clean place.

Provision is made on all Inerteen transformers to btain a top sample of the Inerteen, however on a ransformer that is in operation, a sample may be aken from either the top or bottom since any oisture present will be mixed in, due to circula- ion of the Inerteen. In sampling, allow a small mount of Inerteen to run out to flush the sampling onnection clean before collecting the sample. The nerteen should be put into the sample containers ediately and the caps screwed on tightly. The l for each container should be marked clearly ith the serial number of the transformer or com- artment from which the Inerteen was taken.

Before taking samples from a storage tank, the nerteen should be allowed to settle for approxi- ately twelve hours so that if there is any moisture resent, it, having a lower specific gravity, will rise o the top where the sample is to be taken. A clean eak-thief should be used to obtain the samples. ssentially, the same precautions to prevent mois- re and dirt contamination should be used as out- ned above.

Quantity of Sample. It is recommended that ne 16 oz. bottle of Inerteen be taken as a sample for sting. At least one sample should be taken from tank car of Inerteen. One sample may be taken om each drum, or if desired, a composite sample ay be made from Inerteen from five drums, pro- ded all of the drums are airtight. When the bung first loosened, a hissing sound should be heard, hich indicates that the drum has been airtight. If e test of the composite sample is not satisfactory, a mple from each of the drums represented should sted.

When drums have been stored exposed to the eather, a sample from each drum must be tested determine if it is suitable for use.

PERIODIC INSPECTION

It is desirable that periodic inspections of Inerteen apparatus be made and that samples of Inerteen be taken from each and from all compartments of any apparatus and tested after a short period of service (approximately three months for transformers). Following this, when operating conditions permit, routine sampling and testing of the Inerteen at intervals of six months to one year are suggested. Accurate records should be kept of such inspections and tests and if the Inerteen shows a dielectric strength of less than 22 kv, it should be conditioned. If facilities are not available for testing Inerteen, see "Westinghouse Inerteen Testing Service" below, and also P.L. 44-860. When an appreciable amount of Inerteen is removed from any apparatus, it should be replaced with an equal amount of new Inerteen so that the liquid level in the apparatus is maintained. The Inerteen used for replacement purposes should have a dielectric strength of not less than 30 kv.

INERTEEN TESTING SERVICE

Many users of Inerteen do not have the necessary facilities for testing it. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an Inerteen testing service to provide a careful test by experienced engineers, and a prompt report of test results.

Two special 16 oz. sample bottles per mailing container (W) S#1608 629, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse Office. (The bottle and the container will not be returned to the customer.)

After drawing the sample of Inerteen, the customer should seal the bottle and mail it to the Westinghouse Electric Corporation, Plant Laboratory, Sharon, Pa. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. *The order sheet must be sent to the nearest Westinghouse Office.*

When samples of Inerteen are received for testing, they are sent to the Plant Laboratory and tested in accordance with methods described under "Testing Methods," which follows and is part of this Instruction Book.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination if so requested. (The customer should plainly indicate the type of service desired.)

The physical and chemical examination consists of an examination of the Inerteen by a competent chemist. Recommendations will be made as to the suitability of the Inerteen for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the Inerteen represented should be given as completely as possible.

Power factor test of Inerteen at 60 cycles can be made.

(For details refer to the nearest Westinghouse Office.)

CHARACTERISTICS AND RECONDITIONING

CHARACTERISTICS

Inerteen is chemically stable. It is straw-yellow in color. It is not affected by reaction with other materials regularly used in the manufacture of Inerteen apparatus. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in Inerteen apparatus. Inerteen will not sludge under any operating condition.

The dielectric strength of Inerteen will compare favorably with that of insulating oil when tested under the same conditions. Quality samples of Inerteen tested under laboratory conditions may show a dielectric strength in excess of 40kv. Care must be exercised in handling and testing Inerteen. Inerteen must be kept in clean, sealed containers to prevent loss by evaporation or contamination by moisture or dirt.

Inerteen exerts a strong solvent action on most varnishes, gums, and paints. Such materials are not used in the construction of Inerteen apparatus. No materials should be used in Inerteen apparatus except those approved by the Westinghouse Electric Corporation.

Inerteen has an irritating effect upon the skin. If it is necessary to handle it, see the caution note under Receiving, Storing, and Handling. (See Page 3.) It should be remembered that mineral oil is completely miscible with Inerteen; in fact, it is practically impossible to separate mineral oil and Inerteen.

Specific Characteristics of Inerteen. As outlined in "Method of Testing Askarels A.S.T.M. D901," the specific characteristics of Inerteen are:

1. Burn point: None
2. Chemical stability: No generation of free chlorides under normal operating conditions
3. Color: (Maximum) 400 A.P.H.
4. Condition: Clear
5. Dielectric constant:
   At 1000 cycles 77°F (25°C), 4.0 to 4.3
   At 1000 cycles 212°F (100°C), 3.5 to 3.8
6. Dielectric strength: (Minimum) 77°F (25°C)
   At point of shipment, 35 kv
   At point of receipt, 30 kv
7. Electrical resistivity: (Minimum)
   100 x 10^6 ohms/cm^3 (212°F (100°C) at 500 volts d-c)
8. Fixed chlorine content: (Minimum) 59.1 percent
9. Free chlorides: Less than 0.10 ppm
10. Neutralization number: Less than 0.014 mg. of NaOH/gram.
11. Pour Point: (Maximum) minus 25.6°F (minus 32°C)
12. Refractive index
    At 77°F (25°C), 1.6140 to 1.6160
13. Specific gravity:
    At 60°F/60°F (15.5°C/15.5°C), 1.518 to 1.526
14. Viscosity:
    At 100°F (37.8°C), 56 seconds ±2

RECONDITIONING

Reconditioning will be necessary to remove water, dirt and hydrogen chloride which may be present and contaminating the Inerteen.

The blotter filter press and the Inerteen conditioner (both of which will be explained later in this book under "Apparatus for Reconditioning") will remove water and dirt deposits which may be present. Of the two methods, the Inerteen conditioner is the most effective in removing these two contaminating agents. Any equipment used for filtering

Inerteen should first be thoroughly cleaned with benzine or naphtha. Every trace of any material foreign to Inerteen must be removed. If at all possible separate equipment should be used for filtering Inerteen only.

Hydrogen chloride, caused by arcing, may be eliminated by vigorously bubbling dry nitrogen through Inerteen. The nitrogen should be passed through the drain valve at the bottom of the apparatus and allowed to escape through a vent at the top. The nitrogen should be discharged through a pressure regulator attached to a stand pipe above the level of the Inerteen in the apparatus to prevent the Inerteen from flowing into the regulator. The nitrogen should be bubbled through the Inerteen at a rate of one to three cubic feet per minute for a period of four to six hours. This will require from two to eight cylinders (220 cu. ft. each) of dry nitrogen, based on apparatus containing 150 to 2000 gallons of Inerteen.

Immediate application of the bubbling process will reduce the destructive action of the hydrochloric acid on the working parts and insulation, thereby making it likely that the materials not damaged by arcing may be used in repairing the apparatus. Also, use of the process will in most cases make it possible to satisfactorily reclaim the arced Inerteen.

After the hydrogen chloride has been removed by the bubbling process, the Inerteen should be reclaimed by use of an Inerteen conditioner.

There is no commercially suitable method for separating transformer oil from Inerteen.

TESTING METHODS 500544

Instructions for all tests listed correspond in general to the recommendations of the American Society for Testing Materials.

DIELECTRIC STRENGTH TEST

Apparatus. The testing transformer and the source of supply of energy shall not be less than ½ kva, and the frequency shall not exceed 100 cycles per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by an approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the Inerteen takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 kva or less, as the current is limited by the impedance of the transformer.

The standard test cup for holding the sample of Inerteen shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by Inerteen or gasoline, and non-absorbent as far as moisture, Inerteen, or gasoline are concerned.

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, 1 in. in diameter, with square (90°) edges. The electrodes shall be mounted in the test cup with their axes horizontal and coincident, with a gap of 0.100 in. between their adjacent faces, and with tops of electrodes about 1¼ in. below the top of the cup. (A suitable test cup is shown in Fig. 1, and portable testing outfits in Figs. 2, 3 and 4.)

PROCEDURE

The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100 in., and the electrodes then locked in position.

The electrodes and the test cup shall be wiped clean with dry, calendered tissue paper or with a clean, dry chamois skin and thoroughly rinsed with Inerteen-free, dry gasoline or benzine until they are entirely free from fibers.

The test cup shall be filled with dry, lead-free gasoline or benzine, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms) per second until breakdown occurs. If the dielectric strength is not less than 25 kv, the cup shall be considered in suitable condition for testing the Inerteen. If a lower test value is obtained the cup shall be cleaned with gasoline and the test repeated.

Note: Evaporation of gasoline from the electrodes may chill them sufficiently to cause moisture to condense on their surface. For this reason, after the final rinsing with gasoline, the test cup should be immediately filled with the Inerteen which is being tested, and the test made at once, or the electrodes should be thoroughly dried before using.

The temperature of the test cup and of the Inerteen when tested shall be the same as that of the room, which should be between 68°F and 86°F. (20°C and 30°C.) Testing at lower temperatures is likely to give variable results which may be misleading.

The sample in the container shall be agitated with a swirling motion (to avoid introducing air) so as to mix the Inerteen thoroughly before filling the test cup. This is even more important with used Inerteen than with new Inerteen as the impurities may be precipitated and the test may be misleading.

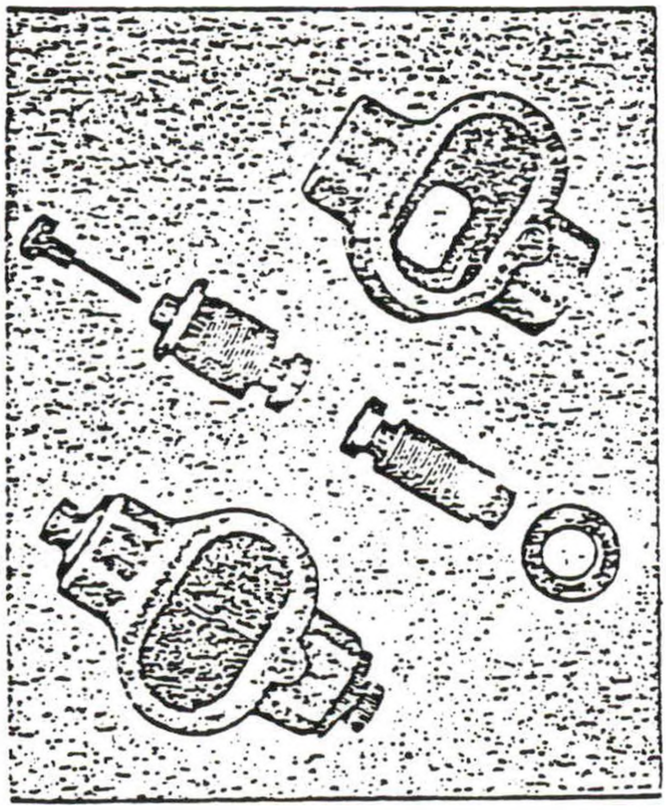


FIG. 1. Fluid Test Cup for Dielectric Test

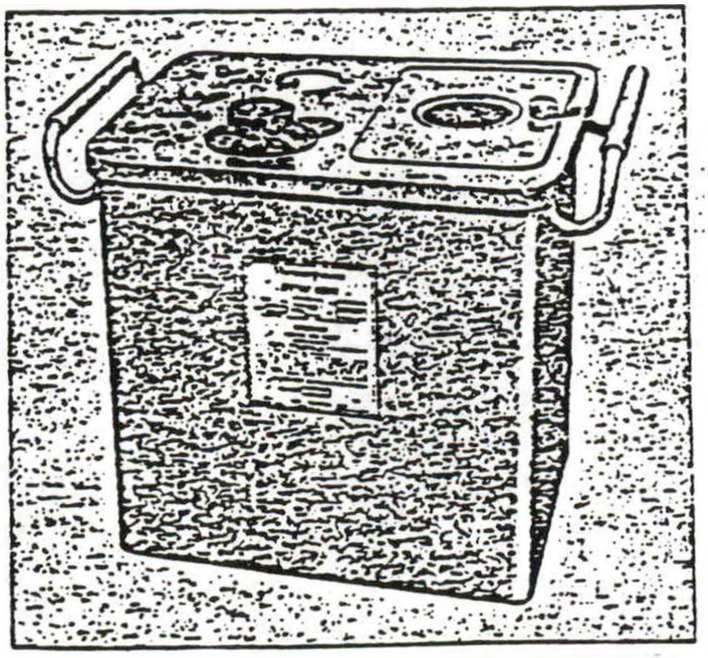


FIG. 2. Portable Oil Testing Set, ¼ Kva. 35,000 Volts

The cup shall be filled with Inerteen to a height of no less than 0.79 in. (20 mm) above the top of the electrodes.

The Inerteen shall be gently agitated by rocking the cup and allowing it to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

Voltages shall be applied and increased uniformly at a rate of approximately 3000 volts (rms) per second until breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded).

TESTS

a. Except as specified in (b) one breakdown test shall be made on each of five fillings of the test cup. If the average deviation from the mean exceeds 10 percent or if any individual test deviates more than 25 percent from the average, additional tests shall be made. The dielectric strength shall be determined by averaging the first five tests that conform to the allowable variations.

b. When Inerteen is tested in considerable quantity, so that the time required for testing is excessive and when it is merely desired to determine whether the breakdown safely exceeds the limit specified, or in those cases where the amount of Inerteen available for test may be very limited, one breakdown test shall be made on each of two fillings of the test cup. If neither breakdown is below this value, the Inerteen may be considered satisfactory and no further tests shall be required. If either of the breakdowns is less than the specified value a breakdown shall be made on each of three additional fillings and test results analyzed in accordance with (a).

Report. The report shall include the volts (rms value) at each breakdown and the average of the two or five breakdowns and the temperature of the Inerteen at the time of the test.

500545 POUR TEST

Note: The procedures covered by the following instructions for the pour test, and especially the neutralization test, require special

ment. The neutralization test must be made by a competent chemist, preferably one specializing in this particular field. Customers who do not possess these facilities are offered, at nominal cost, the use of the Westinghouse Inerteen Testing Service. Contact the nearest Westinghouse Office for details.

The pour point of Inerteen is the lowest temperature at which it will pour or flow when it is chilled without disturbance under certain definite specified conditions.

Apparatus. The test jar (see Fig. 4) shall be clear glass, of cylindrical shape, approximately 1¼ in. inside diameter and 4½ to 5 in. high, with a flat bottom. An ordinary 4 oz. Inerteen sample bottle may be used if the test jar is not available.

The cork shall fit the test jar, and shall be bored centrally to accommodate the test thermometer.

The thermometer shall conform to A.S.T.M. specifications for pour test. It may be ordered as: A.S.T.M. thermometer low cloud and pour, —70°F (—56.7°C) to 70°F (+21.1°C).

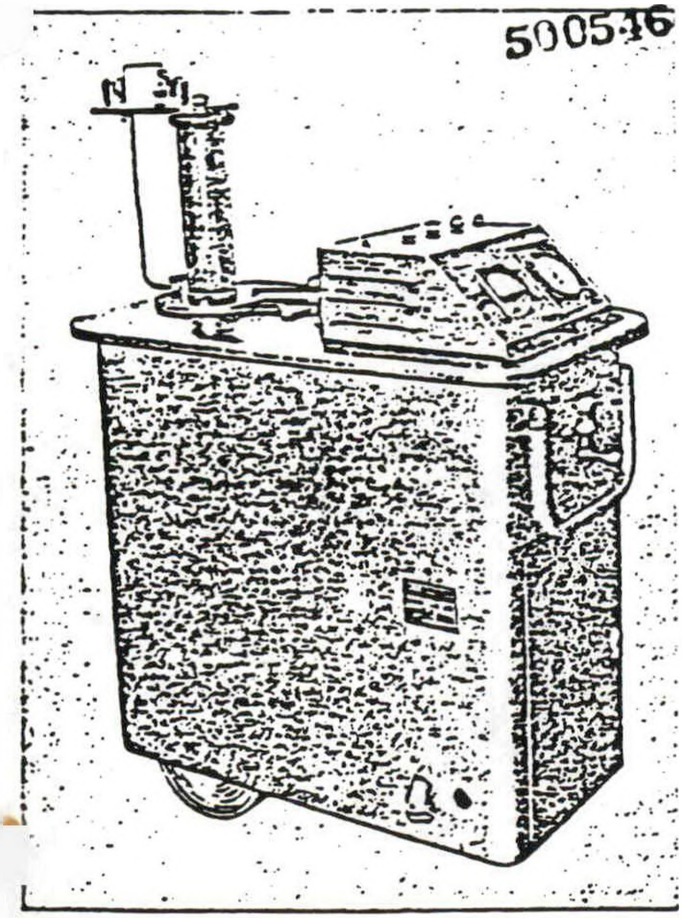


FIG. 3. Portable Trunk Type Insulating Liquid and Insulating Testing Set, 5 Kva, 30,000/60,000 Volts

The jacket shall be of glass or metal and shall be watertight, of cylindrical form, flat bottomed, about 4½ in. deep, with inside diameter ½ in. greater than outside diameter of the test jar.

A disc of cork or felt ¼ in. thick and of the same diameter as the inside of the jacket shall be placed in the bottom of the jacket.

The ring gasket shall be about 3/16 in. thick, made to fit snugly around the outside of the test jar and loosely inside the jacket. This gasket may be made of cork, felt, or other suitable material, elastic enough to cling to the test jar and hard enough to hold its shape. The purpose of the ring gasket is to prevent the test jar from touching the jacket.

The cooling bath shall be of a type suitable for obtaining the required temperature. The size and shape of the bath are optional but a support suitable for holding the jacket firmly in a vertical position is essential. For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it. The required bath temperature may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

Procedure. The Inerteen to be tested shall be brought to a temperature at least 25°F. (14°C.), above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the Inerteen is perfectly clear. (Such filtration shall be made at a temperature at least 25°F. (14°C.), above the approximate cloud point.) The Inerteen shall be poured into the test jar, to a height of not less than 2 in. or more than 2¼ in. When necessary, the Inerteen shall be heated in a water bath just enough so it will pour into the test jar.

The test jar shall be tightly closed by the cork carrying the test thermometer in a vertical position in the center of the jar; the thermometer bulb should be immersed so that the beginning of the capillary shall be ⅛ in. below the surface of the Inerteen.

Heat without stirring to a temperature of 115°F. (46.1°C.) in a bath maintained at not higher than 118°F. (47.8°C.). The Inerteen shall then be cooled to 90°F. (32.2°C.) in air or in a water bath approximately 77 F. (25 C.) in temperature.

The cork or felt disc shall be placed in the bottom of the jacket and the test jar, with the ring gasket, 1 in. above the bottom, shall be inserted into the jacket. The disc, gasket, and inside of jacket shall be clean and dry.

During the cooling of the Inerteen, care shall be taken not to disturb the mass of the Inerteen nor to permit the thermometer to shift in the Inerteen.

The temperature of the cooling bath shall be adjusted so that it is below the pour point—approximately -25.6°F (-32°C)—of the Inerteen by not less than 15°F. (8.3°C) nor more than 30°F. (16.7°C), and the cooling bath shall be maintained at this temperature throughout the test. The jacket containing the test jar shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

Beginning at a temperature 20°F. (11.1°C.) above the expected pour point, at each lower test-thermometer reading which is a multiple of 5°F. (2.8°C). the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether there is a movement of the Inerteen in the test jar. The complete operation of removal and replacement shall require not more than three seconds. As soon as the Inerteen in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly five seconds as noted by a stop watch or other accurate timing device, and observed carefully. If the Inerteen shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure repeated at the next temperature reading 5°F. (2.8°C.) below the previous reading.

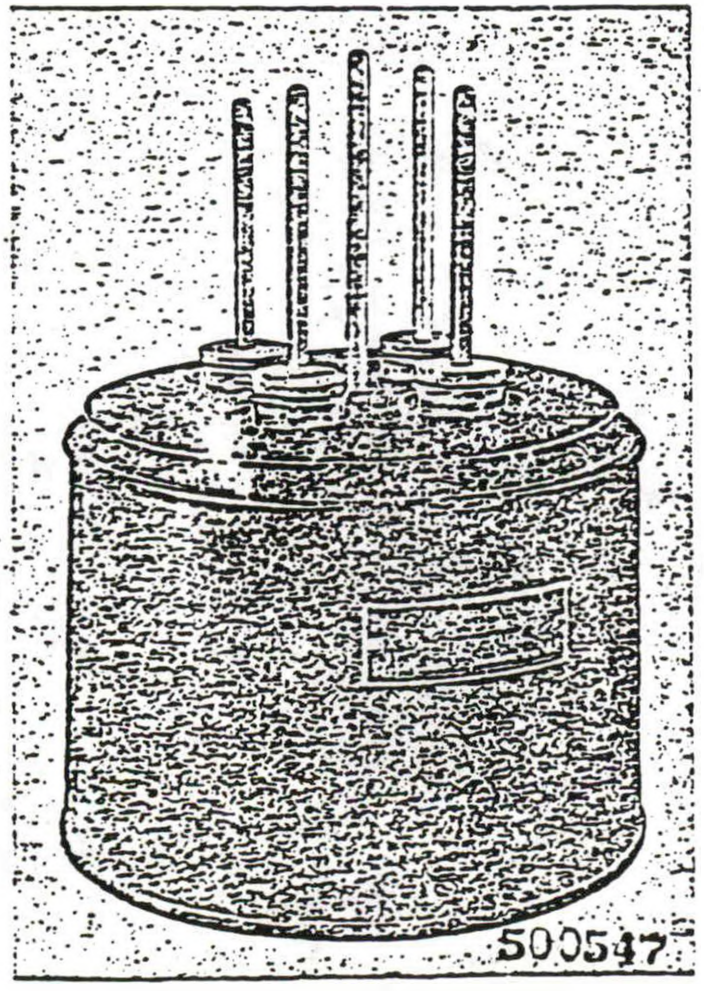


FIG. 4. Apparatus for Pour Test

The test shall be continued in this manner until a point is reached at which the Inerteen in the test jar shows no movement when the test jar is held in a horizontal position for exactly five seconds. The reading of the test thermometer at this temperature, corrected for error if necessary, shall be recorded. The pour point shall be taken as the temperature 5 F. (2.8 C.) above this solid point.

NEUTRALIZATION TEST

The Neutralization Number is the number of milligrams of potassium hydroxide required to neutralize the acid in one gram of Inerteen.

Solutions Required.

a. Standard Potassium Hydroxide Solution (alcoholic, 0.1 N)—add 6 g. of c.p. solid KOH to 1 liter of c.p. anhydrous isopropyl alcohol. Boil, add 2 g. of c.p. Ba (OH)2 and boil again. Cool, filter and store in a chemically resistant bottle protected by a guard tube containing soda lime and soda asbestos (Ascarite). Standardize against pure potassium acid phthalate using phenolphthalein as an indicator.

b. Titration Solvent—Add 500 ml. of c.p. benzene and 5 ml of water to 495 ml of c.p. anhydrous isopropyl alcohol.

c. Alpha-Naphtholbenzein Indicator Solution—Prepare a solution containing 10 g. of alpha-naptholbenzein per liter of c.p. anhydrous isopropyl alcohol.

Procedure. Into a 250 ml Erlenmeyer flask introduce 40 g. of Inerteen weighed accurately. Add 100 ml of the titration solvent and 3 ml of the indicator solution. Titrate immediately at a temperature below 30°C. Consider the end point definite if the color change to green persists for 15 seconds. A blank shall be determined on the solvent.

Calculations. The neutralization number or mg. KOH per g. of Inerteen = $\frac{(A\text{-}B\ (N) \times 56.1}{W}$

A = ml KOH solution required for sample.
B = ml KOH solution required for blank.
N = normality of KOH solution.
W = grams of sample used.

APPARATUS FOR RECONDITIONING

There are several types of reconditioning apparatus available, the relative advantages of each of which are as follows:

1. The Inerteen Conditioner is the most effective method of removing moisture, dirt, and other contaminating materials from Inerteen.

2. The filter press is suitable for treating Inerteen containing only small quantities of water and dirt.

INERTEEN CONDITIONER

The Inerteen Conditioner consists of a clay container, clay filter, a motor-driven positive pressure pump, attendant valves, gauges, and relief devices, all mounted on a common base.

The motor and pump are combined as a unit and a strainer is provided on input to the pump to prevent entrance of large particles. The units are designed to operate under working pressures up to 60 psi. However, the usual operating pressure is 30 psi to 40 psi. Excessive pressures are prevented by two automatic by-pass valves. One by-pass valve connected across the pump is set to by-pass the Inerteen at a pressure of 60 psi to 70 psi. The other by-pass valve is connected on the discharge side of the conditioner. This latter by-pass valve, releasing at a pressure of approximately 5 psi, will avoid breaking the transformer relief diaphragm when no other relief is provided. Pump pressures are indicated by a pressure gauge.

Seven GPM Unit. The activated clay is contained in a tank mounted on one end of the filter frame. This tank is provided with a cover which incorporates an air-trap and vent to remove air which might be present in the tank and piping. The Inerteen is pumped up through the clay, insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through a wire screen prior to entering the paper filter to remove practically all of the clay. The paper filter consists of 18 frames and 17 plates, alternately spaced, mounted in a yoke. One sheet of filter paper is used between each plate and frame to provide a gasket seal and remove all traces of clay from the Inerteen. (See Fig. 8).

Three GPM Unit. This unit utilizes two tanks, one within the other. The activated clay is held in the inner tank by suitable screens at top and bottom. The space below the inner tank is completely sealed off from the rest of the space between the two tanks. The cover is of double-deck construction, incorporating the top screen for the inner tank and the solid cover for the outer tank. The Inerteen is pumped into the lower space and is forced up through the activated clay, insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through the fine mesh upper screen and out into the space between the two tanks. The discharge pipe is at the lower end of the outside tank and any air in the Inerteen is trapped in the upper space of the outside tank where it may be drawn off.

Since the density of Inerteen is considerably greater than that of water, moisture will float on the surface of the Inerteen. It is, therefore, considered advisable to condition Inerteen from the top and return it to the bottom of the Inerteen filled apparatus.

One charge of clay is composed of approximately 40 pounds of 15-30 mesh activated clay.* This relatively large volume of clay makes only occasional changes of clay necessary, depending of course on the amount and condition of the Inerteen filtered. Normally one charge will condition approximately 3000 gallons of Inerteen. The coarse granulated clay used gives maximum surface contact between clay and liquid and makes possible a rapid and thorough mixing of the clay and Inerteen to accomplish complete reconditioning of the Inerteen as it passes through the clay tank. The clay granules are removed from the Inerteen by means of fine screen in the 3 GPM filter and by screen and paper in the 7 GPM filter.

5005-18

The clay never passes through the pump to cause wear on pump parts and consequent loss of pumping capacity. As soon as the charge of activated clay is placed in the tank and the cover clamped in place, the unit is ready for immediate use.

Neither clay nor filter paper can be effectively dried of water after they have once become saturated with Inerteen. Therefore, extreme care should be taken to see that both clay and filter paper are thoroughly dried when placed in the filter.

The clay may be dried in a high temperature oven at 200 deg. C. for six hours and shallow pans are preferred as containers for the clay while drying. A paper drying oven may be used if a high temperature oven is not available, with a drying time extended to approximately twenty-four hours at the oven's highest temperature. The filter paper should be dried six to twelve hours at 85°C. to 100°C.,

*Filter paper and activated clay may be obtained from the Westinghouse Sharon Plant.

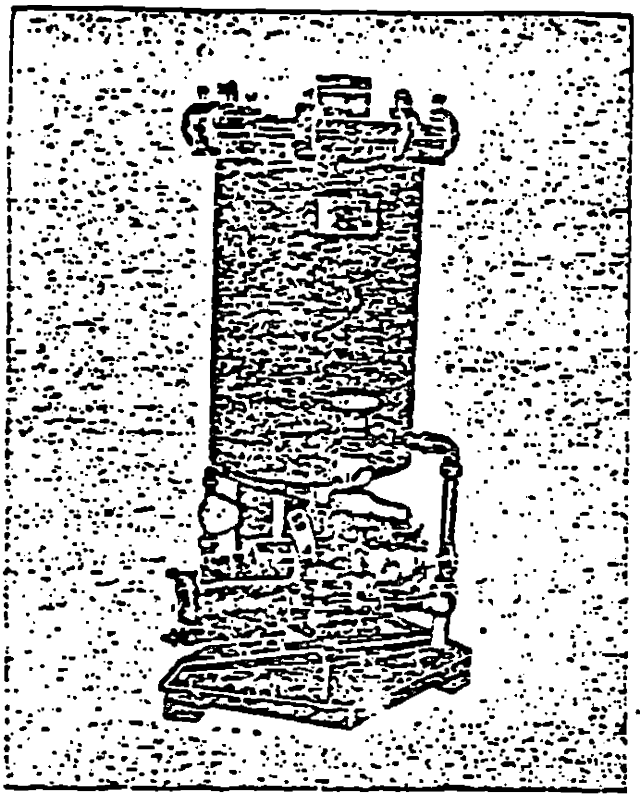


FIG. 5. Three Gallon-per-Minute Conditioner

depending on the condition of the paper and the spacing of the sheets in the oven. Both paper and clay should be placed directly in the filter after the drying process as either, if exposed, will absorb considerable moisture from the atmosphere in a very short time.

Each fresh charge of clay will absorb about three gallons of Inerteen. This should be provided for to prevent depleting the supply in the apparatus, but most of this Inerteen may be recovered when changing clay.

This can be accomplished most effectively by removing the used clay from the filter and placing it in a tank of approximately 30 gallons capacity containing about 5 gallons of water. The tank should have a drain valve at its bottom edge and should be tilted somewhat toward this valve. The clay thus placed in water, having a greater affinity for water, will give up the Inerteen it has absorbed and become saturated with water. The Inerteen being heavier than water will sink to the bottom; the clay and water will float on top. After settling for several hours, most of the Inerteen may be drawn off through the valve. This Inerteen may be reconditioned and used again in recharging the conditioner. The used clay should be discarded.

To Prepare the 7 GPM Conditioner for Operation. Remove the cover and screen from the clay tank and fill the tank with activated clay, 4440-3, to within four inches of the bottom edge of the inner flange. Replace screen and cover. Release the pressure-screw of the filter press and loosen plates and frames. Place one sheet of "S" size blotting paper between the face of each frame and plate. Care should be used to see that the holes thru the plates, frames and paper are in proper alignment before the pressure screw is tightened. Close the discharge, tank by-pass, tank drain, suction and suction-test valves. Open the air discharge valve. Pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons of Inerteen. Start the motor and open the drip pan valve a small amount so that not less than 5 minutes are required to fill the clay tank, saturating the clay with Inerteen. (If Inerteen is admitted too rapidly, it will tend to pack the clay into the top of the tank.) With the valve at the apparatus closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks. Stop motor and close suction-test, air discharge, and drip pan valves.

To begin conditioning Inerteen in Inerteen filled apparatus, open the apperatus valves. Open the conditioner discharge and suction valves. At intervals open air discharge valve to allow trapped air to escape and close when Inerteen starts to flow through valve. Open drip pan valve at intervals too, to remove Inerteen which may have dripped into the drip pan.

When it is necessary to change the clay, first close the valve in the suction line, close the tank

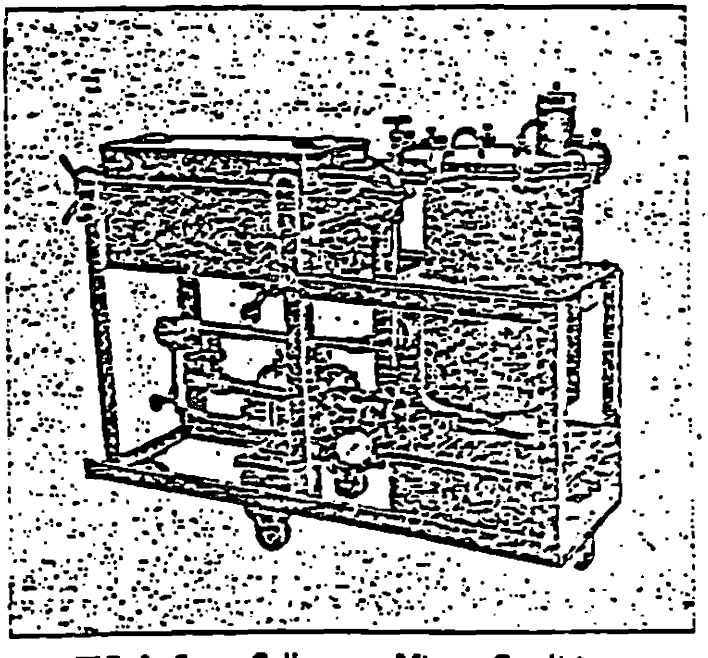


FIG. 6. Seven Gallon-per-Minute Conditioner

inlet and outlet valves, open the tank by-pass valve, the tank drain valve and the air vent valve to permit the free Inerteen in the tank to drain into the lower drip pan. Open the drip pan valve and pump the Inerteen from the drip pan through the filter press. Shut down the motor and remove the clay from the tank and refill with fresh clay as previously described.

To change the filter or blotting papers, stop the motor and close suction and discharge valves. Slowly back off the pressure screw, permitting the Inerteen trapped in the frames to be released gradually. Then back off the pressure screw completely, open up the press and let the surplus Inerteen drain from the papers. Replace the saturated papers with clean dry paper and retighten the press.

If the system-seal is not broken, it will only be necessary to open the discharge and suction valves and start the motor to resume conditioning the Inerteen.

To Prepare the 3 GPM Conditioner for Operation. Remove the cover and screen from the clay tank and fill the inner tank with activated clay, 4440-3, to within four inches of the top. Replace screen and cover. Close the discharge and suction valves and open air discharge and drip pan valves about ½ open. Start motor and pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons. Not less than five minutes should be required to fill the clay tank and saturate the clay with Inerteen. With the valve at the apparatus closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks. Stop motor and close suction-test, air discharge and drip pan valves.

To begin conditioning Inerteen, open apparatus valves, open the conditioner discharge and suction valves and start motor.

At intervals open air discharge valve to let trapped air escape and close as soon as Inerteen flows from the valve.

When it is necessary to change the clay, first stop motor and close the valves in the suction and discharge lines. Remove discharge hose and open the discharge valve and tank drain valve to permit the Inerteen in the tank and discharge hose to drain into a container. After draining is complete, remove inner tank and dump the clay from the inner tank and refill with fresh clay as previously described. The used clay should be discarded.

BLOTTER FILTER PRESS

The blotter filter press (See Fig. 7) is essentially a number of sets of blotter filter papers in parallel, each set containing several thicknesses. The Inerteen is pumped through filter paper which absorbs the water and strains out the sediment.

Other Classes of Service. Although there are other uses, such as cleaning of low-viscosisty insulating compounds, benzine, etc., it is recommended that a cleaning device intended for Inerteen reconditioning should not be used for other classes of work, due to danger of subsequent contamination of the Inerteen.

Capacity. The capacity of these machines, with Inerteen pressure and filtering area fixed, depends on the viscosity of the Inerteen and its freedom from dirt. With fairly clean Inerteen at ordinary room temperature, the capacity of the machines will vary from normal to about 15 percent above normal, depending on the viscosity (which varies with the temperature). It has been found that the best results are obtained when the Inerteen temperature is about 50°C. The average working pressure of these machines is less than 40 psi and the pressure relief valve is set at the factory to by-pass the full flow at from 60 psi to 80 psi.

Apparatus. There are three standard sizes of Westinghouse filter presses: B-5, B-10, and A-30. The letter designates the size of filter paper; the number indicates the relative capacity in gallons per minute.

The complete outfit consists of filterpress, motor, strainer, pump, gas trap, pressure gauge, drip pan, wheels, and piping. The piping is arranged so the line can be tested for leaks under pressure. All machines are mounted on a fabricated structural steel frame. The drip pan can be removed by disconnecting one pipe coupling and four bolts. The strainer can be cleaned by disconnecting three bolts. The pumps are of the helical-gear type to insure quietness and smooth flow of Inerteen. The A-30 pump is connected to the motor through flexible couplings. The B-5 and B-10 pumps are mounted directly on the rear motor bracket and driven through a helical reduction gear.

The filter press proper is made up of a series of cast iron plates and frames assembled alternately, with the filter papers between them. By means of a screw and cast-iron end block, the plates, frames, and papers are forced tightly together. Except for a machined rim which serves as a joint to prevent

the escape of Inerteen, the plates are cast with small pyramids on both surfaces.

The plates and frames have holes in two corners and supporting lugs at the sides. The plates have handles cast on the top edge. When the plates and frames are assembled with the filter papers between, the holes form the inlet and outlet. The frames have the holes in the upper corner connected by small ducts to the middle of the frame. The plates have ducts leading from the surface of the plate to the hole in the lower corner. (See Fig. 8).

The Inerteen enters under pressure at the top corner through the inlet formed by the holes in the frames, plates, and filter papers, flows into the frames through the same ducts, and completely fills the chamber formed by the frame and two sets of filter paper. As there are no outlet ducts in the frame, the Inerteen is forced through the paper and flows along the grooves between the rows of pyramids and out through the ducts provided at the lower corner of the plates. The dry filter paper takes up the moisture and removes the sediment from the Inerteen.

Operation. The filter press is made ready for operation by placing a set of five sheets of filter paper (that have been thoroughly dried in an electric oven) between each filter plate and frame. The holes in the filter paper must line up with the holes in the plates and frames. The sediment is strained out by the first layer of paper and the moisture is taken up by the capillary action of the paper.

If any moisture remains, it indicates that the filter papers are saturated with moisture and should be renewed. No rule can be given as to how often the papers must be changed, as this depends entirely on the condition of the Inerteen. The usual procedure is to run the machine for about half an hour (if the Inerteen is not in very bad condition) and then shut down; remove one sheet from the inlet side of each set and put in a new sheet on the outlet side of each set. (The frame is the inlet side and the plate is the outlet side.) Frequent dielectric tests should be made during this procedure as wet Inerteen may necessitate recharging the filter press with a full set of papers before the five sheets have been removed in succession.

The quickest method of filtering a quantity of Inerteen is to pump all the Inerteen through the filter and into another tank which is clean and dry. If care is taken to change the filter papers before they become saturated, the Inerteen will be clean and dry. If a second tank for holding the Inerteen

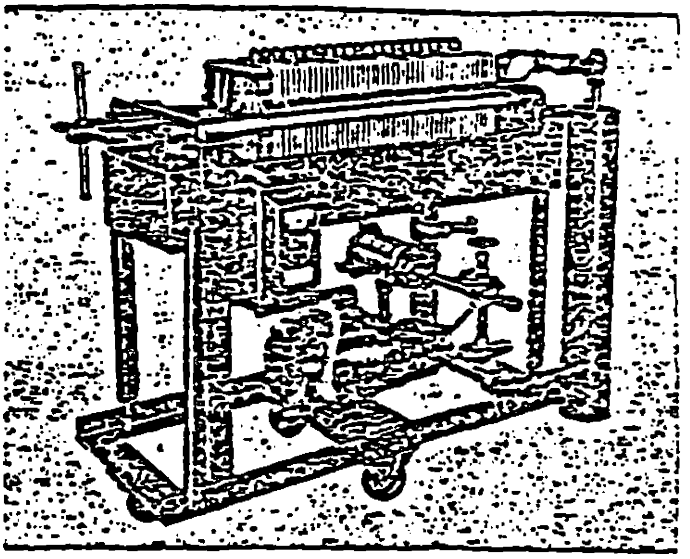


FIG. 7. B-10 Blotter Filter Press

is not available, or if it is desired to filter the Inerteen of apparatus while it is in service, the Inerteen may be pumped from the top of the apparatus tank through the filter and returned to the bottom of the same tank under the surface of the Inerteen. This operation should be continued until the Inerteen in the apparatus tank shows a sufficiently high dielectric strength.

When a large quantity of Inerteen is to be filtered, time may be saved by using two filter presses, one of which may be operated while the other is being recharged.

Filtering through blotter filter papers does not materially reduce organic acidity or improve resistance to emulsification, although the dielectric strength may be restored to a satisfactory value.

The capacity of the filter press is much reduced when operating at low temperatures.

When the Inerteen has to be filtered at low temperatures, an additional pump in the pipe line is desirable.

Inerteen in apparatus contaminated by only a small amount of moisture may be reconditioned by drawing the Inerteen from the top of the apparatus tank, passing it through the filter press, and pumping it back into the bottom of the apparatus. The Inerteen should be put through the system until a sample drawn from the top of the apparatus gives satisfactory dielectric values.

Blotter Filter Paper. The filter paper used is a special grade of blotting paper about .025 in. thick; it contains no coloring matter or chemicals which might injure the Inerteen. Five sheets cut to

the proper size, 12⅞ in. square for the A sizes and 7¾ in. square for the B sizes, and with holes punched to correspond with the holes in the plates and frames, are used between each plate and the adjacent frames.

To obtain the best results in reconditioning Interleen, the paper must be perfectly dry when first placed in the press. Filter paper always takes up moisture if exposed to the air for any length of time and for this reason care must be used in handling. The standard paper is carried in packages containing one ream, carefully wrapped in waxed paper and covered with heavy wrapping paper.

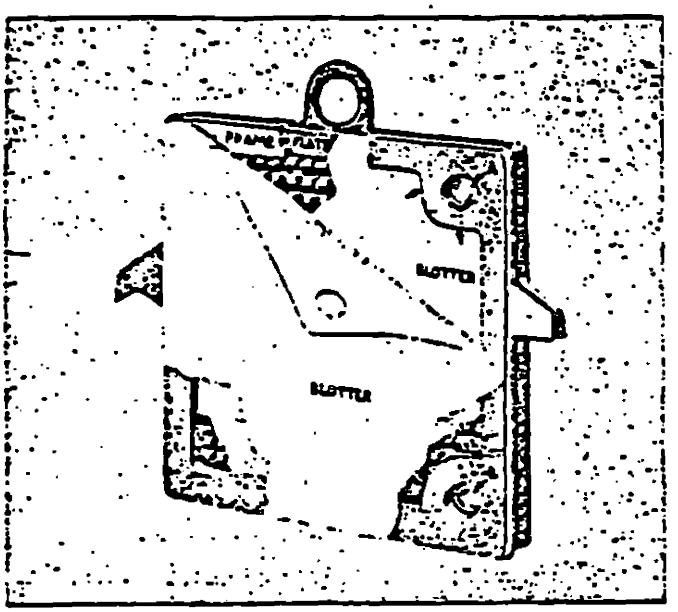


FIG. 8. Blotter Filter Press Frame Showing Blotter Filter Papers in Place

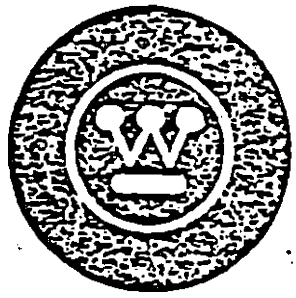
Electric Drying Ovens. Electric drying ovens for use with Type A and Type B filter presses require 2000 watts and 1400 watts respectively. The interior of the ovens is provided with rods for supporting the filter paper to facilitate rapid and thorough drying. An automatic thermostat having a range of 65°C to 120°C is provided for maintaining uniform oven temperature. The thermostat is adjusted at the factory for 100°C, the recommended value, and the setting marked so that the operator may conveniently reset thermostat to 100°C if adjustment is changed.

The standard thermostat-equipped oven is suitable for alternating current only. Ovens to operate on direct current are special and are equipped with a thermometer and a manually operated three-heat switch.

By moving one rod, the Type A oven can be used for drying Type B paper.

The normal capacity of the Type A oven is 240 sheets and the Type B oven is 180 sheets when spaced ¼ inch apart.

Instructions for INERTEEN® Insulating Fluid P.D.S. 54201 CM



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Westinghouse Electric Corporation
Power Transformer Division, Sharon, Pa.

Westinghouse Exhibit 7

I.B. 45-063-99A Effective April, 19[illegible]8, Supersedes I.B. 45-063-99, July, 1965

INERTEEN* INSULATING FLUID

P.D.S. 54201CM

Inerteen is a synthetic non-inflammable and non-explosive insulating and cooling liquid. It has proved its suitability for use in all Westinghouse Inerteen insulated apparatus. In order to insure the proper performance of the apparatus, only Westinghouse Inerteen should be used.

This publication gives the instructions for handling, inspection, and maintenance which experience has shown are important in obtaining the best service from the Inerteen.

* Registered trade-mark for Westinghouse Askarel.

RECEIVING, HANDLING, STORING

SHIPMENT

Inerteen is shipped in tank cars, drums, or cans. The modern tank cars are usually lagged to prevent rapid fluctuations in temperature during transit and thus reduce the amount of expansion and contraction of Inerteen. Changes in the volume of the Inerteen due to temperature changes tend to cause breathing in of moist air resulting in condensation of moisture inside the container, and lowering of the dielectric strength of the Inerteen.

When shipped in drums, the Inerteen and the drums are both heated above room temperature while the drums are being filled, and the bungs are tightened immediately after filling. After cooling to normal temperature, the bungs are again tightened. The drums are provided with screw bungs having gaskets to prevent admission of water.

When shipped in cans, the cans as well as the Inerteen are heated above room temperature while being filled and are hermetically sealed immediately after filling.

STORING

Drums. As soon as a drum of Inerteen has been unloaded, the bung should be examined and tightened if it is loose. It is possible for bungs to become loosened by change in temperature or rough handling in transit. If loosened, be sure Inerteen is tested before using, or combining it with good Inerteen.

It is very desirable that Inerteen in drums be stored in a closed room. Outdoor storage of Inerteen is always hazardous to the Inerteen and should be avoided if at all possible. If it is necessary to store Inerteen outside, protection against direct contact of rain and snow should be provided. Drums stored outdoors should be placed so that bungs will be protected from moisture. It is desirable to cover the drums with a tarpaulin.

Cans. Cans containing Inerteen must not be exposed to the weather. Seals should be kept intact until the Inerteen is actually needed.

Screw caps are provided on the cans to use when the Inerteen is only partially removed after hermetic seal has been broken. By replacing the screw caps, contamination by moisture and dirt will be retarded, but the Inerteen must be tested just before using.

Storage Tank. The storage tank should be mounted on piers so that it will not touch the ground, and will be accessible to all points for inspection for leakage.

It is desirable to maintain the temperature of the Inerteen and tank a little above the temperature of the surrounding air as this prevents condensation of moisture in the tank which would affect the dielectric strength of the Inerteen.

The tank should preferably have a convex bottom, allowing for the installation of a drain cock at the lowest point for removing dirt or tank scale which might settle out. As Inerteen is heavier than water, most all of any water present will, in time rise to the top of the Inerteen. A valve somewhere near the normal top level of the Inerteen should be provided for drawing off water-contaminated Inerteen. Provision for drawing off the Inerteen should also be made near the bottom of the tank.

HANDLING

Caution: Inerteen is a skin irritant, Unnecessary contact with the liquid or its vapor, particularly when it is hot, should be avoided. Especially the eyes, nose, and lips are effected when Inerteen comes in contact with them. Certain safety precautions must be observed when handling Inerteen.

In case Inerteen comes in contact with the skin the parts affected should be thoroughly washed in soapy water and followed by an application of cold cream. A supply of these materials should be kept available at all times where persons are working with Inerteen. Continued exposure may cause eruptions on certain individuals due to the absorption of Inerteen through the pore

of the skin. Cleanliness among workmen handling Inerteen is a very good safeguard against such effects. Application of castor oil is recommended for the eyes, castor oil or cold cream for the nose and lips.

Hot apparatus should not be opened except in well-ventilated places. Large quantities of Inerteen should be handled in a closed system. Workmen should be protected from frequent contact with any appreciable vapor concentration and from frequent skin contact with Inerteen.

In case Inerteen is spilled on one's clothing, the clothing should be changed as soon as possible and the soiled clothing laundered before it is worn again. Gloves such as Westinghouse S#1379 974 should be worn when it is necessary to put one's hand into Inerteen or when parts of apparatus must be handled wet.

Mineral oil is completely miscible with Inerteen and it is practically impossible to separate them. Therefore, it is important to avoid contaminating Inerteen with any kind of oil, since its presence changes the non-inflammable and non-explosive characteristics of Inerteen.

Note: The Inerteen should be sampled and tested before being transferred from the container to the apparatus, particularly in cases where the wire lock-seal has been broken. In cases where the apparatus is received with the Inerteen installed, the Inerteen should be sampled and tested before the apparatus is put into service, as described later in this book.

When putting new apparatus into service, see that the apparatus tank is free from moisture and foreign material.

Although the drums and tank cars are thoroughly washed and dried at the refinery before filling, a certain amount of scale is sometimes loosened from the inside in transit. Therefore, Inerteen which has not been filtered should be strained through three or more thicknesses of muslin, or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. The straining cloths may be stretched across a funnel of large size and should be renewed at frequent intervals.

Important: Extreme precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with Inerteen, and to prevent the entrance of water and dirt during the transfer of the Inerteen to the apparatus.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not possible, protection against moisture must be provided.

All vessels used for transferring the Inerteen should be carefully inspected to see that they are absolutely dry and free from contamination.

Important: Always use all-metal hose or pipe when handling the Inerteen. A hose made of natural rubber should not be used. Inerteen can easily become contaminated from the sulphur in the natural rubber, and should not be allowed to come in contact with it.

When it is necessary to transfer Inerteen from warm surroundings to apparatus exposed to extremely cold weather, even when the dielectric strength at room temperature is high, it is desirable to circulate the Inerteen through an Inerteen conditioner at room temperature. A similar procedure is also advisable in the case of apparatus erected inside and later exposed to cold weather, the reason being that Inerteen will absorb more water at higher temperatures which will be thrown out of solution at lower temperatures. The remainder will be in suspension in the Inerteen and will lower the dielectric strength.

A drum of cold Inerteen when taken into a warm room will "sweat", and the resulting moisture on the surface may mix with the Inerteen as it flows from the drum. Before breaking the seal, the drum should therefore be allowed to stand long enough to reach room temperature, which may require eight hours, or even longer under extreme temperature conditions.

Cleaning Contaminated Drums. The cleaning of drums which have contained used Inerteen requires great care in order to insure a thoroughly clean drum.

It is preferable to return such drums to the supplier where adequate cleaning facilities are available, rather than to attempt to clean them.

If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or benzine, using about one gallon each time, until the solvent shows no discoloration after using. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at the lower end to explore the corners of the drum.

Caution: Do not use a steel pipe because of the danger of a spark igniting the gasoline or benzine vapor.

Next, heat the drum with bunghole down, in a ventilated oven at a temperature of at least 88°C. (190°F.) for sixteen hours. (A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.) Blow out the drum with dry nitrogen or dry air to remove any lingering explosive vapors. Screw the bung on tightly before removing the drum from the oven. Use a new washer with the bung to insure a tight seal.

Caution: Open flames must always be kept away from the oven to prevent igniting inflammable gases which might be remaining in drum when placed in the oven.

Refilling Drums. The practice of refilling drums with Inerteen is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the Inerteen is likely to become contaminated.

If it is necessary to refill them for storage, drums which have been used only for clean, dry Inerteen should be reserved for this purpose. They should be closed immediately after being emptied, to exclude dirt and water. After refilling, they should be examined to see that they do not leak.

Whenever a drum is to be filled with Inerteen, the temperature of the drum and of the Inerteen should be at least 5.5°C. (10°F.) higher than the air, but the temperature of the drum need not be the same as that of the Inerteen.

A new washer should be used with the bung each time the drum is refilled, to insure a tight seal. These washers may be obtained from the nearest Westinghouse Office and it is recommended that a supply be kept on hand. Natural rubber composition washers should never be used as they would be attacked by the Inerteen.

Drums to be refilled with Inerteen for storage should be plainly marked with paint for identification.

SAMPLING AND INSPECTION

A good fireproof insulating liquid is one that will act as an insulating liquid, will carry the heat away from the apparatus, and is fireproof. Westinghouse Inerteen meets these requirements with the following characteristics:

1. High dielectric strength.
2. Freedom from inorganic acid, alkali, and corrosive sulphur. (To prevent injury to insulation and conductors)
3. Low viscosity. (To provide good heat transfer)
4. Low pour point.
5. Fireproof.

CAUSES OF DETERIORATION

The principal causes of deterioration of Inerteen are:

1. Presence of water.
2. Arcing.

Condensation from moist air due to breathing of the apparatus, especially when the apparatus is not continuously in service, may injure the Inerteen. (The moist air drawn into the apparatus condenses moisture on the surface of the Inerteen and inside of the tank.) The Inerteen may also be contaminated with water through leakage such as from leaky cooling coils or covers.

Arcing or burning in Inerteen produces finely divided carbon and gases which are mostly hydrogen chloride. Hydrogen chloride in the presence of moisture forms hydrochloric acid which may soon damage the insulation in the apparatus and cause rusting of ferrous materials.

Since hydrogen chloride is formed quickly after the arcing occurs, neither the Inerteen nor the apparatus should be exposed to the atmosphere (which always contains more or less moisture) until an attempt has been made to remove the hydrogen chloride. See Reconditioning, Page 7, for the method of purification.

SAMPLING INERTEEN

The dielectric strength of Inerteen is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. There have been low dielectric test results reported from the field which, upon investigation, have been found to be largely a matter of carelessness in handling.

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for handling Inerteen and servicing Inerteen be used for no other purpose. Care must be used in taking samples of Inerteen and sealing them prior to testing. It is

desirable that samples of Inerteen be removed from any container on clear days only, and when the [illegible]perature of the Inerteen is at least as high as the [illegible]perature of the surrounding air.

Use only tin containers with screwed metal caps or glass bottles with Inerteen-resistant stoppers to hold Inerteen samples. If it becomes necessary to use other than factory sampling containers, they should be rinsed with clean naptha, washed with strong soap suds, and rinsed thoroughly in hot water, and then dried at approximately 110°C. for four hours with neck down in a circulating air oven. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

Provision is made on all Inerteen transformers to obtain a top sample of the Inerteen, however on a transformer that is in operation, a sample may be taken from either the top or bottom since any moisture present will be mixed in, due to circulation of the Inerteen. In sampling, allow a small amount of Inerteen to run out to flush the sampling connection clean before collecting the sample. The Inerteen should be put into the sample containers immediately and the caps screwed on tightly. The [illegible]l for each container should be marked clearly [illegible] the serial number of the transformer or compartment from which the Inerteen was taken.

Before taking samples from a storage tank, the Inerteen should be allowed to settle for approximately twelve hours so that if there is any moisture present, it, having a lower specific gravity, will rise to the top where the sample is to be taken. A clean sneak-thief should be used to obtain the samples. Essentially, the same precautions to prevent moisture and dirt contamination should be used as outlined above.

Quantity of Sample. It is recommended that one 16 oz. bottle of Inerteen be taken as a sample for testing. At least one sample should be taken from a tank car of Inerteen. One sample may be taken from each drum, or if desired, a composite sample may be made from Inerteen from five drums, provided all of the drums are airtight. When the bung is first loosened, a hissing sound should be heard, which indicates that the drum has been airtight. If the test of the composite sample is not satisfactory, a sample from each of the drums represented should be tested.

When drums have been stored exposed to the weather, a sample from each drum must be tested to determine if it is suitable for use.

PERIODIC INSPECTION

It is desirable that periodic inspections of Inerteen apparatus be made and that samples of Inerteen be taken from each and from all compartments of any apparatus and tested after a short period of service (approximately three months for transformers). Following this, when operating conditions permit, routine sampling and testing of the Inerteen at intervals of six months to one year are suggested. Accurate records should be kept of such inspections and tests and if the Inerteen shows a dielectric strength of less than 22 kv, it should be conditioned. If facilities are not available for testing Inerteen, see "Westinghouse Inerteen Testing Service" below, and also P.L. 44-860. When an appreciable amount of Inerteen is removed from any apparatus, it should be replaced with an equal amount of new Inerteen so that the liquid level in the apparatus is maintained. The Inerteen used for replacement purposes should have a dielectric strength of not less than 30 kv.

INERTEEN TESTING SERVICE

Many users of Inerteen do not have the necessary facilities for testing it. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an Inerteen testing service to provide a careful test by experienced engineers, and a prompt report of test results.

Two special 16 oz. sample bottles per mailing container (W) S.S. 1608 629, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse Office. (The bottle and the container will not be returned to the customer.)

After drawing the sample of Inerteen, the customer should seal the bottle and mail it to the Westinghouse Electric Corporation, Plant Laboratory, Sharon, Pa. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. *The order sheet must be sent to the nearest Westinghouse Office.*

When samples of Inerteen are received for testing, they are sent to the Plant Laboratory and tested in accordance with methods described under "Testing Methods," which follows and is part of this Instruction Book.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination if so requested. (The customer should plainly indicate the type of service desired.)

The physical and chemical examination consists of an examination of the Inerteen by a competent chemist. Recommendations will be made as to the suitability of the Inerteen for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the Inerteen represented should be given as completely as possible.

Power factor test of Inerteen at 60 cycles can be made.

(For details refer to the nearest Westinghouse Office.)

CHARACTERISTICS AND RECONDITIONING

CHARACTERISTICS

Inerteen is chemically stable. It is straw-yellow in color. It is not affected by reaction with other materials regularly used in the manufacture of Inerteen apparatus. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in Inerteen apparatus. Inerteen will not sludge under any operating condition.

The dielectric strength of Inerteen will compare favorably with that of insulating oil when tested under the same conditions. Quality samples of Inerteen tested under laboratory conditions may show a dielectric strength in excess of 40kv. Care must be exercised in handling and testing Inerteen. Inerteen must be kept in clean, sealed containers to prevent loss by evaporation or contamination by moisture or dirt.

Inerteen exerts a strong solvent action on most varnishes, gums, and paints. Such materials are not used in the construction of Inerteen apparatus. No materials should be used in Inerteen apparatus except those approved by the Westinghouse Electric Corporation.

Inerteen has an irritating effect upon the skin. If it is necessary to handle it, see the caution note under Receiving, Storing, and Handling. (See Page 3.) It should be remembered that mineral oil is completely miscible with Inerteen; in fact, it is practically impossible to separate mineral oil and Inerteen.

Specific Characteristics of Inerteen. As outlined in "Method of Testing Askarels A.S.T.M. D901," the specific characteristics of Inerteen are:

1. Burn point: None
2. Chemical stability: No generation of free chlorides under normal operating conditions
3. Color: (Maximum) 100 A.P.H.
4. Condition: Clear
5. Dielectric constant
   At 1000 cycles 77°F (25°C), 5.7 to 5.9
   At 1000 cycles 212°F (100°C), 4.8 to 5.0
6. Dielectric strength: (Minimum) 77°F (25°C)
   At point of shipment, 35 kv
   At point of receipt, 30 kv
7. Electrical resistivity: (Minimum)
   500 x 10^9 ohms/cm^3 (212°F (100°C) at 500 volts d-c)
8. Power factor:
   At 60 cycles, 27°F (25°C) 2%
   At 60 cycles, 212°F (100°C) 25%
9. Fixed chlorine content (Minimum) 42 per-cent
10. Free chlorides: Less than 0.10 ppm
11. Neutralization number: Less than 0.014 mg. of NaOH/gram.
12. Pour Point: (Maximum) plus 7°F (minus 14°C)
13. Refractive index:
    At 77°F (25°C), 1.624 to 1.626
14. Specific gravity:
    At 60°F/60°F (15.5°C/15.5°C), 1.381 to 1.392
15. Density: 11.5 pounds per gal.
16. Viscosity:
    At 100°F (37.8°C), 82-92 seconds
17. Moisture (Maximum) 35 ppm

RECONDITIONING

Reconditioning will be necessary to remove water, dirt and hydrogen chloride which may be present and contaminating the Inerteen.

The blotter filter press and the Inerteen conditioner (both of which will be explained later in this book under "Apparatus for Reconditioning") will remove water and dirt deposits which may be present. Of the two methods, the Inerteen conditioner is the most effective in removing these two contaminating agents. Any equipment used for filtering

Inerteen should first be thoroughly cleaned with benzine or naphtha. Every trace of any material foreign to Inerteen must be removed. If at all possible separate equipment should be used for filtering Inerteen only.

Hydrogen chloride, caused by arcing, may be eliminated by vigorously bubbling dry nitrogen through Inerteen. The nitrogen should be passed through the drain valve at the bottom of the apparatus and allowed to escape through a vent at the top. The nitrogen should be discharged through a pressure regulator attached to a stand pipe above the level of the Inerteen in the apparatus to prevent the Inerteen from flowing into the regulator. The nitrogen should be bubbled through the Inerteen at a rate of one to three cubic feet per minute for a period of four to six hours. This will require from two to eight cylinders (220 cu. ft. each) of dry nitrogen, based on apparatus containing 150 to 2000 gallons of Inerteen.

Immediate application of the bubbling process will reduce the destructive action of the hydrochloric acid on the working parts and insulation, thereby making it likely that the materials not damaged by arcing may be used in repairing the apparatus. Also, use of the process will in most cases make it possible to satisfactorily reclaim the arced Inerteen.

After the hydrogen chloride has been removed by the bubbling process, the Inerteen should be reclaimed by use of an Inerteen conditioner.

There is no commercially suitable method for separating transformer oil from Inerteen.

TESTING METHODS

Instructions for all tests listed correspond in general to the recommendations of the American Society Testing Materials.

DIELECTRIC STRENGTH TEST

Apparatus. The testing transformer and the source of supply of energy shall not be less than ½ kva, and the frequency shall not exceed 100 cycles per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by an approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the Inerteen takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 kva or less, as the current is limited by the impedance of the transformer.

The standard test cup for holding the sample of Inerteen shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by Inerteen or gasoline, and non-absorbent as far as moisture, Inerteen, or gasoline are concerned.

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, 1 in. in diameter, with square (90°) edges. The electrodes shall be mounted in the test cup with their axes horizontal and coincident, with a gap of 0.100 in. between their adjacent faces, and with tops of electrodes about 1¼ in. below the top of the cup. (A suitable test cup is shown in Fig. 1, and portable testing outfits in Figs. 2, 3 and 4.)

PROCEDURE

The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100 in., and the electrodes then locked in position.

The electrodes and the test cup shall be wiped clean with dry, calendered tissue paper or with a clean, dry chamois skin and thoroughly rinsed with Inerteen-free, dry gasoline or benzine until they are entirely free from fibers.

The test cup shall be filled with dry, lint-free gasoline or benzine, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms) per second until breakdown occurs. If the dielectric strength is not less than 25 kv, the cup shall be considered in suitable condition for testing the Inerteen. If a lower test value is obtained the cup shall be cleaned with gasoline and the test repeated.

Note: Evaporation of gasoline from the electrodes may chill them sufficiently to cause moisture to condense on their surface. For this reason, after the final rinsing with gasoline, the test cup should be immediately filled with the Inerteen which is being tested, and the test made at once, or the electrodes should be thoroughly dried before using.

The temperature of the test cup and of the Inerteen when tested shall be the same as that of the room, which should be between 68°F and 86°F. (20°C and 30°C.) Testing at lower temperatures is likely to give variable results which may be misleading.

The sample in the container shall be agitated with a swirling motion (to avoid introducing air) so as to mix the Inerteen thoroughly before filling the test cup. This is even more important with used Inerteen than with new Inerteen as the impurities may be precipitated and the test may be misleading.

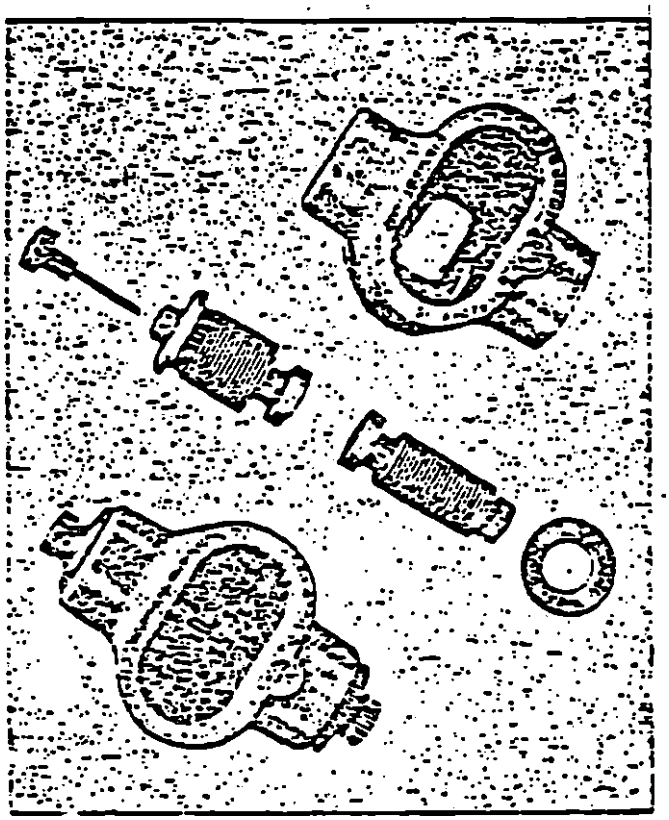

FIG. 1. Fluid Test Cup for Dielectric Test

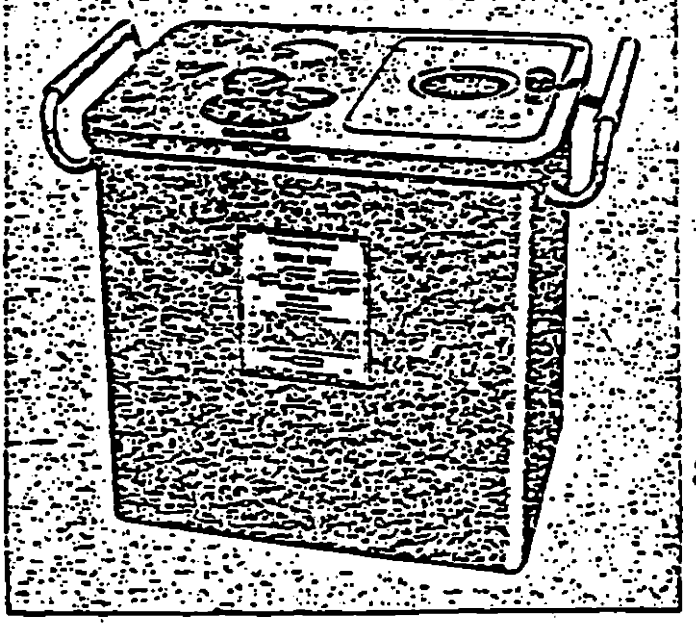

FIG. 2. Portable Oil Testing Set, ½ Kva. 25,000 Volts

The cup shall be filled with Inerteen to a height of no less than 0.79 in. (20 mm) above the top of the electrodes.

The Inerteen shall be gently agitated by rocking the cup and allowing it to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

Voltages shall be applied and increased uniformly at a rate of approximately 3000 volts (rms) per second until breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded).

TESTS

a. Except as specified in (b) one breakdown test shall be made on each of five fillings of the test cup. If the average deviation from the mean exceeds 10 percent or if any individual test deviates more than 25 percent from the average, additional tests shall be made. The dielectric strength shall be determined by averaging the first five tests that conform to the allowable variations.

b. When Inerteen is tested in considerable quantity, so that the time required for testing is excessive and when it is merely desired to determine whether the breakdown safely exceeds the limit specified, or in those cases where the amount of Inerteen available for test may be very limited, one breakdown test shall be made on each of two fillings of the test cup. If neither breakdown is below this value, the Inerteen may be considered satisfactory and no further tests shall be required. If either of the breakdowns is less than the specified value a breakdown shall be made on each of three additional fillings and test results analyzed in accordance with (a).

Report. The report shall include the volts (rms value) at each breakdown and the average of the two or five breakdowns and the temperature of the Inerteen at the time of the test.

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POUR TEST

Note: The procedures covered by the following instructions for the pour test, and especially the neutralization test, require special equip-

ment. The neutralization test must be made by a competent chemist, preferably one specializing in this particular field. Customers who do not possess these facilities are offered, at nominal cost, the use of the Westinghouse Inerteen Testing Service. Contact the nearest Westinghouse Office for details.

The pour point of Inerteen is the lowest temperature at which it will pour or flow when it is chilled without disturbance under certain definite specified conditions.

Apparatus. The test jar (see Fig. 4) shall be clear glass, of cylindrical shape, approximately 1¼ in. inside diameter and 4½ to 5 in. high, with a flat bottom. An ordinary 4 oz. Inerteen sample bottle may be used if the test jar is not available.

The cork shall fit the test jar, and shall be bored centrally to accommodate the test thermometer.

The thermometer shall conform to A.S.T.M. specifications for pour test. It may be ordered as: A.S.T.M. thermometer low cloud and pour, —70°F (—56.7°C) to 70°F (+21.1°C).

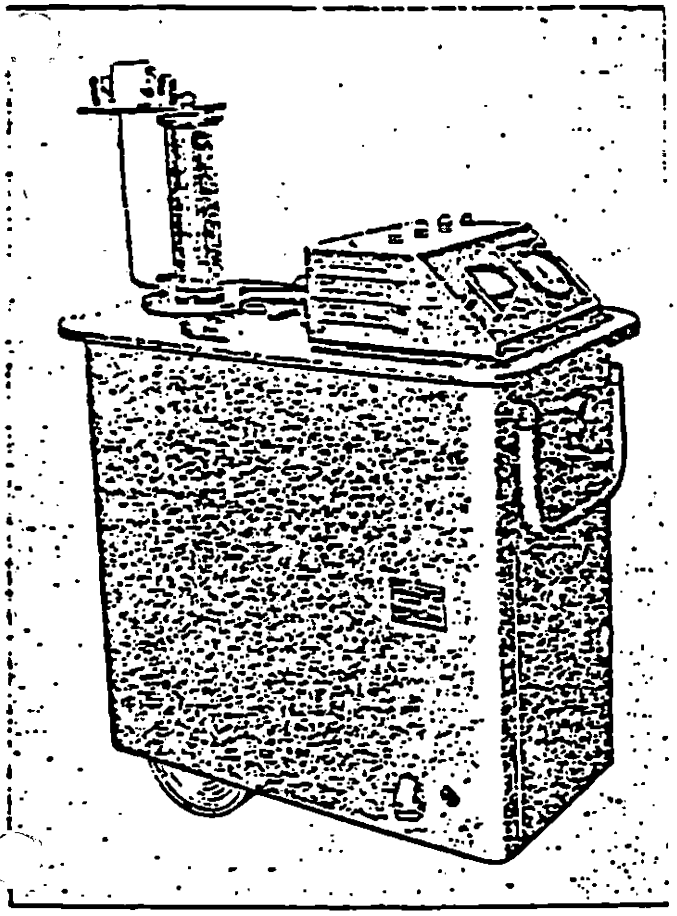

FIG. 3. Portable Trunk Type Insulating Liquid and Insulating Testing Set, 5 Kva, 30,000/60,000 Volts

The jacket shall be of glass or metal and shall be watertight, of cylindrical form, flat bottomed, about 4½ in. deep, with inside diameter ½ in. greater than outside diameter of the test jar.

A disc of cork or felt ¼ in. thick and of the same diameter as the inside of the jacket shall be placed in the bottom of the jacket.

The ring gasket shall be about 3/16 in. thick, made to fit snugly around the outside of the test jar and loosely inside the jacket. This gasket may be made of cork, felt, or other suitable material, elastic enough to cling to the test jar and hard enough to hold its shape. The purpose of the ring gasket is to prevent the test jar from touching the jacket.

The cooling bath shall be of a type suitable for obtaining the required temperature. The size and shape of the bath are optional but a support suitable for holding the jacket firmly in a vertical position is essential. For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it. The required bath temperature may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

Procedure. The Inerteen to be tested shall be brought to a temperature at least 25°F. (14°C.), above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the Inerteen is perfectly clear. (Such filtration shall be made at a temperature at least 25°F. (14°C.), above the approximate cloud point.) The Inerteen shall be poured into the test jar, to a height of not less than 2 in. or more than 2¼ in. When necessary, the Inerteen shall be heated in a water bath just enough so it will pour into the test jar.

The test jar shall be tightly closed by the cork carrying the test thermometer in a vertical position in the center of the jar; the thermometer bulb should be immersed so that the beginning of the capillary shall be ⅛ in. below the surface of the Inerteen.

Heat without stirring to a temperature of 115°F. (46.1°C.) in a bath maintained at not higher than 118°F. (47.8°C.). The Inerteen shall then be cooled to 90°F. (32.2°C.) in air or in a water bath approximately 77 F. (25 C.) in temperature.

The cork or felt disc shall be placed in the bottom of the jacket and the test jar, with the ring gasket, 1 in. above the bottom, shall be inserted into the jacket. The disc, gasket, and inside of jacket shall be clean and dry.

During the cooling of the Inerteen, care shall be taken not to disturb the mass of the Inerteen nor to permit the thermometer to shift in the Inerteen.

The temperature of the cooling bath shall be adjusted so that it is below the pour point—approximately -25.6°F (-32°C)—of the Inerteen by not less than 15°F. (8.3°C) nor more than 30°F. (16.7°C), and the cooling bath shall be maintained at this temperature throughout the test. The jacket containing the test jar shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

Beginning at a temperature 20°F. (11.1°C.) above the expected pour point, at each lower test-thermometer reading which is a multiple of 5°F. (2.8°C). the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether there is a movement of the Inerteen in the test jar. The complete operation of removal and replacement shall require not more than three seconds. As soon as the Inerteen in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly five seconds, as noted by a stop watch or other accurate timing device, and observed carefully. If the Inerteen shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure repeated at the next temperature reading 5°F. (2.8°C.) below the previous reading.

The test shall be continued in this manner until a point is reached at which the Inerteen in the test jar shows no movement when the test jar is held in a horizontal position for exactly five seconds. The reading of the test thermometer at this temperature, corrected for error if necessary, shall be recorded. The pour point shall be taken as the temperature 5 F. (2.8 C.) above this solid point.

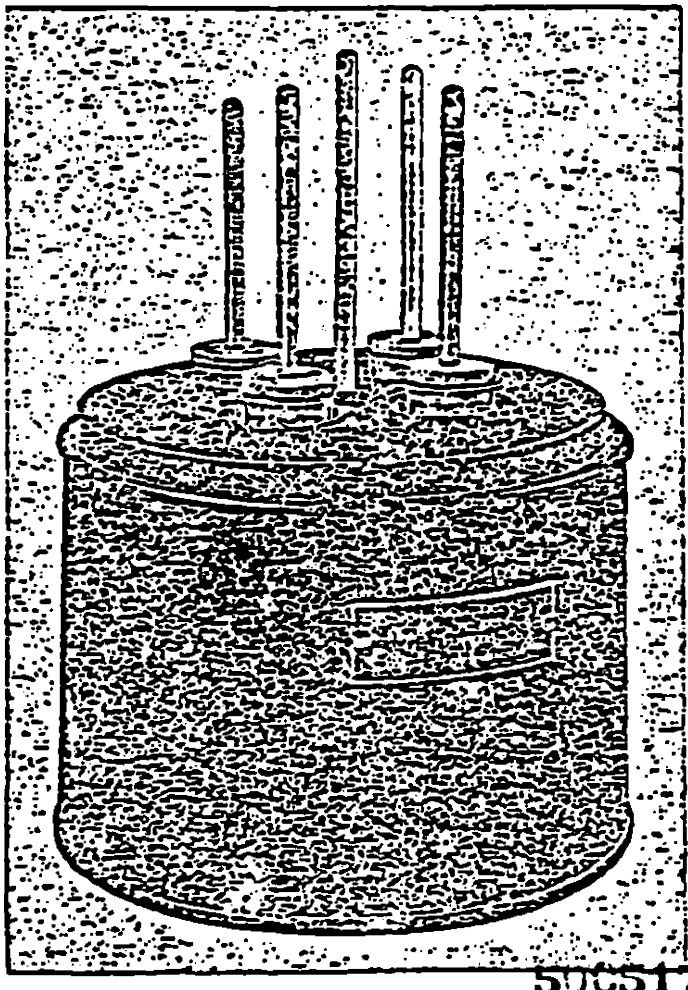

FIG. 4. Apparatus for Pour Test

NEUTRALIZATION TEST

The Neutralization Number is the number of milligrams of potassium hydroxide required to neutralize the acid in one gram of Inerteen.

Solutions Required.

a. Standard Potassium Hydroxide Solution (alcoholic, 0.1 N)—add 6 g. of c.p. solid KOH to 1 liter of c.p. anhydrous isopropyl alcohol. Boil, add 2 g. of c.p. Ba (OH)2 and boil again. Cool, filter and store in a chemically resistant bottle protected by a guard tube containing soda lime and soda asbestos (Ascarite). Standardize against pure potassium acid phthalate using phenolphthalein as an indicator.

b. Titration Solvent—Add 500 ml. of c.p. benzene and 5 ml of water to 495 ml of c.p. anhydrous isopropyl alcohol.

c. Alpha-Naphtholbenzein Indicator Solution—Prepare a solution containing 10 g. of alpha-naphtholbenzein per liter of c.p. anhydrous isopropyl alcohol.

Procedure. Into a 250 ml Erlenmeyer flask introduce 40 g. of Inerteen weighed accurately. Add 100 ml of the titration solvent and 3 ml of the indicator solution. Titrate immediately at a temperature below 30°C. Consider the end point definite if the color change to green persists for 15 seconds. A blank shall be determined on the solvent.

Calculations. The neutralization number or mg KOH per g. of Inerteen $= \frac{(A\text{-}B\ (N) \times 56.1}{W}$

A = ml KOH solution required for sample.
B = ml KOH solution required for blank.
N = normality of KOH solution.
W = grams of sample used.

APPARATUS FOR RECONDITIONING

There are several types of reconditioning apparatus available, the relative advantages of each of which are as follows:

1. The Inerteen Conditioner is the most effective method of removing moisture, dirt, and other contaminating materials from Inerteen.

2. The filter press is suitable for treating Inerteen containing only small quantities of water and dirt.

INERTEEN CONDITIONER

The Inerteen Conditioner consists of a clay container, clay filter, a motor-driven positive pressure pump, attendant valves, gauges, and relief devices, all mounted on a common base.

The motor and pump are combined as a unit and a strainer is provided on input to the pump to prevent entrance of large particles. The units are designed to operate under working pressures up to 60 psi. However, the usual operating pressure is 30 psi to 40 psi. Excessive pressures are prevented by two automatic by-pass valves. One by-pass valve connected across the pump is set to by-pass the Inerteen at a pressure of 60 psi to 70 psi. The other by-pass valve is connected on the discharge side of the conditioner. This latter by-pass valve, releasing at a pressure of approximately 5 psi, will avoid breaking the transformer relief diaphragm when no other relief is provided. Pump pressures are indicated by a pressure gauge.

Seven GPM Unit. The activated clay is contained in a tank mounted on one end of the filter frame. This tank is provided with a cover which incorporates an air-trap and vent to remove air which might be present in the tank and piping. The Inerteen is pumped up through the clay, insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through a wire screen prior to entering the paper filter to remove practically all of the clay. The paper filter consists of 18 frames and 17 plates, alternately spaced, mounted in a yoke. One sheet of filter paper is used between each plate and frame to provide a gasket seal and remove all traces of clay from the Inerteen. (See Fig. 8).

Three GPM Unit. This unit utilizes two tanks, one within the other. The activated clay is held in the inner tank by suitable screens at top and bottom. The space below the inner tank is completely sealed off from the rest of the space between the two tanks. The cover is of double-deck construction, incorporating the top screen for the inner tank and the solid cover for the outer tank. The Inerteen is pumped into the lower space and is forced up through the activated clay, insuring thorough agitation of the clay and Inerteen. The Inerteen is passed through the fine mesh upper screen and out into the space between the two tanks. The discharge pipe is at the lower end of the outside tank and any air in the Inerteen is trapped in the upper space of the outside tank where it may be drawn off.

Since the density of Inerteen is considerably greater than that of water, moisture will float on the surface of the Inerteen. It is, therefore, considered advisable to condition Inerteen from the top and return it to the bottom of the Inerteen filled apparatus.

One charge of clay is composed of approximately 40 pounds of 15-30 mesh activated clay.* This relatively large volume of clay makes only occasional changes of clay necessary, depending of course on the amount and condition of the Inerteen filtered. Normally one charge will condition approximately 3000 gallons of Inerteen. The coarse granulated clay used gives maximum surface contact between clay and liquid and makes possible a rapid and thorough mixing of the clay and Inerteen to accomplish complete reconditioning of the Inerteen as it passes through the clay tank. The clay granules are removed from the Inerteen by means of fine screen in the 3 GPM filter and by screen and paper in the 7 GPM filter.

The clay never passes through the pump to cause wear on pump parts and consequent loss of pumping capacity. As soon as the charge of activated clay is placed in the tank and the cover clamped in place, the unit is ready for immediate use.

Neither clay nor filter paper can be effectively dried of water after they have once become saturated with Inerteen. Therefore, extreme care should be taken to see that both clay and filter paper are thoroughly dried when placed in the filter.

The clay may be dried in a high temperature oven at 200 deg. C. for six hours and shallow pans are preferred as containers for the clay while drying. A paper drying oven may be used if a high temperature oven is not available, with a drying time extended to approximately twenty-four hours at the oven's highest temperature. The filter paper should be dried six to twelve hours at 85°C. to 100°C.,

*Filter paper and activated clay may be obtained from the Westinghouse Sharon Plant.

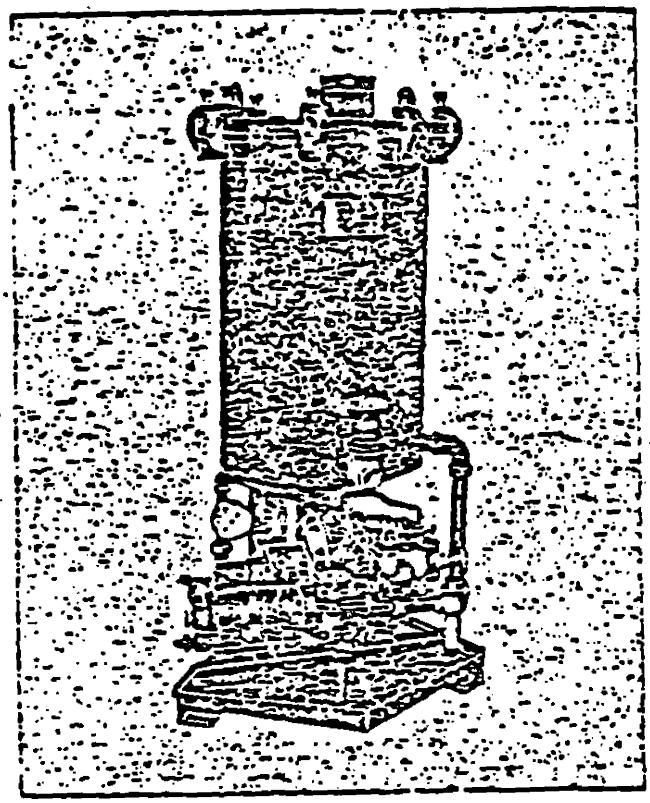

FIG. 5. Three Gallon-per-Minute Conditioner

depending on the condition of the paper and the spacing of the sheets in the oven. Both paper and clay should be placed directly in the filter after the drying process as either, if exposed, will absorb considerable moisture from the atmosphere in a very short time.

Each fresh charge of clay will absorb about three gallons of Inerteen. This should be provided for to prevent depleting the supply in the apparatus, but most of this Inerteen may be recovered when changing clay.

This can be accomplished most effectively by removing the used clay from the filter and placing it in a tank of approximately 30 gallons capacity containing about 5 gallons of water. The tank should have a drain valve at its bottom edge and should be tilted somewhat toward this valve. The clay thus placed in water, having a greater affinity for water, will give up the Inerteen it has absorbed and become saturated with water. The Inerteen being heavier than water will sink to the bottom; the clay and water will float on top. After settling for several hours, most of the Inerteen may be drawn off through the valve. This Inerteen may be reconditioned and used again in recharging the conditioner. The used clay should be discarded.

To Prepare the 7 GPM Conditioner for Operation. Remove the cover and screen from the clay tank and fill the tank with activated clay, 4440-3, to within four inches of the bottom edge of the inner flange. Replace screen and cover. Release the pressure-screw of the filter press and loosen plates and frames. Place one sheet of "B" size blotting paper between the face of each frame and plate. Care should be used to see that the holes thru the plates, frames and paper are in proper alignment before the pressure screw is tightened. Close the discharge, tank by-pass, tank drain, suction and suction-test valves. Open the air discharge valve. Pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons of Inerteen. Start the motor and open the drip pan valve a small amount so that not less than 5 minutes are required to fill the clay tank, saturating the clay with Inerteen. (If Inerteen is admitted too rapidly, it will tend to pack the clay into the top of the tank.) With the valve at the apparatus closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks. Stop motor and close suction-test, air discharge, and drip pan valves.

To begin conditioning Inerteen in Inerteen filled apparatus, open the apparatus valves. Open the conditioner discharge and suction valves. At intervals open air discharge valve to allow trapped air to escape and close when Inerteen starts to flow through valve. Open drip pan valve at intervals too, to remove Inerteen which may have dripped into the drip pan.

When it is necessary to change the clay, first close the valve in the suction line, close the tank

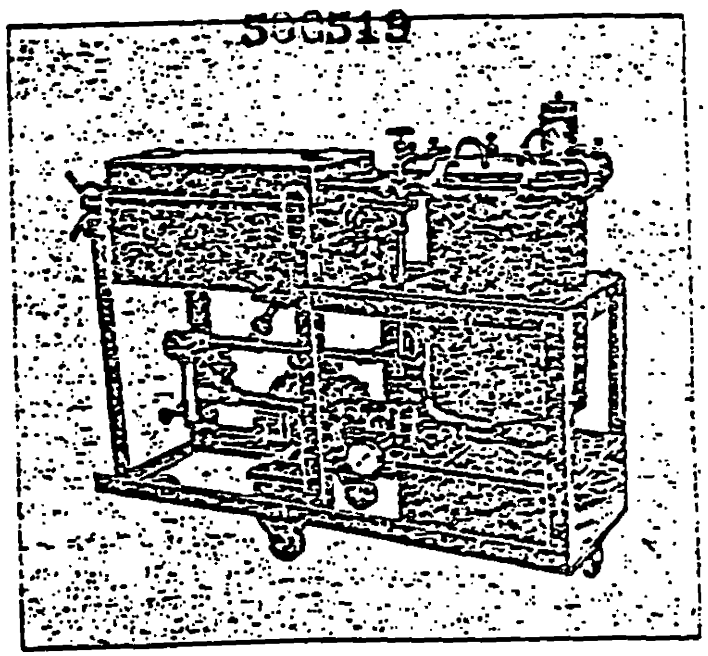

FIG. 6. Seven Gallon-per-Minute Conditioner

inlet and outlet valves, open the tank by-pass valve, the tank drain valve and the air vent valve to permit the free Inerteen in the tank to drain into the lo drip pan. Open the drip pan valve and pump the Inerteen from the drip pan through the filter press. Shut down the motor and remove the clay from the tank and refill with fresh clay as previously described.

To change the filter or blotting papers, stop the motor and close suction and discharge valves. Slowly back off the pressure screw, permitting the Inerteen trapped in the frames to be released gradually. Then back off the pressure screw completely, open up the press and let the surplus Inerteen drain from the papers. Replace the saturated papers with clean dry paper and retighten the press.

If the system-seal is not broken, it will only be necessary to open the discharge and suction valves and start the motor to resume conditioning the Inerteen.

To Prepare the 3 GPM Conditioner for Operation. Remove the cover and screen from the clay tank and fill the inner tank with activated clay, 4440-3, to within four inches of the top. Replace s- n and cover. Close the discharge and suction v s and open air discharge and drip pan valves about ½ open. Start motor and pour sufficient Inerteen into the drip pan to fill the clay tank and wet the clay. This will require approximately eight gallons. Not less than five minutes should be required to fill the clay tank and saturate the clay with Inerteen. With the valve at the apparatus closed, open the suction-test valve to subject the suction line to pressure and thus check it for leaks. Stop motor and close suction-test, air discharge and drip pan valves.

To begin conditioning Inerteen, open apparatus valves, open the conditioner discharge and suction valves and start motor.

At intervals open air discharge valve to let trapped air escape and close as soon as Inerteen flows from the valve.

When it is necessary to change the clay, first stop motor and close the valves in the suction and discharge lines. Remove discharge hose and open the discharge valve and tank drain valve to permit the Inerteen in the tank and discharge hose to drain a container. After draining is complete, remove r tank and dump the clay from the inner tank and refill with fresh clay as previously described. The used clay should be discarded.

BLOTTER FILTER PRESS

The blotter filter press (See Fig. 7) is essentially a number of sets of blotter filter papers in parallel, each set containing several thicknesses. The Inerteen is pumped through filter paper which absorbs the water and strains out the sediment.

Other Classes of Service. Although there are other uses, such as cleaning of low-viscosity insulating compounds, benzine, etc., it is recommended that a cleaning device intended for Inerteen reconditioning should not be used for other classes of work, due to danger of subsequent contamination of the Inerteen.

Capacity. The capacity of these machines, with Inerteen pressure and filtering area fixed, depends on the viscosity of the Inerteen and its freedom from dirt. With fairly clean Inerteen at ordinary room temperature, the capacity of the machines will vary from normal to about 15 percent above normal, depending on the viscosity (which varies with the temperature). It has been found that the best results are obtained when the Inerteen temperature is about 50°C. The average working pressure of these machines is less than 40 psi and the pressure relief valve is set at the factory to by-pass the full flow at from 60 psi to 80 psi.

Apparatus. There are three standard sizes of Westinghouse filter presses: B-5, B-10, and A-30. The letter designates the size of filter paper; the number indicates the relative capacity in gallons per minute.

The complete outfit consists of filterpress, motor, strainer, pump, gas trap, pressure gauge, drip pan, wheels, and piping. The piping is arranged so the line can be tested for leaks under pressure. All machines are mounted on a fabricated structural steel frame. The drip pan can be removed by disconnecting one pipe coupling and four bolts. The strainer can be cleaned by disconnecting three bolts. The pumps are of the helical-gear type to insure quietness and smooth flow of Inerteen. The A-30 pump is connected to the motor through flexible couplings. The B-5 and B-10 pumps are mounted directly on the rear motor bracket and driven through a helical reduction gear.

The filter press proper is made up of a series of cast iron plates and frames assembled alternately, with the filter papers between them. By means of a screw and cast-iron end block, the plates, frames, and papers are forced tightly together. Except for a machined rim which serves as a joint to prevent

the escape of Inerteen, the plates are cast with small pyramids on both surfaces.

The plates and frames have holes in two corners and supporting lugs at the sides. The plates have handles cast on the top edge. When the plates and frames are assembled with the filter papers between, the holes form the inlet and outlet. The frames have the holes in the upper corner connected by small ducts to the middle of the frame. The plates have ducts leading from the surface of the plate to the hole in the lower corner. (See Fig. 8).

The Inerteen enters under pressure at the top corner through the inlet formed by the holes in the frames, plates, and filter papers, flows into the frames through the same ducts, and completely fills the chamber formed by the frame and two sets of filter paper. As there are no outlet ducts in the frame, the Inerteen is forced through the paper and flows along the grooves between the rows of pyramids and out through the ducts provided at the lower corner of the plates. The dry filter paper takes up the moisture and removes the sediment from the Inerteen.

Operation. The filter press is made ready for operation by placing a set of five sheets of filter paper (that have been thoroughly dried in an electric oven) between each filter plate and frame. The holes in the filter paper must line up with the holes in the plates and frames. The sediment is strained out by the first layer of paper and the moisture is taken up by the capillary action of the paper.

If any moisture remains, it indicates that the filter papers are saturated with moisture and should be renewed. No rule can be given as to how often the papers must be changed, as this depends entirely on the condition of the Inerteen. The usual procedure is to run the machine for about half an hour (if the Inerteen is not in very bad condition) and then shut down; remove one sheet from the inlet side of each set and put in a new sheet on the outlet side of each set. (The frame is the inlet side and the plate is the outlet side.) Frequent dielectric tests should be made during this procedure as wet Inerteen may necessitate recharging the filter press with a full set of papers before the five sheets have been removed in succession.

The quickest method of filtering a quantity of Inerteen is to pump all the Inerteen through the filter and into another tank which is clean and dry. If care is taken to change the filter papers before they become saturated, the Inerteen will be clean and dry. If a second tank for holding the Inerteen

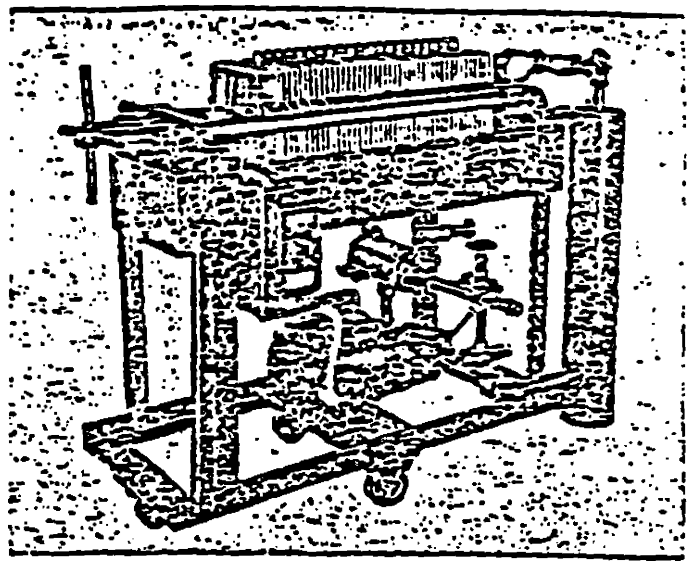

FIG. 7. B-10 Blotter Filter Press

is not available, or if it is desired to filter the Inerteen of apparatus while it is in service, the Inerteen may be pumped from the top of the apparatus tank through the filter and returned to the bottom of the same tank under the surface of the Inerteen. This operation should be continued until the Inerteen in the apparatus tank shows a sufficiently high dielectric strength.

When a large quantity of Inerteen is to be filtered, time may be saved by using two filter presses, one of which may be operated while the other is being recharged.

Filtering through blotter filter papers does not materially reduce organic acidity or improve resistance to emulsification, although the dielectric strength may be restored to a satisfactory value.

The capacity of the filter press is much reduced when operating at low temperatures.

When the Inerteen has to be filtered at low temperatures, an additional pump in the pipe line is desirable.

Inerteen in apparatus contaminated by only a small amount of moisture may be reconditioned by drawing the Inerteen from the top of the apparatus tank, passing it through the filter press, and pumping it back into the bottom of the apparatus. The Inerteen should be put through the system until a sample drawn from the top of the apparatus gives satisfactory dielectric values.

Blotter Filter Paper. The filter paper used is a special grade of blotting paper about .025 in. thick; it contains no coloring matter or chemicals which might injure the Inerteen. Five sheets cut to

the proper size, 12⅞ in. square for the A sizes and 7¾ in. square for the B sizes, and with holes punched to correspond with the holes in the plates and frames, are used between each plate and the adjacent frames.

To obtain the best results in reconditioning Interteen, the paper must be perfectly dry when first placed in the press. Filter paper always takes up moisture if exposed to the air for any length of time and for this reason care must be used in handling. The standard paper is carried in packages containing one ream, carefully wrapped in waxed paper and covered with heavy wrapping paper.

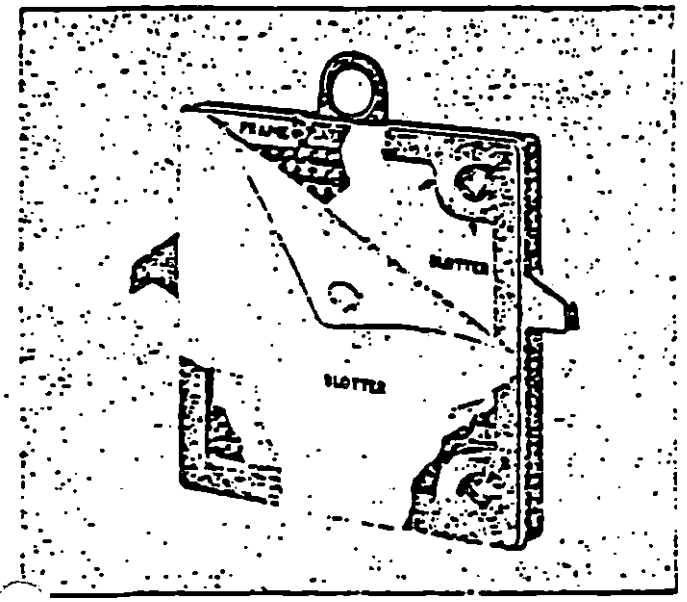

FIG. 8. Blotter Filter Press Frame Showing Blotter Filter Papers in Place

Electric Drying Ovens. Electric drying ovens for use with Type A and Type B filter presses require 2000 watts and 1400 watts respectively. The interior of the ovens is provided with rods for supporting the filter paper to facilitate rapid and thorough drying. An automatic thermostat having a range of 65°C to 120°C is provided for maintaining uniform oven temperature. The thermostat is adjusted at the factory for 100°C, the recommended value, and the setting marked so that the operator may conveniently reset thermostat to 100°C if adjustment is changed.

The standard thermostat-equipped oven is suitable for alternating current only. Ovens to operate on direct current are special and are equipped with a thermometer and a manually operated three-heat switch.

By moving one rod, the Type A oven can be used for drying Type B paper.

The normal capacity of the Type A oven is 240 sheets and the Type B oven is 180 sheets when spaced ¼ inch apart.

Instructions for Inerteen® Insulating Fluid P.D.S. 54201 CM and Installation and Maintenance of Inerteen Transformers

Westinghouse Electric Corporation
Power Transformer Division, Sharon, Pa.

I. B. 45-063-99B Effective September, 1968

Supersedes I.B. 45-063-99A April 1968, I.L. 48-650-2 August 1951, I.L. 48-650-3 May 1951, I.L. 48-650-4 May 1951, I.L. 48-650-5B September 1962, I.L. 48-650-6 May 1951, I.L. 48-650-7 June 1951 and I.L. 47-069-6 January 1965.

Contents

Part I — Inerteen® Insulating Fluid

CHARACTERISTICS

Inerteen is a highly pure, synthetic non-inflammable and non-explosive insulating and cooling liquid. Chemically stable and nearly water white in color, Inerteen is not affected by reaction with other materials regularly used in the manufacture of Inerteen apparatus. It is non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in Inerteen apparatus. Inerteen will not sludge under any operating condition. Water is the main enemy of Inerteen and keeping it dry will insure long service life.

The dielectric strength of Inerteen will compare favorably with that of insulating oil when tested under the same conditions. Quality samples of Inerteen tested under laboratory conditions may show a dielectric strength in excess of 40 kv. Care must be exercised in handling and testing Inerteen. Inerteen must be kept in clean, sealed containers to prevent loss by evaporation or contamination by moisture or dirt.

Inerteen exerts a strong solvent action on most varnishes, gums, and paints. Such materials are not used in the construction of Inerteen apparatus. No materials should be used in Inerteen apparatus except those approved by the Westinghouse Electric Corporation.

Inerteen has an irritating effect upon the skin. If it is necessary to handle it, see the caution note on the title page. It should be remembered that mineral oil is completely miscible with Inerteen; in fact, it is impossible to separate mineral oil and Inerteen.

Specific Characteristics of Inerteen

As outlined in "Method of Testing Askarels A.S.T.M. D901," the specific characteristics of Inerteen are:

1. Burn point: None

2. Chemical stability: No generation of free chlorides under normal operating conditions

3. Color: (Maximum) 100 A.P.H.

4. Condition: Clear

5. Dielectric constant:

At 1000 cycles 77°F (25°C), 5.7 to 5.9
At 1000 cycles 212°F (100°C), 4.8 to 5.0

6. Dielectric strength: (Minimum) 77°F (25°C)

At point of shipment, 35 kv
At point of receipt, 30 kv

7. Electrical Resistivity: (Minimum)

500×10^9 ohms/cm^3 (212°F (100°C) at 500 volts d-c)

8. Power factor:

At 60 hertz, 77°F (25°C) 2%
At 60 hertz, 212°F (100°C) 25%

9. Fixed chlorine content: (Minimum) 42 percent

10. Free chlorides: Less than 0.10 ppm

11. Neutralization number: Less than 0.014 mg of NaOH/gram

12. Pour Point: (Maximum) plus 2°F (minus 19°C)

13. Refractive index:

At 77°F (25°C), 1.624 to 1.626

14. Specific gravity:

At 60°F/60°F (15.5°C/15.5°C), 1.381 to 1.392

15. Density: 11.5 pounds per gallon

16. Viscosity:

At 100°F (37.8°C), 82-92 seconds

17. Moisture: (Maximum) 35 ppm

HANDLING

CAUTION

Inerteen is a skin irritant. Unnecessary contact with the liquid or its vapor, particularly

when hot, should be avoided. The eyes, nose, and lips are affected when Inerteen comes in contact with them. All safety precautions must be observed when handling Inerteen.

If accidently spilled on the hands, no skin irritation will occur if the parts are thoroughly washed with soap and water. Continued exposure may cause eruptions on some individuals due to the absorption of Inerteen through the pores of the skin. Hot apparatus should not be opened except in a well-ventilated area. Large quantities of Inerteen should be handled in a closed system. In case Inerteen is spilled on one's clothing, the clothing should be changed at once and laundered before being worn again. Inerteen resistant gloves should be worn when it is necessary to work in Inerteen. If Inerteen gets into the eyes, flush with water and get eye first aid from a physician. Mineral oil is recommended for the eyes, castor oil or skin cream for the nose and lips. CLEANLINESS AMONG WORKMEN HANDLING INERTEEN IS A VERY GOOD SAFEGUARD AGAINST SKIN IRRITATION.

NOTE

Always use all-metal hose or pipe when handling the Inerteen. Rubber hoses should not be used. Inerteen can easily become *contaminated from the rubber, and should* not be allowed to come in contact with it.

When it is necessary to transfer Inerteen to operate the apparatus must be at least as warm the Inerteen. All Inerteen should be circulated through an Inerteen conditioner or filter press to remove water or rust.

A drum of cold Inerteen when taken into a warm room will "sweat", and the resulting moisture on the surface may mix with the Inerteen as it flows from the drum. Before breaking the seal, the drum should therefore be allowed to stand long enough to reach room temperature, which may require eight hours, or even longer under extreme temperature conditions.

STORING

[illegible]

[illegible] as a drum of Inerteen has been unloaded, the bung should be examined and tightened if it is loose. It is possible for bungs to become loosened by change in temperature or rough handling in transit. Be sure all Inerteen is tested before using.

It is desirable that Inerteen in drums be stored indoors. Outdoor storage of Inerteen is always hazardous to the Inerteen and should be avoided if at all possible. If it is necessary to store Inerteen outside, the drums should be placed so that the bungs are down so they are protected from moisture. It is desirable to cover the drums with a tarpaulin.

TESTING SERVICE

Many users of Inerteen do not have the necessary facilities for testing it. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an Inerteen testing service to provide a careful test by experienced engineers, and a prompt report of test results.

Two special 16 oz. sample bottles per mailing container (W) S#1608629, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse Office. (The bottle and the container will not be returned to the customer.)

After drawing the sample of Inerteen, the customer should seal the bottle and mail it to the Westinghouse Electric Corporation, Plant Laboratory, Sharon, Penna. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. *The order sheet must be sent to the nearest Westinghouse Office.*

When samples of Inerteen are received for testing, they are sent to the Plant Laboratory and tested in accordance with standard A.S.T.M. methods.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination if so requested. (The customer should plainly indicate the type of service desired.)

The physical and chemical examination consists of an examination of the Inerteen by a competent chemist. Recommendations will be

made as to the suitability of the Inerteen for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the Inerteen represented should be given as completely as possible.

Power factor test of Inerteen at 60 cycles can be made.

(For details refer to the nearest Westinghouse Office.)

RECONDITIONING

Causes of Deterioration

The principle causes of deterioration of Inerteen are:

1. Presence of water.
2. Arcing.

Arcing or burning in Inerteen produces finely divided carbon and gases which are mostly hydrogen chloride. Hydrogen chloride in the presence of moisture forms hydrochloric acid which may soon damage the insulation in the apparatus and cause rusting of ferrous materials.

Since hydrogen chloride is formed quickly after the arcing occurs, neither the Inerteen nor the apparatus should be exposed to the atmosphere (which always contains more or less moisture) until an attempt has been made to remove the hydrogen chloride.

Reconditioning

Reconditioning will be necessary to remove water, dirt and hydrogen chloride which may be present and contaminating the Inerteen.

The blotter filter press and the Inerteen conditioner will remove water and dirt deposits which may be present. Of the two methods, the Inerteen conditioner is the most effective in removing these two contaminating agents. Any equipment used for filtering Inerteen should first be thoroughly cleaned with benzine or naphtha. Every trace of any material foreign to Inerteen must be removed. If at all possible separate equipment should be used for filtering Inerteen only.

Hydrogen chloride, caused by arcing, may be eliminated by vigorously bubbling dry nitrogen through Inerteen. The nitrogen should be passed through the drain valve at the bottom of the apparatus and allowed to escape through a vent at the top. The nitrogen should be discharged through a pressure regulator attached to a stand pipe above the level of the Inerteen in the apparatus to prevent the Inerteen from flowing into the regulator. The nitrogen should be bubbled through the Inerteen at a rate of one to three cubic feet per minute for a period of four to six hours. This will require from two to eight cylinders (220 cu. ft. each) of dry nitrogen, based on apparatus containing 150 to 2000 gallons of Inerteen.

Immediate application of the bubbling process will reduce the destructive action of the hydrochloric acid on the working parts and insulation, thereby making it likely that the materials not damaged by arcing may be used in repairing the apparatus. Also, use of the process will in most cases make it possible to satisfactorily reclaim the arced Inerteen.

After the hydrogen chloride has been removed by the bubbling process, the Inerteen should be reclaimed by use of an Inerteen conditioner.

There is no commercially suitable method for separating transformer oil from Inerteen.

Part II — Installation and Maintenance of Inerteen Transformers

INSTALLATION

For convenience in handling, all transformers are equipped with lugs or eyes for lifting and moving the complete assembly filled with Inerteen by use of a crane. Additional means are provided for the heavier parts such as covers, core and coils, radiators and terminal chambers. Jacking lugs are also supplied on either the base or corners of the tank. A transformer should only be lifted or moved by jacks placed against these lugs and not against the cooling tubes, radiator valves, or other fittings.

An indoor installation requires that the room in which the transformers are placed must be well ventilated so that the heated air can readily escape and be replaced by cooler air from the outside. If the room is poorly ventilated, this exchange of air takes place too slowly and the temperature of the air in the room may become excessively high. At any given load the temperature rise of a self-cooled transformer will be a fixed number of degrees above the temperature of the surrounding air. The temperature of the transformer is the sum of this rise and the air temperature; therefore, care must be taken to provide a room sufficiently ventilated to permit operation of transformers at a reasonable temperature. Area of the air inlets should be such that the ambient temperature never exceeds 40°C (104°F) with an average over twenty-four hours not exceeding 30°C (86°F); 50 to 60 square feet per 1000 kva of transformer capacity has been satisfactory. Outlet openings with the same total area should be provided.

Self-cooled transformers should always be well separated from one another and from adjacent walls, partitions, etc., in order to permit free air circulation about the cases. This separation should not be less than 24 to 36 inches depending on the size of the units.

INSPECTION

All Inerteen transformers are carefully inspected and tested at the factory and they are in good condition when shipped, but it is desirable to inspect each transformer thoroughly before placing it in service.

When a transformer is shipped complete and filled with Inerteen, this inspection should include a check of the Inerteen level, the tightening or adjustment of any parts that may have become loose or out of place, and determining the extent to which moisture may have entered the transformer. The latter can best be determined from the dielectric strength of the Inerteen. Inerteen used for filling transformers should have a dielectric strength of 30 kv or higher. When it tests less than this the Inerteen should be filtered. If the dielectric strength is very low or if there is any other evidence of moisture, it is necessary to dry the transformer.

Inerteen transformers should be dried by the short circuit method with the transformer immersed in the Inerteen and with the tank sealed tightly. During the drying out operation, the Inerteen should be circulated through a filter press or preferably through an Inerteen conditioner. A filter press will remove dirt and most of the moisture, but the conditioner will remove these and other contaminating materials as well.

The desired load current should be obtained by short circuiting one winding and impressing the proper impedance voltage on the other winding. The full load impedance may usually be found on the instruction plate for the transformer; if the impedance of the transformer is not known, it should be requested from the Westinghouse Electric Corporation, Sharon, Pennsylvania, by identifying the transformer with its serial number.

If the transformer is at or lower than room temperature at the start of the drying process, circulation of 125 to 150% of full load current will hasten the heating, and a higher top Inerteen temperature can be obtained more quickly by blanketing the coolers when tubular coolers are used or by shutting off the radiator valves when radiators are used. The cover should be lagged to prevent condensation.

The loading should be carefully watched and when the top Inerteen reaches a temperature of 60°C, the load should be reduced to obtain an approximately constant top Inerteen temperature based on the following table:

Short Circuit Amperes in Percent of Load	Maximum Temperature of the Top Inerteen
50%	85°C
75%	80°C
85%	75°C

While the windings of the transformer heat up, do not permit the temperature of the top Inerteen to exceed the value specified for a given percentage of load. This precaution is necessary because the windings will heat up more quickly and operate at a higher temperature than the Inerteen. If the windings are allowed to reach too high a temperature, the insulation will be damaged. The drying of a transformer should be continued until the dielectric strength of samples of Inerteen taken from the transformer test at 30 kv or higher.

The cover should be kept tightly sealed during the temperature run, and until the transformer has cooled down to room temperature to prevent condensation. This also prevents the release of hot Inerteen vapors which are quite objectionable, particularly if the ventilation is poor.

CAUTION

It is not safe to attempt the drying out of transformers unless constant attention is given to the job.

ACCESSORIES AND FITTINGS

Bushings, fittings, and accessories when boxed and shipped separately should be mounted as shown on the outline drawing. Proper installation instructions when necessary are included in the instruction leaflets for component parts. Care must be exercised when these components are fitted to eliminate the accidental introduction of moisture in any form inside the transformer. Where blind flanges are removed before fittings are mounted, the level of the Inerteen must be lowered below the openings that will be made.

FINISH

Any portion of the paint film damaged during shipment or installation must be repaired as quickly as possible.

To do this, clean the damaged portion by means of a scraper or sandpaper, wipe thoroughly with a solvent dampened cloth, apply Westinghouse primer paint and allow it to dry for at least 24 hours, then apply a coat of Westinghouse finish paint.

FILLING

Use only all-metal hose or pipe when filling, since the lining of most other types of hose may be soluble in Inerteen and will contaminate it in a short time. All joints should be tight; where practical, fill through the drain valve to keep aeration to a minimum and vent the top of the tank to allow the air to escape. Be sure that valves and pipe connections between the main tank and any Inerteen filled compartments are open for free circulation of gas and liquid. Otherwise, trapped air or gas may cause the Inerteen level in some parts of the transformer to be below the safe operating level.

If it is necessary to fill a transformer out-of-doors, particularly on a damp day, care should be taken to prevent the entrance of moisture. In order to avoid condensation the temperature inside the unit should be kept several degrees above the outside air temperature.

The tank and compartments, if any, should be filled at ambient temperature to the point on the gauges marked "25°–Liquid Level." If the ambient varies greatly from 25°C (77°F) when filled, the Inerteen level should be checked when the average fluid temperature is 25°C; sufficient Inerteen should be added to or drained from the tank to bring the level to the proper height. The transformer should never be operated or left standing even out of service without the Inerteen level being indicated on the gauge.

Filling Under Vacuum

Entrapped air is a potential source of trouble in all liquid filled transformers. Therefore, it is desirable to fill all Inerteen transformers under a full vacuum. This is done for the transformers shipped from the factory and should be done where practicable when transformers are filled in the field, providing the transformer cases have been so designed. If the cases have not been designed for full vacuum and it is imperative to

get the maximum winding impulse strength immediately, the transformers should be filled with Inerteen under full vacuum by placing them in an auxiliary vacuum tank.

Where purchaser does not have an established technique for vacuum filling, the following procedures may be used whether vacuum is applied directly to the transformer or the complete transformer is placed in an auxiliary vacuum tank.

1. Apply and maintain continuously a vacuum of at least 28 inches of mercury for at least one-half hour to units rated 25 kv and below, or for four hours to units above 25 kv.

2. While retaining the vacuum, slowly fill with Inerteen to the normal 25°C level or with approximately 90% of the required amount where it is impossible to gauge properly.

3. Maintain the specified vacuum for at least one-half hour after filling.

4. Adjust Inerteen to normal level and seal the transformer tank. Do not reopen until the temperature of the top of the fluid is equal to or higher than the ambient temperature in order to avoid condensation on the surface of the Inerteen.

In those cases where the transformers are not filled under vacuum, full voltage should not be applied to the windings for several hours after the Inerteen has been put into the case. This time is necessary to allow the air bubbles to escape.

PLACING IN SERVICE

Pressure Testing

All Inerteen transformers are pressure-tested at the factory and shipped free of leaks. After installation and before voltage is applied, it is desirable to pressure-test each transformer, especially if any fittings or covers have been removed and replaced during installation. Compressed dry nitrogen or dry air may be used for the purpose. It is recommended that the space above the Inerteen be blown out with dry nitrogen, then close all vents and apply a pressure-test of five pounds per square inch for a period of six to eight hours. The test pressure can best be limited by the use of a pressure regulator attached to the nitrogen cylinder. A check for leaks of joints above the Inerteen level may be made by painting them with a solution of soap and glycerin and watching for gas bubbles. At the conclusion of the test the internal pressure should be returned to normal by momentarily venting the gas space.

High Altitude

Where transformers are to be used at a high altitude (more than 3000 feet above sea level) a fitting above the liquid level should be opened to equalize the internal and external pressures at a temperature of approximately 25°C before placing the transformer in service.

Grounding Transformer Tank

Regardless of the type of foundation or floor on which a transformer is to rest, the tank should be definitely and permanently grounded to eliminate the possibility of obtaining static shocks or being injured by accidental grounding of a winding to the case. A ground pad or lug is always provided near the bottom of the tank for the purpose of connecting the grounded lead.

CAUTION

A good low-resistance ground is necessary for adequate protection—a poor ground may be worse than none at all.

Grounding Low Voltage Winding

Every effort is made in insulating transformers to guard against any chance of breakdown between high voltage and low voltage windings; however, in order to be absolutely safe, it is advisable that low voltage circuits with which persons may come in contact be grounded. The maximum voltage that can be obtained to ground is then limited to the normal voltage that exists between the grounded point and the line; this is true even though the high voltage and low voltage windings become connected electrically.

In grounding the winding, the neutral point should be used if it is available. When transformers operate on single phase circuits with the middle point of the low voltage, the maximum voltage that can exist between any part of the low voltage circuit and ground is one-half of the low voltages.

MAKING CONNECTIONS

A diagram, usually on the metal instruction plate attached to the side of the case, shows the proper power terminal connections to be made for various voltages. Care should be taken to see that all connections and only those shown are properly made, for a wrong connection may cause severe damage.

Some installations require an auxiliary source of power or control leads to be wired to terminals at the transformer; a wiring diagram, either a separate drawing or included as part of the outline drawing, shows the connections to be made.

Voltage Application

When voltage is first applied to the transformer, it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be disclosed before damage can result. After full voltage has been applied successfully, the transformer should be operated without load for a few hours. It should be kept under close observation during this time and also during the first few hours while loaded.

INSPECTION

It is desirable that periodic inspections of Inerteen apparatus be made and that samples of Inerteen be taken from each and from all compartments of any apparatus and tested after a short period of service (approximately three months for transformers). Following this, when operating conditions permit, routine sampling and testing of the Inerteen at intervals of six months to one year are suggested. Accurate records should be kept of such inspections and tests and if the Inerteen shows a dielectric strength of less than 28 kv, it should be conditioned. If facilities are not available for testing Inerteen, see "Westinghouse Inerteen Testing Service," P.L. 45-825. When an appreciable amount of Inerteen is removed from any apparatus, it should be replaced with an equal amount of new Inerteen so that the liquid level in the apparatus is maintained. The Inerteen used for replacement purposes should have a dielectric strength of not less than 30 kv.

Any increase in operating temperature at normal load should be investigated and if the cause cannot be determined, the transformer should be taken out of service and given a thorough inspection.

Any symptoms, such as unusual noises, high or low Inerteen levels, operation of relief devices, etc., should be investigated at once.

Transformers which have been subjected to unusually severe operating conditions, such as overloads, frequent short circuits, or special units should be inspected at least once a year. This can usually be done adequately by lowering the Inerteen level and inspecting with a light through the manhole. Before this inspection is made, the Inerteen should be allowed to cool to reduce the amount of Inerteen fumes given off which are quite objectionable and should not be inhaled.

During periodic inspection, all accessories should be inspected to see if they are operating properly.

SAMPLING INERTEEN

All sampling and testing equipment must be thoroughly dry and clean. It is recommended that sampling and testing equipment used for handling Inerteen and servicing Inerteen be used for no other purpose. Care must be used in taking samples of Inerteen and sealing them prior to testing. It is desirable that samples of Inerteen be removed from any container on clear days only, and when the temperature of the Inerteen is at least as high as the temperature of the surrounding air.

Use only tin containers with screwed metal caps or glass bottles with Inerteen-resistant stoppers to hold Inerteen samples. If it becomes necessary to use other than factory sampling containers, they should be rinsed with clean naphtha, washed with strong soap suds, and rinsed thoroughly in hot water, and then dried at approximately 110°C for four hours with neck down in a circulating air oven. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place.

Provision is made on all Inerteen transformers to obtain a top sample of the Inerteen, however, on a transformer that is in operation, a sample may be taken from either the top or bottom since any moisture present will be mixed in, due to circulation of the Inerteen. In sampling, allow a small amount of Inerteen to run out to flush the sampling connection clean before collecting the sample. The Inerteen should be put into the sample containers immediately and the caps screwed on tightly. The label for each container should be marked clearly with the serial number of the transformer or compartment from which the Inerteen was taken.

Before taking samples from a storage tank, the Inerteen should be allowed to settle for approximately twelve hours so that if there is any moisture present, it, having a lower specific gravity, will rise to the top where the sample is to be taken. A clean sneak-thief should be used to obtain the samples. Essentially, the same precautions to prevent moisture and dirt contamination should be used as outlined above.

Quantity of Sample

It is recommended that one 16 oz. bottle of Inerteen be taken as a sample for testing. At least one sample should be taken from a tank car of Inerteen. One sample may be taken from each drum, or if desired, a composite sample may be made from Inerteen from five drums, provided all the drums are airtight. When the bung is first loosened, a hissing sound should be heard, which indicates that the drum has been airtight. If the test of the composite sample is not satisfactory, a sample from each of the drums represented should be tested.

When drums have been stored exposed to the weather, a sample from each drum must be tested to determine if it is suitable for use.

Westinghouse Electric Corporation
Power Transformer Division, Sharon, Pa.

Printed in U.S.A. (W.P.D.)

Inerteen® and Environmental Contamination

Inerteen is a synthetic insulating fluid made by the chlorination of a relatively common chemical, biphenyl. The chlorination is necessary to impart nonflammable properties to the Inerteen. The resulting polychlorinated biphenyl (PCB's) are relatively insoluble in water but soluble in fat, and are extremely persistent in the environment. It has been indicated by several laboratories that measurable amounts of the PCB's are present in our general environment and may have some effect on certain species of wildlife. While askarels are generally regarded as being nontoxic to humans, it is reasonable to assume that very high standards of control will be issued by the Government in the overall program against pollution. Therefore, tight control on the usage and disposal of Inerteen must be exercised.

770

While the electrical users of askarel type fluids provide sealed systems, there still remains a problem of waste disposal when the equipment exceeds its useful life or undergoes repair.

For scrap Inerteen fluid, Monsanto has arranged for return of this material in sealed drums. Ship prepaid to

Monsanto Company
W. G. Krummrich Plant
Sauget, Illinois

Attn: Supervisor Dept. 246

A charge will be made for all returned Inerteen.

Inerteen soaked coils, insulation scrap, filter cartridges, and other materials must be stored until appropriate methods can be provided to dispose of them properly.

There is considerable work being done at the present time on this whole problem. We will continue the use of Inerteen because of its outstanding performance record and safety features. If modification of the present askarels can be made without sacrificing the nonflammable and other insulating properties, but which still make them less harmful to wildlife, they will be used in our Inerteen.

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Westinghouse Electric Corporation
POWER TRANSFORMER DIVISION
SHARON PA. • MUNCIE, IND. • S. BOSTON, VA.

Printed in U.S.A.

Instructions for Handling Inerteen® Insulating Fluid P.D.S. 54201 CM and Installation and Maintenance of Inerteen Transformers

Westinghouse Exhibit 9

Westinghouse Electric Corporation

POWER TRANSFORMER DIVISION, SHARON, PENNSYLVANIA • MUNCIE, INDIANA
DISTRIBUTION TRANSFORMER DIVISION, SOUTH BOSTON, VIRGINIA

I.B. 45-063-99C Effective August, 1971 Supersedes I.B. 45-063-99B, September 1968

PLAINTIFF'S EXHIBIT 489

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CONTENTS

Part I — Inerteen® Insulating Fluid

CHARACTERISTICS

Inerteen is a highly pure, synthetic non-inflammable and non-explosive insulating and cooling liquid. Chemically stable and nearly water white in color, Inerteen is not affected by reaction with other materials regularly used in the manufacture of Inerteen apparatus. It is non-oxidizing and non-corrosive at temperature considerably above those normally obtained in Inerteen apparatus. Inerteen will not sludge under any operating condition. Water is the main enemy of Inerteen and keeping it dry will insure long service life.

The dielectric strength of Inerteen will compare favorably with that of insulating oil when tested under the same conditions. Quality samples of Inerteen tested under laboratory conditions may show a dielectric strength in excess of 40KV. Care must be exercised in handling and testing Inerteen. Inerteen must be kept in clean, sealed containers to prevent loss by evaporation or contamination by moisture or dirt.

Inerteen exerts a strong solvent action on most varnishes, gums, and paints. Such materials are not used in the construction of Inerteen apparatus. No materials should be used in Inerteen apparatus except those approved by the Westinghouse Electric Corporation.

Inerteen has an irritating effect upon the skin. If it is necessary to handle it, see the precautions under "Handling". It should be remembered that mineral oil is completely miscible with Inerteen; in fact, it is impossible to separate mineral oil and Inerteen.

SPECIFIC CHARACTERISTICS OF INERTEEN

As outlined in "Method of Testing Askarels A.S.T.M. D901," the specific characteristics of Inerteen are:

1. Burn point: None
2. Chemical stability: No generation of free chlorides under normal operating conditions.
3. Color: (Maximum) 100 A.P.H.
4. Condition: Clear
5. Dielectric constant:
   At 1000 hertz 77°F (25°C), 5.7 to 5.9
   At 1000 hertz 212°F (100°C), 4.8 to 5.0
6. Dielectric strength: (Minimum) 77°F (25°C)
   At point of shipment, 35KV
   At point of receipt, 30KV
7. Electrical Resistivity: (Minimum)
   500 x 10^9 ohms/cm^3 (212°F (100°C) at 500 volts DC)
8. Power factor:
   At 60 hertz, 77°F (25°C) 2%
   At 60 hertz, 212°F (100°C) 25%
9. Fixed chlorine content: (Minimum) 42 percent
10. Free chlorides: Less than 0.10 ppm
11. Neutralization number: Less than 0.014 mg of KOH/gram
12. Pour Point: (Maximum) plus 7°F (minus 14°C)
13. Refractive index:
    At 77°F (25°C), 1.624 to 1.626
14. Specific gravity:
    At 60°F/60°F (15.5°C/15.5°C), 1.381 to 1.392
15. Density: 11.5 pounds per gallon
16. Viscosity:
    At 100°F (37.8°C), 82-92 seconds
17. Moisture: (Maximum) 35 ppm

ENVIRONMENTAL CONSIDERATIONS

Inerteen is a synthetic insulating fluid made by the chlorination of a relatively common chemical, biphenyl. The chlorination is necessary to impart nonflammable properties to the Inerteen. The resulting polychlorinated biphenyls (PCB's) are relatively insoluble in water but soluble in fat.

and extremely persistent in the environment. It has been shown by several laboratories that measurable amounts of the PCB's, particularly those with more than 50% chlorination, are present in our general environment and are a threat to certain species of wildlife. While Inerteen is generally regarded as being non-toxic to humans, very high standards of control in the overall program against pollution must be exercised.

Electrical apparatus (such as transformers and capacitors) using Inerteen are normally sealed to prevent escape of Inerteen into the environment. However, a carefully planned program of waste disposal must be followed at every step of the equipment life. This includes manufacture, repair and final disposition of the fluid and the Inerteen contaminated parts. To date the only acceptable destruction of the PCB's is by incineration at 2250°C or higher under carefully controlled conditions. At this temperature Inerteen will breakdown into HCl, CO_2 and water vapor. An alkaline scrubber is necessary to neutralize the HCl and the final products released to the atmosphere are CO_2 and steam. To be sure that the Inerteen and Inerteen contaminated materials do not contaminate the environment they must be incinerated in approved equipment.

HANDLING

1. Safety Precautions

Breathing. The odor of Inerteen is noticeable at concentrations below the Maximum Acceptable Concentration. Concentrations which exceed this may cause irritation of the eyes, nose, throat and upper respiratory tract. Much higher concentrations could cause internal reactions.

Swallowing. Inerteen is highly toxic if taken internally. Swallowing of an ounce or two could cause severe irritation of the digestive tract and serious internal reactions.

Skin Irritation. Although Inerteen is only a moderate skin irritant when contact is for short duration, it can be absorbed through the skin. Repeated contact over prolonged periods may result in severe dermatitis which may persist for many months after removal from exposure.

Protective Equipment. When necessary, under emergency conditions, to enter a space containing very high concentrations of Inerteen fumes or vapor, either an approved gas mask or self-contained breathing equipment, should be worn. For lower, but still significant concentrations, cartridge type chemical respirator should be worn. If the odor of Inerteen is noticed while wearing respiratory equipment, the wearer should go immediately into fresh air.

Neoprene coated aprons and neoprene coated gloves may be used where necessary to protect the skin. Hand cream designed to protect against oils and petroleum solvents, (such as Ply 9 Gel made by Milburn Co. of Detroit) may be of some value where the use of gloves is not practical.

When handling Inerteen, wash hands often with warm soapy water and in case of spillage onto clothing, remove the clothing as soon as possible. The clothing must then be laundered prior to use.

2. Storage

Inerteen is shipped in tank cars, drums or cans. Inerteen in drums or cans should be stored in a covered area and when stored out-of-doors the bungs should be down to prevent collection of water around the bung. A storage tank should be mounted on piers above the ground and accessible to all points for inspection for leakage. There should be a curb on the ground around the tank to contain any spillage or leakage.

It is desirable, if possible, to keep Inerteen in storage at a temperature slightly above ambient to prevent moisture condensation.

SAMPLING AND INSPECTION

Sampling. Each container of Inerteen must be sampled and tested prior to being added to a transformer and then should be added only if the dielectric strength is 30KV or above.

It is desirable that periodic inspection of Inerteen apparatus be made and that samples of Inerteen be taken from each compartment and tested. Initially a sample should be taken after about 3 months of operation and then, where operating conditions permit, at intervals of 6 months to 1 year. Accurate records should be maintained and if dielectric strength drops below 22KV it should be reconditioned.

If facilities are not available for testing Inerteen, see "Westinghouse Inerteen Testing Service" below.

Westinghouse Inerteen Testing Service. Many users of Inerteen do not have the necessary facilities for testing. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an Inerteen testing service to provide careful tests by experienced engineer, and provide a prompt report on the test results.

Two special 16 oz. sample bottles per mailing container Westinghouse S#24B1743602, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse Office. (The bottle and the container will not be returned to the customer.)

After drawing the sample of Inerteen, the customer should seal the bottle and mail it to the Westinghouse Electric Corporation, Materials Engineering Laboratory, Sharon, Pa. 16146. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. The order sheet must be sent to the nearest Westinghouse office.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination if so requested. (The customer should plainly indicate the type of service desired.)

The physical and chemical examination consists of an examination of the Inerteen by a competent chemist. Recommendations will be made as to the suitability of the Inerteen for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the Inerteen represented should be given as completely as possible. (For details refer to the nearest Westinghouse Office).

SAMPLING INERTEEN

The dielectric strength of Inerteen is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. There have been low dielectric test results reported from the field which, upon investigation, have been found to be largely a matter of poor sampling. All sampling and testing equipment used for handling Inerteen and servicing Inerteen should be used for no other purpose. Care must be used in taking samples of Inerteen and sealing them prior to testing. It is desirable that samples of Inerteen be removed from any container on clear days only, and when the temperature of the Inerteen is at least as high as the temperature of the surrounding air.

Use only tin containers with screwed metal caps or glass bottles with Inerteen resistant lids to hold Inerteen samples. If it becomes necessary to use other than factory sampling containers, they should be rinsed with clean naptha, washed with detergent and water, and rinsed thoroughly in hot water, and then dried at approximately 110°C for four hours with neck down in circulating air oven. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place. An aluminum foil liner should be put in the lid.

Provision is made on all Inerteen transformers to obtain a top sample of the Inerteen, however on a transformer that is in operation, a sample may be taken from either the top or bottom since any moisture present will be mixed in, due to circulation of Inerteen. In sampling, allow at least one quart of Inerteen to run out to flush the sampling connection before collecting the sample. This flush material must be collected in a suitable container for disposition as per the section on "Inerteen Disposal" page 6. The Inerteen should be put into the sample containers immediately and the caps screwed on tightly. The label for each container should be marked clearly with the serial number of the transformer or compartment from which the Inerteen was taken.

Before taking samples from a storage tank, the Inerteen should be allowed to settle for approximately twelve hours so that if there is any moisture present, it, having a lower specific gravity, will rise to the top where the sample is to be taken. A clean sneak-thief should be used to obtain the samples. Essentially, the same precautions to prevent moisture and dirt contamination should be used as outlined above.

It is recommended that one 16 oz. bottle of Inerteen be taken as a sample for testing. At least one sample should be taken from a tank car of Inerteen. One sample may be taken from each drum, or if desired, a composite sample may be made from Inerteen from five drums, provided all of the drums are airtight. When the bung is first loosened, a hissing sound should be heard, which indicates that the drum has been airtight. When the composite type of testing is used and a sample is found to be unsatisfactory, a sample from each of the drums represented must be tested.

When drums have been stored exposed to the weather, a sample from each drum must be tested to determine if it is suitable for use.

DISPOSITION OF SAMPLE & CONTAINER All samples must be collected in sealed, labelled containers for disposition as described in section on "Inerteen Disposal" page 6. All solvent rinses of test containers must be handled in a like manner.

All containers, rags, and other solid materials involved in testing must be collected for proper disposition.

TESTING METHODS

Instruction for all tests listed correspond in general to the recommendations of the American Society for Testing Materials.

1. Dielectric Strength Test

The testing transformer and the source of supply of energy shall not be less than 1/2 KVA, and the frequency shall not exceed 100 Hertz per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by an approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the Inerteen takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 KVA or less, as the current is limited by the impedance of the transformer.

The standard test cup for holding the sample of Inerteen shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by Inerteen or benzine and non-absorbent as far as moisture, Inerteen, or gasoline are concerned.

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, 1 in. in diameter, with square (90°) edges. The electrodes shall be mounted in the test cup with their axes horizontal and coincident, with a gap of 0.100 in. between their adjacent faces, and with tops of electrodes about 1-1/4 in. below the top of the

cup. (A suitable test cup is shown in Fig. 1, and portable testing outfits in Fig. 2.)

a. Procedure

The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100 in., and the electrodes then locked in position.

The electrodes and the test cup shall be wiped clean with dry, calendered tissue paper or with a clean, dry chamois skin and thoroughly rinsed with Inerteen-free, dry benzine until they are entirely free from fibers.

The test cup shall be filled with dry benzine, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms) per second until breakdown occurs. If the dielectric strength is not less than 25KV, the cup shall be considered in suitable condition for testing the Inerteen. If a lower test value is obtained the cup shall be cleaned with benzine and the test repeated.

The temperature of the test cup and of the Inerteen when tested shall be the same as that of the room, which should be between 68°F and 86°F. (20°C and 30°C) Testing at lower temperatures is likely to give variable results which may be misleading.

The sample in the container shall be agitated with a swirling motion (to avoid introducing air) so as to mix the Inerteen thoroughly before filling the test cup. This is even more important with used Inerteen than with new Inerteen as the impurities may be precipitated and the test may be misleading.

The cup shall be filled with Inerteen to a height of no less than 0.79 in. (20 mm) above the top of the electrodes.

The Inerteen shall be gently agitated by rocking the cup and allowing it to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

Voltages shall be applied and increased uniformly at a rate of approximately 3000 volts (rms) per second until breakdown occurs as indicated by a continuous discharge across

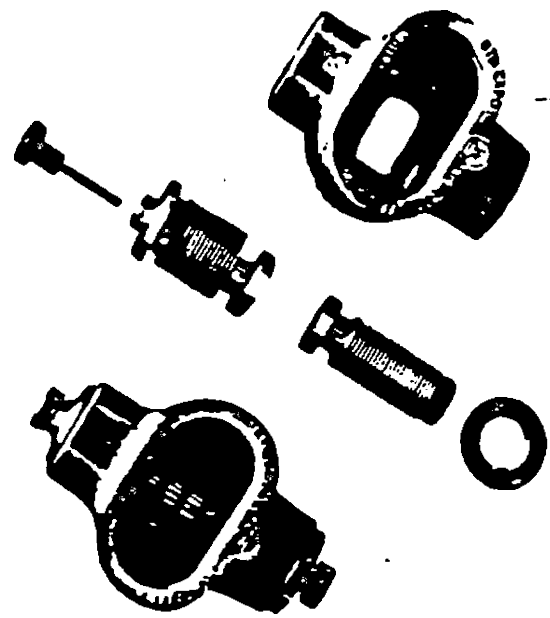

Fig. 1. Fluid Test Cup for Dielectric Test

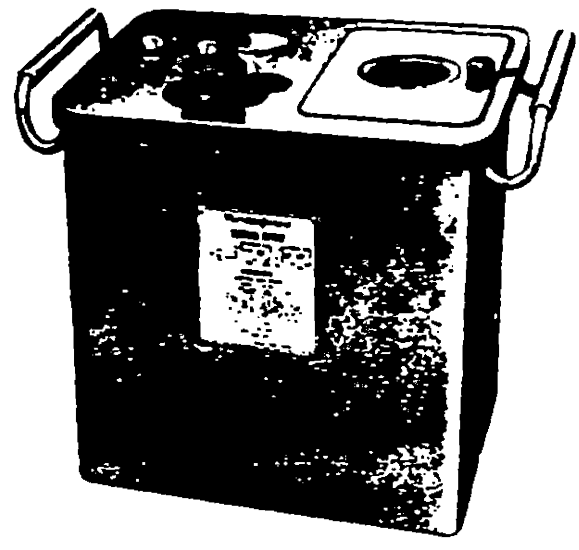

Fig. 2. Portable Oil Testing Set, 1/2 KVA, 35,000 Volts

the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded).

b. Number of Tests

I. Except as specified in (II) one breakdown test shall be made on each of five fillings of the test cup. If the average deviation from the mean exceeds 10 percent or if any individual test deviates more than 25 percent from the average, additional tests shall be made. The dielectric strength shall be determined by averaging the first five tests that conform to the allowable variations.

II. When Inerteen is tested in considerable quantity, so that the time required for testing is excessive and when it is merely desired to determine whether the breakdown safely exceeds the limit specified, or in those cases where the amount of Inerteen available for test may be very limited, one breakdown test shall be made on each of two fillings of the test cup. If neither breakdown is below this value, the Inerteen may be considered satisfactory and no further tests shall be required. If either of the breakdowns is less than the specified value a breakdown shall be made on each of three additional fillings and test results analyzed in accordance with (I).

c. Report

The report shall include the volts (rms value) at each breakdown and the average of the two or five breakdowns and the temperature of the Inerteen at the time of the test.

2. Neutralization Test

The Neutralization number is the number of milligrams of potassium hydroxide required to neutralize the acid in one gram of Inerteen.

Solutions Required

a. Standard Potassium Hydroxide Solution (alcoholic, 0.1N) – add 6 g. of c.p. solid KOH to 1 liter of c.p. anhydrous isopropyl alcohol. Boil, add 2 g. of c.p. $Ba(OH)_2$ and boil again. Cool, filter and store in a chemically resistant bottle protected by a guard tube containing soda lime and soda asbestos (Ascarite). Standardize against pure potassium acid phthalate using phenolphthalein as an indicator.

b. Titration Solvent – Add 500 ml. of c.p. benzene and 5 ml. of water to 495 ml. of c.p. anhydrous isopropyl alcohol.

Procedure. Into a 250 ml. Erlenmeyer flask introduce 40 g. of Inerteen weighed accurately. Add 100 ml. of the titration solvent and 3 ml. of the indicator solution. Titrate immediately at a temperature below 30°C. Consider the end point definite if the color change to green persists for 15 seconds. A blank shall be determined on the solvent.

Calculations. The neutralization number or mg. KOH per g. of Inerteen $= \frac{(A-B)(N) \times 56.1}{W}$

A = ml. KOH solution required for sample.
B = ml. KOH solution required for blank.
N = normality of KOH solution.
W = grams of sample used.

RECONDITIONING

Reconditioning will be necessary to remove water, foreign material and hydrogen chloride which may be present and contaminating Inerteen. The blotter filter press, cartridge filter and the Inerteen conditioner will remove water and dirt which may be present. Various models of each of these types of apparatus are available. The Inerteen conditioner is the most effective for removing moisture, dirt, and other contaminating materials. It basically consists of a clay container, a clay filter, pump, attendant valves, gauges and fittings.

Water cannot be effectively removed from either clay or filter material once they have become saturated with Inerteen therefore care

should be taken to see that these materials are thoroughly dry prior to use. Any equipment used for conditioning Inerteen should first be thoroughly cleaned with benzine or naphtha to remove all traces of material foreign to Inerteen. If at all possible, separate equipment should be used for filtering Inerteen only.

Hydrogen chloride, caused by arcing, may be eliminated by vigorously bubbling dry nitrogen through Inerteen. This should be done as quickly as possible following the failure to prevent the attack of HCl on the cellulose insulation. The nitrogen should be passed in through the drain valve at the bottom and allowed to escape through a vent at the top. The nitrogen should be discharged through a pressure regulator attached to a stand pipe above the level of the Inerteen in the transformer to prevent the Inerteen from flowing into the regulator. The nitrogen should be bubbled through the Inerteen at a rate of one to three cubic feet per minute for a period of 4 to 6 hours. This may require two to eight cylinders (220 cu. ft. each) depending on the size of the apparatus.

DISPOSAL

Inerteen Liquid. Collect all scrap Inerteen liquid in a suitable metal container which can be satisfactorily sealed. Once the Inerteen is collected it may be returned in sealed drums or tank cars to Monsanto or other certified disposal company. Ship prepaid to:

Monsanto Company
W. G. Krummrich Plant
Sauget, Illinois
Attention: Supervisor Dept., 246

A charge will be made for all returned Inerteen.

Solvent-Rinses Contaminated with Inerteen. Solvent rinses or other liquids contaminated with Inerteen should also be collected in sealed drums or tank cars and sent either to Monsanto or other certified disposal company.

Solids Contaminated with Inerteen. All solids materials contaminated with Inerteen must be stored in impervious containers until disposal. This includes all glass, metals, papers, insulation, clay rags, filter cartridges, etc.

These materials may be incinerated if suitable arrangements can be made for it to be done at a temperature sufficient to breakdown the Inerteen. Or they may be purged by cleaning with a proper fluid and the resultant fluid then may be incinerated using an approved procedure and temperature.

The following disposition is recommended for various materials.

Material	Disposition
Absorbing clay, filter paper, cartridges sawdust and rags	Incinerate
Coils	Solvent clean or incinerate
Cores	Solvent clean
Tanks & Frames	Solvent clean
Copper or Aluminum	Solvent clean
Insulation	Incinerate

Incineration. Incineration, whether of liquids or contaminated solid materials, must be done at a temperature of at least 2250°C and the stack must be equipped with a suitable scrubber to remove HCl.

Cleaning Contaminated Drums. The cleaning of drums which have contained used Inerteen requires great care in order to insure a thoroughly clean drum.

It is preferable to return such drums to the supplier where adequate cleaning facilities are available, rather than to attempt to clean them.

If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or petroleum distillate, using about one gallon each time, until the solvent shows no discoloration after using. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at

the lower end to explore the corners of the drum. Collect all solvent rinse material for disposition as described above.

CAUTION: Do not use a steel pipe because of the danger of a spark igniting the gasoline or petroleum distillate vapor.

Next, heat the drum with bunghole down in a ventilated oven at a temperature of at least 88°C. (190°F) for sixteen hours. (A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.) Blow out the drum with dry nitrogen or dry air to remove any lingering explosive vapors. Screw the bung on tightly before removing the drum from the oven. Use a new washer with the bung to insure a tight seal.

CAUTION: Open flames must always be kept away from the oven to prevent igniting inflammable gases which might be remaining in drum when placed in the oven.

The practice of refilling drums with Inerteen is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the Inerteen is likely to become contaminated.

Part II — Installation and Maintenance Inerteen Transformers

INSTALLATION

For convenience in handling, all transformers are equipped with lugs or eyes for lifting and moving the complete assembly filled with Inerteen by use of a crane. Additional means are provided for the heavier parts such as covers, core and coils, radiators and terminal chambers. Jacking lugs are also supplied on either the base or corners of the tank. A transformer should only be lifted or moved by jacks placed against these lugs and not against the cooling tubes, radiator valves, or other fittings.

An indoor installation requires that the room in which the transformers are placed must be well ventilated so that the heated air can readily escape and be replaced by cooler air from the outside. If the room is poorly ventilated, this exchange of air takes place too slowly and the temperature of the air in the room may become excessively high. At any given load the temperature rise of a self-cooled transformer will be a fixed number of degrees above the temperature of the surrounding air. The temperature of the transformer is the sum of this rise and the air temperature; therefore, care must be taken to provide a room sufficiently ventilated to permit operation of transformers at a reasonable temperature. Area of the air inlets should be such that the ambient temperature never exceeds 40°C (104°F) with an average over twenty-four hours not exceeding 30°C (86°F): 50 to 60 square feet per 1000 kva of transformer capacity has been satisfactory. Outlet openings with the same total area should be provided.

Self-cooled transformers should always be well separated from one another and from adjacent walls, partitions, etc., in order to permit free air circulation about the cases. This separation should not be less than 24 to 36 inches depending on the size of the units.

INSPECTION

All Inerteen transformers are carefully inspected and tested at the factory and they are in good

condition when shipped; but it is desirable to inspect each transformer thoroughly before placing it in service.

When a transformer is shipped complete and filled with Inerteen, this inspection should include a check of the Inerteen level, the tightening or adjustment of any parts that may have become loose or out of place, and determining the extent to which moisture may have entered the transformer. The latter can best be determined from the dielectric strength of the Inerteen. Inerteen used for filling transformers should have a dielectric strength of 30KV or higher. When it tests less than this the Inerteen should be filtered. If the dielectric strength is very low or if there is any other evidence of moisture, it is necessary to dry the transformer.

Inerteen transformers should be dried by the short circuit method with the transformer immersed in the Inerteen and with the tank sealed tightly. During the drying out operation, the Inerteen should be circulated through a filter press or preferably through an Inerteen conditioner. A filter press will remove dirt and most of the moisture, but the conditioner will remove these and other contaminating materials as well.

The desired load current should be obtained by short circuiting one winding and impressing the proper impedance voltage on the other winding. The full load impedance may usually be found on the instruction plate for the transformers; if the impedance of the transformer is not known, it should be requested from the Westinghouse Electric Corporation, Sharon, Pennsylvania, by identifying the transformer with its serial number.

If the transformer is at or lower than room temperature at the start of the drying process, circulation of 125 to 150% of full load current will hasten the heating, and a higher top Inerteen temperature can be obtained more quickly by blanketing the coolers when tubular coolers are used or by shutting off the radiator valves when radiators are used. The cover should be lagged to prevent condensation.

The loading should be carefully watched and when the top Inerteen reaches a temperature of 60°C, the load should be reduced to obtain an approximately constant top Inerteen temperature based on the following table:

Short Circuit Amperes in Percent of Load	Maximum Temperature of the Top Inerteen
50%	85°C
75%	80°C
85%	75°C

While the windings of the transformer heat up, do not permit the temperature of the top Inerteen to exceed the value specified for a given percentage of load. This precaution is necessary because the windings will heat up more quickly and operate at a higher temperature than the Inerteen. If the windings are allowed to reach too high a temperature, the insulation will be damaged. The drying of a transformer should be continued until the dielectric strength of samples of Inerteen taken from the transformer test at 30KV or higher.

The cover should be kept tightly sealed during the temperature run, and until the transformer has cooled down to room temperature to prevent condensation. This also prevents the release of hot Inerteen vapors which are quite objectionable, particularly if the ventilation is poor.

CAUTION: It is not safe to attempt the drying out of transformers unless constant attention is given to the job.

ACCESSORIES AND FITTINGS

Bushings, fittings, and accessories when boxed and shipped separately should be mounted as shown on the outline drawing. Proper installation

instructions when necessary are included in the instruction leaflets for component parts. Care must be exercised when these components are fitted to eliminate the accidental introduction of moisture in any form inside the transformer. Where blind flanges are removed before fittings are mounted, the level of the Inerteen must be lowered below the openings that will be made.

FINISH

Any portion of the paint film damaged during shipment or installation must be repaired as quickly as possible.

To do this, clean the damaged portion by means of a scraper or sandpaper, wipe thoroughly with a solvent dampened cloth, apply Westinghouse primer paint and allow it to dry for at least 24 hours, then apply a coat of Westinghouse finish paint.

FILLING

When putting new apparatus into service, see that the apparatus tank is free from moisture and foreign material.

IMPORTANT: Extreme precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with Inerteen, and to prevent the entrance of water and dirt during the transfer of the Inerteen to the apparatus.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day: if this is not possible, protection against moisture must be provided.

All vessels used for transferring the Inerteen should be carefully inspected to see that they are absolutely dry and free from contamination. Use only all-metal hose or pipe when filling, since the lining of most other types of hose may be soluble in Inerteen and will contaminate it in a short time. All joints should be tight; where practical, fill through the drain valve to keep aeration to a minimum and vent the top of the tank to allow the air to escape. Be sure that valves and pipe connections between the main tank and any Inerteen filled compartments are open for free circulation of gas and liquid. Otherwise, trapped air or gas may cause the Inerteen level in some parts of the transformer to be below the safe operating level.

If it is necessary to fill a transformer out-of-doors, particularly on a damp day, care should be taken to prevent the entrance of moisture. In order to avoid condensation the temperature inside the unit should be kept several degrees above the outside air temperature.

The tank and compartments, if any, should be filled at ambient temperature to the point on the gauges marked "25° – Liquid Level." If the ambient varies greatly from 25°C (77°F) when filled, the Inerteen level should be checked when the average fluid temperature is 25°C; sufficient Inerteen should be added to or drained from the tank to bring the level to the proper height. The transformer should never be operated or left standing, even out of service without the Inerteen level being indicated on the gauge.

Filling Under Vacuum. Entrapped air is a potential source of trouble in all liquid filled transformers. Therefore, it is desirable to fill all Inerteen transformers under a full vacuum. This is done for the transformers shipped from the factory and should be done where practicable when transformers are filled in the field, providing the transformer cases have been so designed. If the cases have not been designed for full vacuum and it is imperative to get the maximum winding impulse strength immediately, the transformers should be filled with Inerteen under full vacuum by placing them in an auxiliary vacuum tank.

Where purchaser does not have an established technique for vacuum filling, the following procedures may be used whether vacuum is applied

directly to the transformer or the complete transformer is placed in an auxiliary vacuum tank.

1. Apply and maintain continuously a vacuum of at least 28 inches of mercury for at least one-half hour to units rated 25KV and below, or for four hours to units above 25KV.

2. While retaining the vacuum, slowly fill with Inerteen to the normal 25°C level or with approximately 90% of the required amount where it is impossible to gauge properly.

3. Maintain the specified vacuum for at least one-half hour after filling.

4. Adjust Inerteen to normal level and seal the transformer tank. Do not reopen until the temperature at the top of the fluid is equal to or higher than the ambient temperature in order to avoid condensation on the surface of the Inerteen.

In those cases where the transformers are not filled under vacuum, full voltage should not be applied to the windings for at least 24 hours after the Inerteen has been put into the case. This time is necessary to allow the air bubbles to escape.

PLACING IN SERVICE

Pressure Testing. All Inerteen transformers are pressure-tested at the factory and shipped free of leaks. After installations and before voltage is applied, it is desirable to pressure-test each transformer, especially if any fittings or covers have been removed and replaced during installation. Compressed dry nitrogen or dry air may be used for the purpose. It is recommended that the space above the Inerteen be blown out with dry nitrogen, then close all vents and apply a pressure-test of five pounds per square inch for a period of six to eight hours. The test pressure can best be limited by the use of a pressure regulator attached to the nitrogen cylinder. A check for leaks of joints above the Inerteen level may be made by painting them with a solution of soap and glycerin and watching for gas bubbles. At the conclusion of the test the internal pressure should be returned to normal by momentarily venting the gas space.

High Altitude. Where transformers are to be used at a high altitude (more than 3000 feet above sea level) a fitting above the liquid level should be opened to equalize the internal and external pressures at a temperature of approximately 25°C before placing the transformer in service.

Grounding Transformer Tank. Regardless of the type of foundation or floor on which a transformer is to rest, the tank should be definitely and permanently grounded to eliminate the possibility of obtaining static shocks or being injured by accidental grounding of a winding to the case. A ground pad or lug is always provided near the bottom of the tank for the purpose of connecting the grounded lead.

CAUTION: A good low-resistance ground is necessary for adequate protection — a poor ground may be worse than none at all.

Grounding Low Voltage Winding. Every effort is made in insulating transformers to guard against any chance of breakdown between high voltage and low voltage windings; however, in order to be absolutely safe, it is advisable that low voltage circuits with which persons may come in contact be grounded. The maximum voltage that can be obtained to ground is then limited to the normal voltage that exists between the grounded point and the line; this is true even though the high voltage and low voltage windings become connected electrically.

In grounding the winding, the neutral point should be used if it is available. When transformers operate on single phase circuits with the middle point of the low voltage, the maximum voltage that can exist between any part of the low voltage circuit and ground is one-half of the low voltages.

MAKING CONNECTIONS

A diagram, usually on the metal instruction plate attached to the side of the case, shows the proper

power terminal connections to be made for various voltages. Care should be taken to see that all connections and only those shown are properly made, for a wrong connection may cause severe damage.

Some installations require an auxiliary source of power or control leads to be wired to terminals at the transformer; a wiring diagram, either a separate drawing or included as part of the outline drawing, shows the connections to be made.

Voltage Application. When voltage is first applied to the transformer, it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be disclosed before damage can result. After full voltage has been applied successfully, the transformer should be operated without load for a few hours. It should be kept under close observation during this time and also during the first few hours while loaded.

INSPECTION

It is desirable that periodic inspections of Inerteen apparatus be made and that samples of Inerteen be taken from each and from all compartments of any apparatus and tested after a short period of service. See section on Sampling and Inspection.

Any increase in operating temperature at normal load should be investigated and if the cause cannot be determined, the transformer should be taken out of service and given a thorough inspection.

Any symptoms, such as unusual noises, high or low Inerteen levels, operation of relief device, etc., should be investigated at once.

Transformers which have been subjected to unusually severe operating conditions, such as overloads, frequent short circuits, or special units should be inspected at least once a year. This can usually be done adequately by lowering the Inerteen level and inspecting with a light through the manhole. Before this inspection is made, the Inerteen should be allowed to cool to reduce the amount of Inerteen fumes given off which are quite objectionable and should not be inhaled.

During periodic inspection, all accessories should be inspected to see if they are operating properly.

CAUTION: Never enter a vault or any other confined area in which a transformer relief device has been known to operate or in which a transformer has failed, until the area has been thoroughly ventilated. Then enter cautiously, with another person in attendance. The pungent, somewhat irritating fumes of hydrogen chloride are easily detected and can serve as a guide in entering the enclosure.

Memorandum

790733

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

Instructions for Handling Inerteen® Insulating Fluid P.D.S. 54201 CM and Installation and Maintenance of Inerteen Transformers

Westinghouse Electric Corporation

SMALL POWER TRANSFORMER DIVISION, SOUTH BOSTON, VIRGINIA
SHARON TRANSFORMER DIVISION, SHARON, PENNSYLVANIA

I.B..45-063-99D Effective February, 1976 Supersedes I.B. 45-063-99C, August, 1971

CONTENTS

Part I — Inerteen® Insulating Fluid

See American National Standards Institute Guidelines C107.1-1974 for complete information on handling and disposal of Askarels. Copies are available from: ANSI, 1430 Broadway, New York, N.Y. 10018

CHARACTERISTICS

Inerteen is a highly pure, synthetic non-inflammable and non-explosive insulating and cooling liquid. Chemically stable and nearly water white in color, Inerteen is not affected by reaction with other materials regularly used in the manufacture of Inerteen apparatus. It is non-oxidizing and non-corrosive at temperature considerably above those normally obtained in Inerteen apparatus. Inerteen will not sludge under any operating condition. Water is the main enemy of Inerteen and keeping it dry will insure long service life.

The dielectric strength of Inerteen will compare favorably with that of insulating oil when tested under the same conditions. Quality samples of Inerteen tested under laboratory conditions may show a dielectric strength in excess of 40KV. Care must be exercised in handling and testing Inerteen. Inerteen must be kept in clean, sealed containers to prevent loss by evaporation or contamination by moisture or dirt.

Inerteen exerts a strong solvent action on most varnishes, gums, and paints. Such materials are not used in the construction of Inerteen apparatus. No materials should be used in Inerteen apparatus except those approved by the Westinghouse Electric Corporation.

Inerteen has an irritating effect upon the skin. If it is necessary to handle it, see the precautions under "Handling". It should be remembered that mineral oil is completely miscible with Inerteen; in fact, it is impossible to separate mineral oil and Inerteen.

SPECIFIC CHARACTERISTICS OF INERTEEN

As outlined in "Method of Testing Askarels A.S.T.M. D901," the specific characteristics of Inerteen are:

1. Burn point: None
2. Chemical stability: No generation of free chlorides under normal operating conditions.
3. Color: (Maximum) 100 A.P.H.
4. Condition: Clear
5. Dielectric constant:
   At 1000 hertz 77°F (25°C), 5.7 to 5.9
   At 1000 hertz 212°F (100°C), 4.8 to 5.0
6. Dielectric strength: (Minimum) 77°F (25°C)
   At point of shipment, 35KV
   At point of receipt, 30KV
7. Electrical Resistivity: (Minimum)
   500×10^9 ohms/cm^3 (212°F (100°C) at 500 volts DC)
8. Power factor:
   At 60 hertz, 77°F (25°C) 2%
   At 60 hertz, 212°F (100°C) 25%
9. Fixed chlorine content: (Minimum) 42 percent
10. Free chlorides: Less than 0.10 ppm
11. Neutralization number: Less than 0.014 mg of KOH/gram
12. Pour Point: (Maximum) plus 7°F (minus 14°C)
13. Refractive index:
    At 77°F (25°C), 1.624 to 1.626
14. Specific gravity:
    At 60°F/60°F (15.5°C/15.5°C), 1.381 to 1.392
15. Density: 11.5 pounds per gallon
16. Viscosity:
    At 100°F (37.8°C), 82-92 seconds
17. Moisture: (Maximum) 35 ppm

ENVIRONMENTAL CONSIDERATIONS

Inerteen is a synthetic insulating fluid made by the chlorination of a relatively common chemical, biphenyl. The chlorination is necessary to impart nonflammable properties to the Inerteen. The resulting polychlorinated biphenyls (PCB's) are relatively insoluble in water but soluble in fat,

and extremely persistent in the environment. It has been shown by several laboratories that measurable amounts of the PCB's, particularly those with more than 50% chlorination, are present in our general environment and are a threat to certain species of wildlife. While Inerteen is generally regarded as being non-toxic to humans, very high standards of control in the overall program against pollution must be exercised.

Electrical apparatus (such as transformers and capacitors) using Inerteen are normally sealed to prevent escape of Inerteen into the environment. However, a carefully planned program of waste disposal must be followed at every step of the equipment life. This includes manufacture, repair and final disposition of the fluid and the Inerteen contaminated parts. To date the only acceptable destruction of the PCB's is by incineration at 2250°C or higher under carefully controlled conditions. At this temperature Inerteen will breakdown into HCl, CO_2 and water vapor. An alkaline scrubber is necessary to neutralize the HCl and the final products released to the atmosphere are CO_2 and steam. To be sure that the Inerteen and Inerteen contaminated materials do not contaminate the environment they must be incinerated in approved equipment.

HANDLING

1. Safety Precautions

Breathing. The odor of Inerteen is noticeable at concentrations below the Maximum Acceptable Concentration. Concentrations which exceed this may cause irritation of the eyes, nose, throat and upper respiratory tract. Much higher concentrations could cause internal reactions.

Swallowing. Inerteen is highly toxic if taken internally. Swallowing of an ounce or two could cause severe irritation of the digestive tract and serious internal reactions.

Skin Irritation. Although Inerteen is only a moderate skin irritant when contact is for short duration, it can be absorbed through the skin. Repeated contact over prolonged periods may result in severe dermatitis which may persist for many months after removal from exposure.

Protective Equipment. When necessary, under emergency conditions, to enter a space containing very high concentrations of Inerteen fumes or vapor, either an approved gas mask or self-contained breathing equipment, should be worn. For lower, but still significant concentrations, cartridge type chemical respirator should be worn. If the odor of Inerteen is noticed while wearing respiratory equipment, the wearer should go immediately into fresh air.

Neoprene coated aprons and neoprene coated gloves may be used where necessary to protect the skin. Hand cream designed to protect against oils and petroleum solvents, (such as Ply 9 Gel made by Milburn Co. of Detroit) may be of some value where the use of gloves is not practical.

When handling Inerteen, wash hands often with warm soapy water and in case of spillage onto clothing, remove the clothing as soon as possible. The clothing must then be laundered prior to use.

2. Storage

Inerteen is shipped in tank cars, drums or cans. Inerteen in drums or cans should be stored in a covered area and when stored out-of-doors the bungs should be down to prevent collection of water around the bung. A storage tank should be mounted on piers above the ground and accessible to all points for inspection for leakage. There should be a curb on the ground around the tank to contain any spillage or leakage.

It is desirable, if possible, to keep Inerteen in storage at a temperature slightly above ambient to prevent moisture condensation.

SAMPLING AND INSPECTION

Sampling. Each container of Inerteen must be sampled and tested prior to being added to a transformer and then should be added only if the dielectric strength is 30KV or above.

It is desirable that periodic inspection of Inerteen apparatus be made and that samples of Inerteen be taken from each compartment and tested. Initially a sample should be taken after about 3 months of operation and then, where operating conditions permit, at intervals of 6 months to 1 year. Accurate records should be maintained and if dielectric strength drops below 22KV it should be reconditioned.

If facilities are not available for testing Inerteen, see "Westinghouse Inerteen Testing Service" below.

Westinghouse Inerteen Testing Service. Many users of Inerteen do not have the necessary facilities for testing. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an Inerteen testing service to provide careful tests by experienced engineer, and provide a prompt report on the test results.

Two special 16 oz. sample bottles per mailing container Westinghouse S#24B1743602, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse Office. (The bottle and the container will not be returned to the customer.)

After drawing the sample of Inerteen, the customer should seal the bottle and mail it to the Westinghouse Electric Corporation, Materials Engineering Laboratory, Sharon, Pa. 16146. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. The order sheet must be sent to the nearest Westinghouse office.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination if so requested. (The customer should plainly indicate the type of service desired.)

The physical and chemical examination consists of an examination of the Inerteen by a competent chemist. Recommendations will be made as to the suitability of the Inerteen for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the Inerteen represented should be given as completely as possible. (For details refer to the nearest Westinghouse Office).

SAMPLING INERTEEN

The dielectric strength of Inerteen is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. There have been low dielectric test results reported from the field which, upon investigation, have been found to be largely a matter of poor sampling. All sampling and testing equipment used for handling Inerteen and servicing Inerteen should be used for no other purpose. Care must be used in taking samples of Inerteen and sealing them prior to testing. It is desirable that samples of Inerteen be removed from any container on clear days only, and when the temperature of the Inerteen is at least as high as the temperature of the surrounding air.

Use only tin containers with screwed metal caps or glass bottles with Inerteen resistant lids to hold Inerteen samples. If it becomes necessary to use other than factory sampling containers, they should be rinsed with clean naptha, washed with detergent and water, and rinsed thoroughly in hot water, and then dried at approximately 110°C for four hours with neck down in circulating air oven. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place. An aluminum foil liner should be put in the lid.

Provision is made on all Inerteen transformers to obtain a top sample of the Inerteen, however on a transformer that is in operation, a sample may be taken from either the top or bottom since any moisture present will be mixed in, due to circulation of Inerteen. In sampling, allow at least one quart of Inerteen to run out to flush the sampling connection before collecting the sample. This flush material must be collected in a suitable container for disposition as per the section on "Inerteen Disposal" page 6. The Inerteen should be put into the sample containers immediately and the caps screwed on tightly. The label for each container should be marked clearly with the serial number of the transformer or compartment from which the Inerteen was taken.

Before taking samples from a storage tank, the Inerteen should be allowed to settle for approximately twelve hours so that if there is any moisture present, it, having a lower specific gravity, will rise to the top where the sample is to be taken. A clean sneak-thief should be used to obtain the samples. Essentially, the same precautions to prevent moisture and dirt contamination should be used as outlined above.

It is recommended that one 16 oz. bottle of Inerteen be taken as a sample for testing. At least one sample should be taken from a tank car of Inerteen. One sample may be taken from each drum, or if desired, a composite sample may be made from Inerteen from five drums, provided all of the drums are airtight. When the bung is first loosened, a hissing sound should be heard, which indicates that the drum has been airtight. When the composite type of testing is used and a sample is found to be unsatisfactory, a sample from each of the drums represented must be tested.

When drums have been stored exposed to the weather, a sample from each drum must be tested to determine if it is suitable for use.

DISPOSITION OF SAMPLE & CONTAINER. All samples must be collected in sealed, labelled containers for disposition as described in section on "Inerteen Disposal" page 9. All solvent rinses of test containers must be handled in a like manner.

All containers, rags, and other solid materials involved in testing must be collected for proper disposition.

TESTING METHODS

Instruction for all tests listed correspond in general to the recommendations of the American Society for Testing Materials.

1. Dielectric Strength Test

The testing transformer and the source of supply of energy shall not be less than 1/2 KVA, and the frequency shall not exceed 100 Hertz per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by an approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the Inerteen takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 KVA or less, as the current is limited by the impedance of the transformer.

The standard test cup for holding the sample of Inerteen shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by Inerteen or benzine and non-absorbent as far as moisture, Inerteen, or gasoline are concerned.

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, 1 in. in diameter, with square (90°) edges. The electrodes shall be mounted in the test cup with their axes horizontal and coincident, with a gap of 0.100 in. between their adjacent faces, and with tops of electrodes about 1-1/4 in. below the top of the

cup. (A suitable test cup is shown in Fig. 1, and portable testing outfits in Fig. 2.)

a. Procedure

The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100 in., and the electrodes then locked in position.

The electrodes and the test cup shall be wiped clean with dry, calendered tissue paper or with a clean, dry chamois skin and thoroughly rinsed with Inerteen-free, dry benzine until they are entirely free from fibers.

The test cup shall be filled with dry benzine, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms) per second until breakdown occurs. If the dielectric strength is not less than 25KV, the cup shall be considered in suitable condition for testing the Inerteen. If a lower test value is obtained the cup shall be cleaned with benzine and the test repeated.

The temperature of the test cup and of the Inerteen when tested shall be the same as that of the room, which should be between 68°F and 86°F. (20°C and 30°C) Testing at lower temperatures is likely to give variable results which may be misleading.

The sample in the container shall be agitated with a swirling motion (to avoid introducing air) so as to mix the Inerteen thoroughly before filling the test cup. This is even more important with used Inerteen than with new Inerteen as the impurities may be precipitated and the test may be misleading.

The cup shall be filled with Inerteen to a height of no less than 0.79 in. (20 mm) above the top of the electrodes.

The Inerteen shall be gently agitated by rocking the cup and allowing it to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

Voltages shall be applied and increased uniformly at a rate of approximately 3000 volts (rms) per second until breakdown occurs as indicated by a continuous discharge across

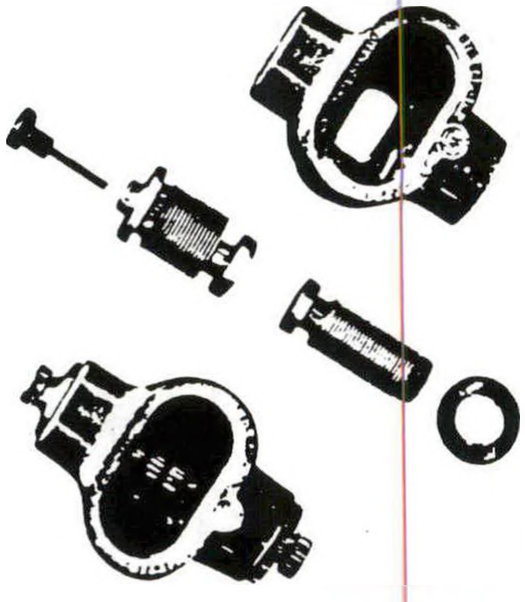

Fig. 1. Fluid Test Cup for Dielectric Test

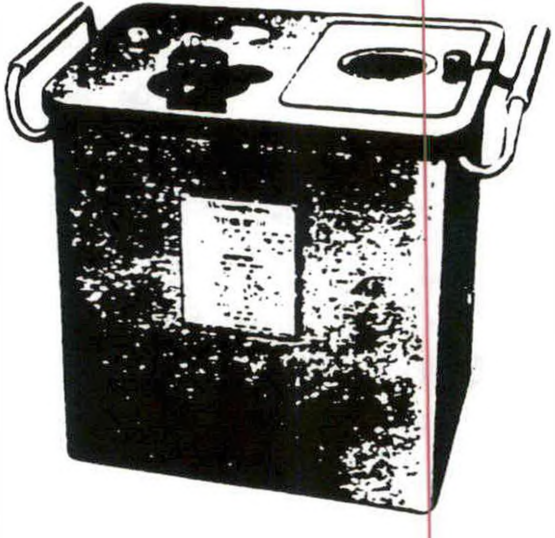

Fig. 2. Portable Oil Testing Set, 1/2 KVA, 35,000 Volts

the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded).

b. Number of Tests

I. Except as specified in (II) one breakdown test shall be made on each of five fillings of the test cup. If the average deviation from the mean exceeds 10 percent or if any individual test deviates more than 25 percent from the average, additional tests shall be made. The dielectric strength shall be determined by averaging the first five tests that conform to the allowable variations.

II. When Inerteen is tested in considerable quantity, so that the time required for testing is excessive and when it is merely desired to determine whether the breakdown safely exceeds the limit specified, or in those cases where the amount of Inerteen available for test may be very limited, one breakdown test shall be made on each of two fillings of the test cup. If neither breakdown is below this value, the Inerteen may be considered satisfactory and no further tests shall be required. If either of the breakdowns is less than the specified value a breakdown shall be made on each of three additional fillings and test results analyzed in accordance with (I).

c. Report

The report shall include the volts (rms value) at each breakdown and the average of the two or five breakdowns and the temperature of the Inerteen at the time of the test.

2. Neutralization Test

The Neutralization number is the number of milligrams of potassium hydroxide required to neutralize the acid in one gram of Inerteen.

Solutions Required

a. Standard Potassium Hydroxide Solution (alcoholic, 0.1N) – add 6 g. of c.p. solid KOH to 1 liter of c.p. anhydrous isopropyl alcohol. Boil, add 2 g. of c.p. Ba $(OH)_2$ and boil again. Cool, filter and store in a chemically resistant bottle protected by a guard tube containing soda lime and soda asbestos (Ascarite). Standardize against pure potassium acid phthalate using phenolphthalein as an indicator.

b. Titration Solvent – Add 500 ml. of c.p. benzene and 5 ml. of water to 495 ml. of c.p. anhydrous isopropyl alcohol.

Procedure. Into a 250 ml. Erlenmeyer flask introduce 40 g. of Inerteen weighed accurately. Add 100 ml. of the titration solvent and 3 ml. of the indicator solution. Titrate immediately at a temperature below 30°C. Consider the end point definite if the color change to green persists for 15 seconds. A blank shall be determined on the solvent.

Calculations. The neutralization number or mg.

$$\text{KOH per g. of Inerteen} = \frac{(A\text{-}B\ (N) \times 56.1}{W}$$

A = ml. KOH solution required for sample.
B = ml. KOH solution required for blank.
N = normality of KOH solution.
W = grams of sample used.

RECONDITIONING

Reconditioning will be necessary to remove water, foreign material and hydrogen chloride which may be present and contaminating Inerteen. The blotter filter press, cartridge filter and the Inerteen conditioner will remove water and dirt which may be present. Various models of each of these types of apparatus are available. The Inerteen conditioner is the most effective for removing moisture, dirt, and other contaminating materials. It basically consists of a clay container, a clay filter, pump, attendant valves, gauges and fittings.

Water cannot be effectively removed from either clay or filter material once they have become saturated with Inerteen therefore care

should be taken to see that these materials are thoroughly dry prior to use. Any equipment used for conditioning Inerteen should first be thoroughly cleaned with benzine or naphtha to remove all traces of material foreign to Inerteen. If at all possible, separate equipment should be used for filtering Inerteen only.

Hydrogen chloride, caused by arcing, may be eliminated by vigorously bubbling dry nitrogen through Inerteen. This should be done as quickly as possible following the failure to prevent the attack of HCl on the cellulose insulation. The nitrogen should be passed in through the drain valve at the bottom and allowed to escape through a vent at the top. The nitrogen should be discharged through a pressure regulator attached to a stand pipe above the level of the Inerteen in the transformer to prevent the Inerteen from flowing into the regulator. The nitrogen should be bubbled through the Inerteen at a rate of one to three cubic feet per minute for a period of 4 to 6 hours. This may require two to eight cylinders (220 cu. ft. each) depending on the size of the apparatus.

DISPOSAL

Inerteen Liquid. Collect all scrap Inerteen liquid in a suitable metal container which can be satisfactorily sealed. Once the Inerteen is collected it may be returned in sealed drums or tank cars to Monsanto or other certified disposal companies as listed below. Ship prepaid to:

Monsanto Company W. G. Krummrich Plant Sauget, Illinois Attention: Supervisor Dept., 246	Nuclear Engineering Company Disposal Division Sheffield, Illinois
Chem-Trol Pollution Service, Inc. 4818 Lake Avenue Blasdell, New York 14219	Rollins-Purle, Inc. Box 3349 Wilmington, Delaware 19899

A charge will be made for all returned Inerteen.

Solvent-Rinses Contaminated with Inerteen. Solvent rinses or other liquids contaminated with Inerteen should also be collected in sealed drums or tank cars and sent either to Monsanto or other certified disposal company.

Solids Contaminated with Inerteen. All solids materials contaminated with Inerteen must be stored in impervious containers until disposal. This includes all glass, metals, papers, insulation, clay rags, filter cartridges, etc.

These materials may be incinerated if suitable arrangements can be made for it to be done at a temperature sufficient to breakdown the Inerteen. Or they may be purged by cleaning with a proper fluid and the resultant fluid then may be incinerated using an approved procedure and temperature.

The following disposition is recommended for various materials.

Material	Disposition
Absorbing clay, filter paper, cartridges sawdust and rags	Incinerate
Coils	Solvent clean or incinerate
Cores	Solvent clean
Tanks & Frames	Solvent clean
Copper or Aluminum	Solvent clean
Insulation	Incinerate

Incineration. Incineration, whether of liquids or contaminated solid materials, must be done at a temperature of at least 2250°C and the stack must be equipped with a suitable scrubber to remove HCl.

Cleaning Contaminated Drums. The cleaning of drums which have contained used Inerteen requires great care in order to insure a thoroughly clean drum.

It is preferable to return such drums to the supplier where adequate cleaning facilities are available, rather than to attempt to clean them.

If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or petroleum distillate, using about one gallon each time, until the solvent shows no discoloration after using. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at

the lower end to explore the corners of the drum. Collect all solvent rinse material for disposition as described above.

CAUTION: Do not use a steel pipe because of the danger of a spark igniting the gasoline or petroleum distillate vapor.

Next, heat the drum with bunghole down in a ventilated oven at a temperature of at least 88°C. (190°F) for sixteen hours. (A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.) Blow out the drum with dry nitrogen or dry air to remove any lingering explosive vapors. Screw the bung on tightly before removing the drum from the oven. Use a new washer with the bung to insure a tight seal.

CAUTION: Open flames must always be kept away from the oven to prevent igniting inflammable gases which might be remaining in drum when placed in the oven.

The practice of refilling drums with Inerteen is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the Inerteen is likely to become contaminated.

Part II — Installation and Maintenance of Inerteen Transformers

INSTALLATION

For convenience in handling, all transformers are equipped with lugs or eyes for lifting and moving the complete assembly filled with Inerteen by use of a crane. Additional means are provided for the heavier parts such as covers, core and coils, radiators and terminal chambers. Jacking lugs are also supplied on either the base or corners of the tank. A transformer should only be lifted or moved by jacks placed against these lugs and not against the cooling tubes, radiator valves, or other fittings.

An indoor installation requires that the room in which the transformers are placed must be well ventilated so that the heated air can readily escape and be replaced by cooler air from the outside. If the room is poorly ventilated, this exchange of air takes place too slowly and the temperature of the air in the room may become excessively high. At any given load the temperature rise of a self-cooled transformer will be a fixed number of degrees above the temperature of the surrounding air. The temperature of the transformer is the sum of this rise and the air temperature; therefore, care must be taken to provide a room sufficiently ventilated to permit operation of transformers at a reasonable temperature. Area of the air inlets should be such that the ambient temperature never exceeds 40°C (104°F) with an average over twenty-four hours not exceeding 30°C (86°F); 50 to 60 square feet per 1000 kva of transformer capacity has been satisfactory. Outlet openings with the same total area should be provided.

Self-cooled transformers should always be well separated from one another and from adjacent walls, partitions, etc., in order to permit free air circulation about the cases. This separation should not be less than 24 to 36 inches depending on the size of the units.

INSPECTION

All Inerteen transformers are carefully inspected and tested at the factory and they are in good

condition when shipped; but it is desirable to inspect each transformer thoroughly before placing it in service.

When a transformer is shipped complete and filled with Inerteen, this inspection should include a check of the Inerteen level, the tightening or adjustment of any parts that may have become loose or out of place, and determining the extent to which moisture may have entered the transformer. The latter can best be determined from the dielectric strength of the Inerteen. Inerteen used for filling transformers should have a dielectric strength of 30KV or higher. When it tests less than this the Inerteen should be filtered. If the dielectric strength is very low or if there is any other evidence of moisture, it is necessary to dry the transformer.

Inerteen transformers should be dried by the short circuit method with the transformer immersed in the Inerteen and with the tank sealed tightly. During the drying out operation, the Inerteen should be circulated through a filter press or preferably through an Inerteen conditioner. A filter press will remove dirt and most of the moisture, but the conditioner will remove these and other contaminating materials as well.

The desired load current should be obtained by short circuiting one winding and impressing the proper impedance voltage on the other winding. The full load impedance may usually be found on the instruction plate for the transformers; if the impedance of the transformer is not known, it should be requested from the Westinghouse Electric Corporation, Sharon, Pennsylvania, by identifying the transformer with its serial number.

If the transformer is at or lower than room temperature at the start of the drying process, circulation of 125 to 150% of full load current will hasten the heating, and a higher top Inerteen temperature can be obtained more quickly by blanketing the coolers when tubular coolers are used or by shutting off the radiator valves when radiators are used. The cover should be lagged to prevent condensation.

The loading should be carefully watched and when the top Inerteen reaches a temperature of 60°C, the load should be reduced to obtain an approximately constant top Inerteen temperature based on the following table:

Short Circuit Amperes in Percent of Load	Maximum Temperature of the Top Inerteen
50%	85°C
75%	80°C
85%	75°C

While the windings of the transformer heat up, do not permit the temperature of the top Inerteen to exceed the value specified for a given percentage of load. This precaution is necessary because the windings will heat up more quickly and operate at a higher temperature than the Inerteen. If the windings are allowed to reach too high a temperature, the insulation will be damaged. The drying of a transformer should be continued until the dielectric strength of samples of Inerteen taken from the transformer test at 30KV or higher.

The cover should be kept tightly sealed during the temperature run, and until the transformer has cooled down to room temperature to prevent condensation. This also prevents the release of hot Inerteen vapors which are quite objectionable, particularly if the ventilation is poor.

CAUTION: It is not safe to attempt the drying out of transformers unless constant attention is given to the job.

ACCESSORIES AND FITTINGS

Bushings, fittings, and accessories when boxed and shipped separately should be mounted as shown on the outline drawing. Proper installation

instructions when necessary are included in the instruction leaflets for component parts. Care must be exercised when these components are fitted to eliminate the accidental introduction of moisture in any form inside the transformer. Where blind flanges are removed before fittings are mounted, the level of the Inerteen must be lowered below the openings that will be made.

FINISH

Any portion of the paint film damaged during shipment or installation must be repaired as quickly as possible.

To do this, clean the damaged portion by means of a scraper or sandpaper, wipe thoroughly with a solvent dampened cloth, apply Westinghouse primer paint and allow it to dry for at least 24 hours, then apply a coat of Westinghouse finish paint.

FILLING

When putting new apparatus into service, see that the apparatus tank is free from moisture and foreign material.

IMPORTANT: Extreme precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with Inerteen, and to prevent the entrance of water and dirt during the transfer of the Inerteen to the apparatus.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not possible, protection against moisture must be provided.

All vessels used for transferring the Inerteen should be carefully inspected to see that they are absolutely dry and free from contamination. Use only all-metal hose or pipe when filling, since the lining of most other types of hose may be soluble in Inerteen and will contaminate it in a short time. All joints should be tight; where practical, fill through the drain valve to keep aeration to a minimum and vent the top of the tank to allow the air to escape. Be sure that valves and pipe connections between the main tank and any Inerteen filled compartments are open for free circulation of gas and liquid. Otherwise, trapped air or gas may cause the Inerteen level in some parts of the transformer to be below the safe operating level.

If it is necessary to fill a transformer out-of-doors, particularly on a damp day, care should be taken to prevent the entrance of moisture. In order to avoid condensation the temperature inside the unit should be kept several degrees above the outside air temperature.

The tank and compartments, if any, should be filled at ambient temperature to the point on the gauges marked "25° – Liquid Level." If the ambient varies greatly from 25°C (77°F) when filled, the Inerteen level should be checked when the average fluid temperature is 25°C; sufficient Inerteen should be added to or drained from the tank to bring the level to the proper height. The transformer should never be operated or left standing, even out of service without the Inerteen level being indicated on the gauge.

Filling Under Vacuum. Entrapped air is a potential source of trouble in all liquid filled transformers. Therefore, it is desirable to fill all Inerteen transformers under a full vacuum. This is done for the transformers shipped from the factory and should be done where practicable when transformers are filled in the field, providing the transformer cases have been so designed. If the cases have not been designed for full vacuum and it is imperative to get the maximum winding impulse strength immediately, the transformers should be filled with Inerteen under full vacuum by placing them in an auxiliary vacuum tank.

Where purchaser does not have an established technique for vacuum filling, the following procedures may be used whether vacuum is applied

directly to the transformer or the complete transformer is placed in an auxiliary vacuum tank.

1. Apply and maintain continuously a vacuum of at least 28 inches of mercury for at least one-half hour to units rated 25KV and below, or for four hours to units above 25KV.

2. While retaining the vacuum, slowly fill with Inerteen to the normal 25°C level or with approximately 90% of the required amount where it is impossible to gauge properly.

3. Maintain the specified vacuum for at least one-half hour after filling.

4. Adjust Inerteen to normal level and seal the transformer tank. Do not reopen until the temperature at the top of the fluid is equal to or higher than the ambient temperature in order to avoid condensation on the surface of the Inerteen.

In those cases where the transformers are not filled under vacuum, full voltage should not be applied to the windings for at least 24 hours after the Inerteen has been put into the case. This time is necessary to allow the air bubbles to escape.

PLACING IN SERVICE

Pressure Testing. All Inerteen transformers are pressure-tested at the factory and shipped free of leaks. After installations and before voltage is applied, it is desirable to pressure-test each transformer, especially if any fittings or covers have been removed and replaced during installation. Compressed dry nitrogen or dry air may be used for the purpose. It is recommended that the space above the Inerteen be blown out with dry nitrogen, then close all vents and apply a pressure-test of five pounds per square inch for a period of six to eight hours. The test pressure can best be limited by the use of a pressure regulator attached to the nitrogen cylinder. A check for leaks of joints above the Inerteen level may be made by painting them with a solution of soap and glycerin and watching for gas bubbles. At the conclusion of the test the internal pressure should be returned to normal by momentarily venting the gas space.

High Altitude. Where transformers are to be used at a high altitude (more than 3000 feet above sea level) a fitting above the liquid level should be opened to equalize the internal and external pressures at a temperature of approximately 25°C before placing the transformer in service.

Grounding Transformer Tank. Regardless of the type of foundation or floor on which a transformer is to rest, the tank should be definitely and permanently grounded to eliminate the possibility of obtaining static shocks or being injured by accidental grounding of a winding to the case. A ground pad or lug is always provided near the bottom of the tank for the purpose of connecting the grounded lead.

CAUTION: A good low-resistance ground is necessary for adequate protection — a poor ground may be worse than none at all.

Grounding Low Voltage Winding. Every effort is made in insulating transformers to guard against any chance of breakdown between high voltage and low voltage windings; however, in order to be absolutely safe, it is advisable that low voltage circuits with which persons may come in contact be grounded. The maximum voltage that can be obtained to ground is then limited to the normal voltage that exists between the grounded point and the line; this is true even though the high voltage and low voltage windings become connected electrically.

In grounding the winding, the neutral point should be used if it is available. When transformers operate on single phase circuits with the middle point of the low voltage, the maximum voltage that can exist between any part of the low voltage circuit and ground is one-half of the low voltages.

MAKING CONNECTIONS

A diagram, usually on the metal instruction plate attached to the side of the case, shows the proper

power terminal connections to be made for various voltages. Care should be taken to see that all connections and only those shown are properly made, for a wrong connection may cause severe damage.

Some installations require an auxiliary source of power or control leads to be wired to terminals at the transformer; a wiring diagram, either a separate drawing or included as part of the outline drawing, shows the connections to be made.

Voltage Application. When voltage is first applied to the transformer, it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be disclosed before damage can result. After full voltage has been applied successfully, the transformer should be operated without load for a few hours. It should be kept under close observation during this time and also during the first few hours while loaded.

INSPECTION

It is desirable that periodic inspections of Inerteen apparatus be made and that samples of Inerteen be taken from each and from all compartments of any apparatus and tested after a short period of service. See section on Sampling and Inspection.

Any increase in operating temperature at normal load should be investigated and if the cause cannot be determined, the transformer should be taken out of service and given a thorough inspection.

Any symptoms, such as unusual noises, high or low Inerteen levels, operation of relief device, etc., should be investigated at once.

Transformers which have been subjected to unusually severe operating conditions, such as overloads, frequent short circuits, or special units should be inspected at least once a year. This can usually be done adequately by lowering the Inerteen level and inspecting with a light through the manhole. Before this inspection is made, the Inerteen should be allowed to cool to reduce the amount of Inerteen fumes given off which are quite objectionable and should not be inhaled.

During periodic inspection, all accessories should be inspected to see if they are operating properly.

CAUTION: Never enter a vault or any other confined area in which a transformer relief device has been known to operate or in which a transformer has failed, until the area has been thoroughly ventilated. Then enter cautiously, with another person in attendance. The pungent, somewhat irritating fumes of hydrogen chloride are easily detected and can serve as a guide in entering the enclosure.

Memorandum

8497.77

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

849778

Instructions for Handling Inerteen® Insulating Fluid P.D.S. 54201 CM and Installation and Maintenance of Inerteen Transformers

Westinghouse Exhibit 11

Westinghouse Electric Corporation

SMALL POWER TRANSFORMER DIVISION, SOUTH BOSTON, VIRGINIA
SHARON TRANSFORMER DIVISION, SHARON, PENNSYLVANIA

I.B. 45-063-99E Effective June, 1976 Supersedes I.B. 45-063-99D, February, 1976

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PLAINTIFF'S EXHIBIT 491

CONTENTS

Part I — Inerteen® Insulating Fluid

See American National Standards Institute Guidelines C107.1-1974 for complete information on handling and disposal of Askarels. Copies are available from: ANSI, 1430 Broadway, New York, N.Y. 10018

CHARACTERISTICS

Inerteen is a highly pure, synthetic non-inflammable and non-explosive insulating and cooling liquid. Chemically stable and nearly water white in color, Inerteen is not affected by reaction with other materials regularly used in the manufacture of Inerteen apparatus. It is non-oxidizing and non-corrosive at temperature considerably above those normally obtained in Inerteen apparatus. Inerteen will not sludge under any operating condition. Water is the main enemy of Inerteen and keeping it dry will insure long service life.

The dielectric strength of Inerteen will compare favorably with that of insulating oil when tested under the same conditions. Quality samples of Inerteen tested under laboratory conditions may show a dielectric strength in excess of 40KV. Care must be exercised in handling and testing Inerteen. Inerteen must be kept in clean, sealed containers to prevent loss by evaporation or contamination by moisture or dirt.

Inerteen exerts a strong solvent action on most varnishes, gums, and paints. Such materials are not used in the construction of Inerteen apparatus. No materials should be used in Inerteen apparatus except those approved by the Westinghouse Electric Corporation.

Inerteen has an irritating effect upon the skin. If it is necessary to handle it, see the precautions under "Handling". It should be remembered that mineral oil is completely miscible with Inerteen; in fact, it is impossible to separate mineral oil and Inerteen.

SPECIFIC CHARACTERISTICS OF INERTEEN

As outlined in "Method of Testing Askarels A.S.T.M. D901," the specific characteristics of Inerteen are:

1. Burn point: None
2. Chemical stability: No generation of free chlorides under normal operating conditions.
3. Color: (Maximum) 100 A.P.H.
4. Condition: Clear
5. Dielectric constant:
   At 1000 hertz 77°F (25°C), 5.7 to 5.9
   At 1000 hertz 212°F (100°C), 4.8 to 5.0
6. Dielectric strength: (Minimum) 77°F (25°C)
   At point of shipment, 35KV
   At point of receipt, 30KV
7. Electrical Resistivity: (Minimum)
   500×10^9 ohms/cm^3 (212°F (100°C) at 500 volts DC)
8. Power factor:
   At 60 hertz, 77°F (25°C) 2%
   At 60 hertz, 212°F (100°C) 25%
9. Fixed chlorine content: (Minimum) 42 percent
10. Free chlorides: Less than 0.10 ppm
11. Neutralization number: Less than 0.014 mg of KOH/gram
12. Pour Point: (Maximum) plus 7°F (minus 14°C)
13. Refractive index:
    At 77°F (25°C), 1.624 to 1.626
14. Specific gravity:
    At 60°F/60°F (15.5°C/15.5°C), 1.381 to 1.392
15. Density: 11.5 pounds per gallon
16. Viscosity:
    At 100°F (37.8°C), 82-92 seconds
17. Moisture: (Maximum) 35 ppm

ENVIRONMENTAL CONSIDERATIONS

Inerteen is a synthetic insulating fluid made by the chlorination of a relatively common chemical, biphenyl. The chlorination is necessary to impart nonflammable properties to the Inerteen. The resulting polychlorinated biphenyls (PCB's) are relatively insoluble in water but soluble in fat,

and extremely persistent in the environment. It has been shown by several laboratories that measurable amounts of the PCB's, particularly those with more than 50% chlorination, are present in our general environment and are a threat to certain species of wildlife. While Inerteen is generally regarded as being non-toxic to humans, very high standards of control in the overall program against pollution must be exercised.

Electrical apparatus (such as transformers and capacitors) using Inerteen are normally sealed to prevent escape of Inerteen into the environment. However, a carefully planned program of waste disposal must be followed at every step of the equipment life. This includes manufacture, repair and final disposition of the fluid and the Inerteen contaminated parts. To date the only acceptable destruction of the PCB's is by incineration at 2250°C or higher under carefully controlled conditions. At this temperature Inerteen will breakdown into HCl, CO_2 and water vapor. An alkaline scrubber is necessary to neutralize the HCl and the final products released to the atmosphere are CO_2 and steam. To be sure that the Inerteen and Inerteen contaminated materials do not contaminate the environment they must be incinerated in approved equipment.

HANDLING

1. Safety Precautions

Breathing. The odor of Inerteen is noticeable at concentrations below the Maximum Acceptable Concentration. Concentrations which exceed this may cause irritation of the eyes, nose, throat and upper respiratory tract. Much higher concentrations could cause internal reactions.

Swallowing. Inerteen is highly toxic if taken internally. Swallowing of an ounce or two could cause severe irritation of the digestive tract and serious internal reactions.

Skin Irritation. Although Inerteen is only a moderate skin irritant when contact is for short duration, it can be absorbed through the skin. Repeated contact over prolonged periods may result in severe dermatitis which may persist for many months after removal from exposure.

Protective Equipment. When necessary, under emergency conditions, to enter a space containing very high concentrations of Inerteen fumes or vapor, either an approved gas mask or self-contained breathing equipment, should be worn. For lower, but still significant concentrations, cartridge type chemical respirator should be worn. If the odor of Inerteen is noticed while wearing respiratory equipment, the wearer should go immediately into fresh air.

Neoprene coated aprons and neoprene coated gloves may be used where necessary to protect the skin. Hand cream designed to protect against oils and petroleum solvents, (such as Ply 9 Gel made by Milburn Co. of Detroit) may be of some value where the use of gloves is not practical.

When handling Inerteen, wash hands often with warm soapy water and in case of spillage onto clothing, remove the clothing as soon as possible. The clothing must then be laundered prior to use.

2. Storage

Inerteen is shipped in tank cars, drums or cans. Inerteen in drums or cans should be stored in a covered area and when stored out-of-doors the bungs should be down to prevent collection of water around the bung. A storage tank should be mounted on piers above the ground and accessible to all points for inspection for leakage. There should be a curb on the ground around the tank to contain any spillage or leakage.

It is desirable, if possible, to keep Inerteen in storage at a temperature slightly above ambient to prevent moisture condensation.

SAMPLING AND INSPECTION

Sampling. Each container of Inerteen must be sampled and tested prior to being added to a transformer and then should be added only if the dielectric strength is 30KV or above.

It is desirable that periodic inspection of Inerteen apparatus be made and that samples of Inerteen be taken from each compartment and tested. Initially a sample should be taken after about 3 months of operation and then, where operating conditions permit, at intervals of 6 months to 1 year. Accurate records should be maintained and if dielectric strength drops below 22KV it should be reconditioned.

If facilities are not available for testing Inerteen, see "Westinghouse Inerteen Testing Service" below.

Westinghouse Inerteen Testing Service. Many users of Inerteen do not have the necessary facilities for testing. In order that these users may be able to make the periodic tests recommended, Westinghouse Electric Corporation has established an Inerteen testing service to provide careful tests by experienced engineer, and provide a prompt report on the test results.

Two special 16 oz. sample bottles per mailing container Westinghouse S#24B1743602, as well as necessary packing and printed matter, may be obtained by contacting the nearest Westinghouse Office. (The bottle and the container will not be returned to the customer.)

After drawing the sample of Inerteen, the customer should seal the bottle and mail it to the Westinghouse Electric Corporation, Materials Engineering Laboratory, Sharon, Pa. 16146. To simplify these details, an instruction and order sheet and a printed return label have been included in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. The order sheet must be sent to the nearest Westinghouse office.

In addition to dielectric tests, Westinghouse is also prepared to make a physical and chemical examination if so requested. (The customer should plainly indicate the type of service desired.)

The physical and chemical examination consists of an examination of the Inerteen by a competent chemist. Recommendations will be made as to the suitability of the Inerteen for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning. In submitting samples for this service, the history of the Inerteen represented should be given as completely as possible. (For details refer to the nearest Westinghouse Office).

SAMPLING INERTEEN

The dielectric strength of Inerteen is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. There have been low dielectric test results reported from the field which, upon investigation, have been found to be largely a matter of poor sampling. All sampling and testing equipment used for handling Inerteen and servicing Inerteen should be used for no other purpose. Care must be used in taking samples of Inerteen and sealing them prior to testing. It is desirable that samples of Inerteen be removed from any container on clear days only, and when the temperature of the Inerteen is at least as high as the temperature of the surrounding air.

Use only tin containers with screwed metal caps or glass bottles with Inerteen resistant lids to hold Inerteen samples. If it becomes necessary to use other than factory sampling containers, they should be rinsed with clean naptha, washed with detergent and water, and rinsed thoroughly in hot water, and then dried at approximately 110°C for four hours with neck down in circulating air oven. If the containers are not used immediately after cleaning, they should be sealed tightly and stored in a dry, clean place. An aluminum foil liner should be put in the lid.

Provision is made on all Inerteen transformers to obtain a top sample of the Inerteen, however on a transformer that is in operation, a sample may be taken from either the top or bottom since any moisture present will be mixed in, due to circulation of Inerteen. In sampling, allow at least one quart of Inerteen to run out to flush the sampling connection before collecting the sample. This flush material must be collected in a suitable container for disposition as per the section on "Inerteen Disposal" page 6. The Inerteen should be put into the sample containers immediately and the caps screwed on tightly. The label for each container should be marked clearly with the serial number of the transformer or compartment from which the Inerteen was taken.

Before taking samples from a storage tank, the Inerteen should be allowed to settle for approximately twelve hours so that if there is any moisture present, it, having a lower specific gravity, will rise to the top where the sample is to be taken. A clean sneak-thief should be used to obtain the samples. Essentially, the same precautions to prevent moisture and dirt contamination should be used as outlined above.

It is recommended that one 16 oz. bottle of Inerteen be taken as a sample for testing. At least one sample should be taken from a tank car of Inerteen. One sample may be taken from each drum, or if desired, a composite sample may be made from Inerteen from five drums, provided all of the drums are airtight. When the bung is first loosened, a hissing sound should be heard, which indicates that the drum has been airtight. When the composite type of testing is used and a sample is found to be unsatisfactory, a sample from each of the drums represented must be tested.

When drums have been stored exposed to the weather, a sample from each drum must be tested to determine if it is suitable for use.

DISPOSITION OF SAMPLE & CONTAINER. All samples must be collected in sealed, labelled containers for disposition as described in section on "Inerteen Disposal" page 9. All solvent rinses of test containers must be handled in a like manner.

All containers, rags, and other solid materials involved in testing must be collected for proper disposition.

TESTING METHODS

Instruction for all tests listed correspond in general to the recommendations of the American Society for Testing Materials.

1. Dielectric Strength Test

The testing transformer and the source of supply of energy shall not be less than 1/2 KVA, and the frequency shall not exceed 100 Hertz per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by an approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the Inerteen takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 KVA or less, as the current is limited by the impedance of the transformer.

The standard test cup for holding the sample of Inerteen shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by Inerteen or benzine and non-absorbent as far as moisture, Inerteen, or gasoline are concerned.

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, 1 in. in diameter, with square (90°) edges. The electrodes shall be mounted in the test cup with their axes horizontal and coincident, with a gap of 0.100 in. between their adjacent faces, and with tops of electrodes about 1-1/4 in. below the top of the

cup. (A suitable test cup is shown in Fig. 1, and portable testing outfits in Fig. 2.)

a. Procedure

The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100 in., and the electrodes then locked in position.

The electrodes and the test cup shall be wiped clean with dry, calendered tissue paper or with a clean, dry chamois skin and thoroughly rinsed with Inerteen-free, dry benzine until they are entirely free from fibers.

The test cup shall be filled with dry benzine, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms) per second until breakdown occurs. If the dielectric strength is not less than 25KV, the cup shall be considered in suitable condition for testing the Inerteen. If a lower test value is obtained the cup shall be cleaned with benzine and the test repeated.

The temperature of the test cup and of the Inerteen when tested shall be the same as that of the room, which should be between 68°F and 86°F. (20°C and 30°C) Testing at lower temperatures is likely to give variable results which may be misleading.

The sample in the container shall be agitated with a swirling motion (to avoid introducing air) so as to mix the Inerteen thoroughly before filling the test cup. This is even more important with used Inerteen than with new Inerteen as the impurities may be precipitated and the test may be misleading.

The cup shall be filled with Inerteen to a height of no less than 0.79 in. (20 mm) above the top of the electrodes.

The Inerteen shall be gently agitated by rocking the cup and allowing it to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

Voltages shall be applied and increased uniformly at a rate of approximately 3000 volts (rms) per second until breakdown occurs as indicated by a continuous discharge across

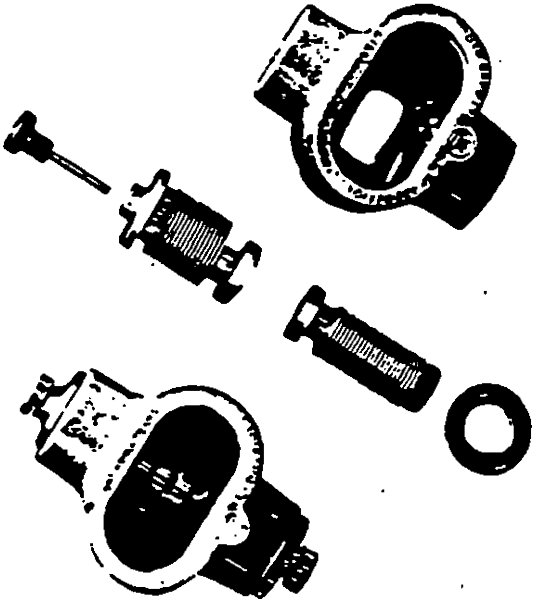

Fig. 1. Fluid Test Cup for Dielectric Test

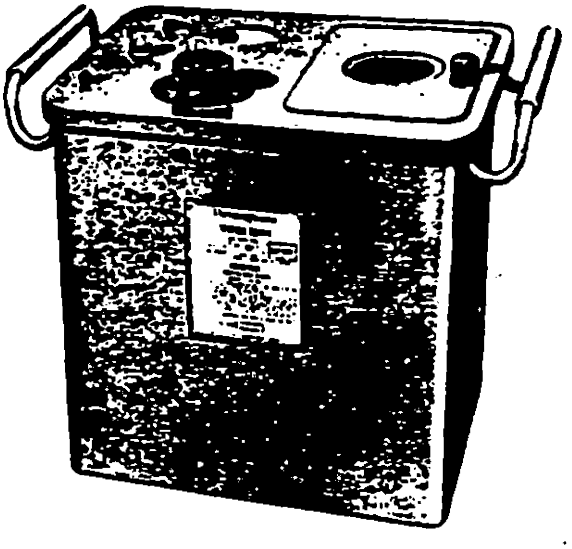

Fig. 2. Portable Oil Testing Set, 1/2 KVA, 35,000 Volts

the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded).

b. Number of Tests

I. Except as specified in (II) one breakdown test shall be made on each of five fillings of the test cup. If the average deviation from the mean exceeds 10 percent or if any individual test deviates more than 25 percent from the average, additional tests shall be made. The dielectric strength shall be determined by averaging the first five tests that conform to the allowable variations.

II. When Inerteen is tested in considerable quantity, so that the time required for testing is excessive and when it is merely desired to determine whether the breakdown safely exceeds the limit specified, or in those cases where the amount of Inerteen available for test may be very limited, one breakdown test shall be made on each of two fillings of the test cup. If neither breakdown is below this value, the Inerteen may be considered satisfactory and no further tests shall be required. If either of the breakdowns is less than the specified value a breakdown shall be made on each of three additional fillings and test results analyzed in accordance with (I).

c. Report

The report shall include the volts (rms value) at each breakdown and the average of the two or five breakdowns and the temperature of the Inerteen at the time of the test.

2. Neutralization Test

The Neutralization number is the number of milligrams of potassium hydroxide required to neutralize the acid in one gram of Inerteen.

Solutions Required

a. Standard Potassium Hydroxide Solution (alcoholic, 0.1N) – add 6 g. of c.p. solid KOH to 1 liter of c.p. anhydrous isopropyl alcohol. Boil, add 2 g. of c.p. $Ba(OH)_2$ and boil again. Cool, filter and store in a chemically resistant bottle protected by a guard tube containing soda lime and soda asbestos (Ascarite). Standardize against pure potassium acid phthalate using phenolphthalein as an indicator.

b. Titration Solvent – Add 500 ml. of c.p. benzene and 5 ml. of water to 495 ml. of c.p. anhydrous isopropyl alcohol.

Procedure. Into a 250 ml. Erlenmeyer flask introduce 40 g. of Inerteen weighed accurately. Add 100 ml. of the titration solvent and 3 ml. of the indicator solution. Titrate immediately at a temperature below 30°C. Consider the end point definite if the color change to green persists for 15 seconds. A blank shall be determined on the solvent.

Calculations. The neutralization number or mg.

$$\text{KOH per g. of Inerteen} = \frac{(A-B\,(N) \times 56.1}{W}$$

A = ml. KOH solution required for sample.
B = ml. KOH solution required for blank.
N = normality of KOH solution.
W = grams of sample used.

RECONDITIONING

Reconditioning will be necessary to remove water, foreign material and hydrogen chloride which may be present and contaminating Inerteen. The blotter filter press, cartridge filter and the Inerteen conditioner will remove water and dirt which may be present. Various models of each of these types of apparatus are available. The Inerteen conditioner is the most effective for removing moisture, dirt, and other contaminating materials. It basically consists of a clay container, a clay filter, pump, attendant valves, gauges and fittings.

Water cannot be effectively removed from either clay or filter material once they have become saturated with Inerteen therefore care

should be taken to see that these materials are thoroughly dry prior to use. Any equipment used for conditioning Inerteen should first be thoroughly cleaned with benzine or naphtha to remove all traces of material foreign to Inerteen. If at all possible, separate equipment should be used for filtering Inerteen only.

Hydrogen chloride, caused by arcing, may be eliminated by vigorously bubbling dry nitrogen through Inerteen. This should be done as quickly as possible following the failure to prevent the attack of HCl on the cellulose insulation. The nitrogen should be passed in through the drain valve at the bottom and allowed to escape through a vent at the top. The nitrogen should be discharged through a pressure regulator attached to a stand pipe above the level of the Inerteen in the transformer to prevent the Inerteen from flowing into the regulator. The nitrogen should be bubbled through the Inerteen at a rate of one to three cubic feet per minute for a period of 4 to 6 hours. This may require two to eight cylinders (220 cu. ft. each) depending on the size of the apparatus.

DISPOSAL

Inerteen Liquid. Collect all scrap Inerteen liquid in a suitable metal container which can be satisfactorily sealed. Once the Inerteen is collected it may be returned in sealed drums or tank cars to Monsanto or other certified disposal companies as listed below. Ship prepaid to:

Monsanto Industrial Chemicals Company 800 North Lindbergh Boulevard St. Louis, Missouri 63166	Nuclear Engineering Company Disposal Division Sheffield, Illinois 61361
Chem-Trol Pollution Services, Inc. 1550 Balmer Road Model City, New York 14107	Wes Con, Inc. 409 Shoshone Street, South P. O. Box 564 Twin Falls, Idaho 83301

Rollins Environmental Services, Inc.

P.O. Box 221 Bridgeport, N.J. 08014	P.O. Box 609 Deer Park, Texas 77536	11351 Scenic Highway Baton Rouge, La. 70807

A charge will be made for all returned Inerteen.

Solvent-Rinses Contaminated with Inerteen. Solvent rinses or other liquids contaminated with Inerteen should also be collected in sealed drums or tank cars and sent either to Monsanto or other certified disposal company.

Solids Contaminated with Inerteen. All solids materials contaminated with Inerteen must be stored in impervious containers until disposal. This includes all glass, metals, papers, insulation, clay rags, filter cartridges, etc.

These materials may be incinerated if suitable arrangements can be made for it to be done at a temperature sufficient to breakdown the Inerteen. Or they may be purged by cleaning with a proper fluid and the resultant fluid then may be incinerated using an approved procedure and temperature.

The following disposition is recommended for various materials.

Material	Disposition
Absorbing clay, filter paper, cartridges sawdust and rags	Incinerate
Coils	Solvent clean or incinerate
Cores	Solvent clean
Tanks & Frames	Solvent clean
Copper or Aluminum	Solvent clean
Insulation	Incinerate

Incineration. Incineration, whether of liquids or contaminated solid materials, must be done at a temperature of at least 2250°C and the stack must be equipped with a suitable scrubber to remove HCl.

Cleaning Contaminated Drums. The cleaning of drums which have contained used Inerteen requires great care in order to insure a thoroughly clean drum.

It is preferable to return such drums to the supplier where adequate cleaning facilities are available, rather than to attempt to clean them.

If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or petroleum distillate, using about one gallon each time, until the solvent shows no discoloration after using. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at

the lower end to explore the corners of the drum. Collect all solvent rinse material for disposition as described above.

CAUTION: Do not use a steel pipe because of the danger of a spark igniting the gasoline or petroleum distillate vapor.

Next, heat the drum with bunghole down in a ventilated oven at a temperature of at least 88°C. (190°F) for sixteen hours. (A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater.) Blow out the drum with dry nitrogen or dry air to remove any lingering explosive vapors. Screw the bung on tightly before removing the drum from the oven. Use a new washer with the bung to insure a tight seal.

CAUTION: Open flames must always be kept away from the oven to prevent igniting inflammable gases which might be remaining in drum when placed in the oven.

The practice of refilling drums with Inerteen is undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the Inerteen is likely to become contaminated.

Part II — Installation and Maintenance of Inerteen Transformers

INSTALLATION

For convenience in handling, all transformers are equipped with lugs or eyes for lifting and moving the complete assembly filled with Inerteen by use of a crane. Additional means are provided for the heavier parts such as covers, core and coils, radiators and terminal chambers. Jacking lugs are also supplied on either the base or corners of the tank. A transformer should only be lifted or moved by jacks placed against these lugs and not against the cooling tubes, radiator valves, or other fittings.

An indoor installation requires that the room in which the transformers are placed must be well ventilated so that the heated air can readily escape and be replaced by cooler air from the outside. If the room is poorly ventilated, this exchange of air takes place too slowly and the temperature of the air in the room may become excessively high. At any given load the temperature rise of a self-cooled transformer will be a fixed number of degrees above the temperature of the surrounding air. The temperature of the transformer is the sum of this rise and the air temperature; therefore, care must be taken to provide a room sufficiently ventilated to permit operation of transformers at a reasonable temperature. Area of the air inlets should be such that the ambient temperature never exceeds 40°C (104°F) with an average over twenty-four hours not exceeding 30°C (86°F); 50 to 60 square feet per 1000 kva of transformer capacity has been satisfactory. Outlet openings with the same total area should be provided.

Self-cooled transformers should always be well separated from one another and from adjacent walls, partitions, etc., in order to permit free air circulation about the cases. This separation should not be less than 24 to 36 inches depending on the size of the units.

INSPECTION

All Inerteen transformers are carefully inspected and tested at the factory and they are in good

condition when shipped; but it is desirable to inspect each transformer thoroughly before placing it in service.

When a transformer is shipped complete and filled with Inerteen, this inspection should include a check of the Inerteen level, the tightening or adjustment of any parts that may have become loose or out of place, and determining the extent to which moisture may have entered the transformer. The latter can best be determined from the dielectric strength of the Inerteen. Inerteen used for filling transformers should have a dielectric strength of 30KV or higher. When it tests less than this the Inerteen should be filtered. If the dielectric strength is very low or if there is any other evidence of moisture, it is necessary to dry the transformer.

Inerteen transformers should be dried by the short circuit method with the transformer immersed in the Inerteen and with the tank sealed tightly. During the drying out operation, the Inerteen should be circulated through a filter press or preferably through an Inerteen conditioner. A filter press will remove dirt and most of the moisture, but the conditioner will remove these and other contaminating materials as well.

The desired load current should be obtained by short circuiting one winding and impressing the proper impedance voltage on the other winding. The full load impedance may usually be found on the instruction plate for the transformers; if the impedance of the transformer is not known, it should be requested from the Westinghouse Electric Corporation, Sharon, Pennsylvania, by identifying the transformer with its serial number.

If the transformer is at or lower than room temperature at the start of the drying process, circulation of 125 to 150% of full load current will hasten the heating, and a higher top Inerteen temperature can be obtained more quickly by blanketing the coolers when tubular coolers are used or by shutting off the radiator valves when radiators are used. The cover should be lagged to prevent condensation.

The loading should be carefully watched and when the top Inerteen reaches a temperature of 60°C, the load should be reduced to obtain an approximately constant top Inerteen temperature based on the following table:

Short Circuit Amperes in Percent of Load	Maximum Temperature of the Top Inerteen
50%	85°C
75%	80°C
85%	75°C

While the windings of the transformer heat up, do not permit the temperature of the top Inerteen to exceed the value specified for a given percentage of load. This precaution is necessary because the windings will heat up more quickly and operate at a higher temperature than the Inerteen. If the windings are allowed to reach too high a temperature, the insulation will be damaged. The drying of a transformer should be continued until the dielectric strength of samples of Inerteen taken from the transformer test at 30KV or higher.

The cover should be kept tightly sealed during the temperature run, and until the transformer has cooled down to room temperature to prevent condensation. This also prevents the release of hot Inerteen vapors which are quite objectionable, particularly if the ventilation is poor.

CAUTION: It is not safe to attempt the drying out of transformers unless constant attention is given to the job.

ACCESSORIES AND FITTINGS

Bushings, fittings, and accessories when boxed and shipped separately should be mounted as shown on the outline drawing. Proper installation

instructions when necessary are included in the instruction leaflets for component parts. Care must be exercised when these components are fitted to eliminate the accidental introduction of moisture in any form inside the transformer. Where blind flanges are removed before fittings are mounted, the level of the Inerteen must be lowered below the openings that will be made.

FINISH

Any portion of the paint film damaged during shipment or installation must be repaired as quickly as possible.

To do this, clean the damaged portion by means of a scraper or sandpaper, wipe thoroughly with a solvent dampened cloth, apply Westinghouse primer paint and allow it to dry for at least 24 hours, then apply a coat of Westinghouse finish paint.

FILLING

When putting new apparatus into service, see that the apparatus tank is free from moisture and foreign material.

IMPORTANT: Extreme precautions must be taken to insure the absolute dryness and cleanliness of the apparatus before filling it with Inerteen, and to prevent the entrance of water and dirt during the transfer of the Inerteen to the apparatus.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not possible, protection against moisture must be provided.

All vessels used for transferring the Inerteen should be carefully inspected to see that they are absolutely dry and free from contamination. Use only all-metal hose or pipe when filling, since the lining of most other types of hose may be soluble in Inerteen and will contaminate it in a short time. All joints should be tight; where practical, fill through the drain valve to keep aeration to a minimum and vent the top of the tank to allow the air to escape. Be sure that valves and pipe connections between the main tank and any Inerteen filled compartments are open for free circulation of gas and liquid. Otherwise, trapped air or gas may cause the Inerteen level in some parts of the transformer to be below the safe operating level.

If it is necessary to fill a transformer out-of-doors, particularly on a damp day, care should be taken to prevent the entrance of moisture. In order to avoid condensation the temperature inside the unit should be kept several degrees above the outside air temperature.

The tank and compartments, if any, should be filled at ambient temperature to the point on the gauges marked "25° – Liquid Level." If the ambient varies greatly from 25°C (77°F) when filled, the Inerteen level should be checked when the average fluid temperature is 25°C; sufficient Inerteen should be added to or drained from the tank to bring the level to the proper height. The transformer should never be operated or left standing, even out of service without the Inerteen level being indicated on the gauge.

Filling Under Vacuum. Entrapped air is a potential source of trouble in all liquid filled transformers. Therefore, it is desirable to fill all Inerteen transformers under a full vacuum. This is done for the transformers shipped from the factory and should be done where practicable when transformers are filled in the field, providing the transformer cases have been so designed. If the cases have not been designed for full vacuum and it is imperative to get the maximum winding impulse strength immediately, the transformers should be filled with Inerteen under full vacuum by placing them in an auxiliary vacuum tank.

Where purchaser does not have an established technique for vacuum filling, the following procedures may be used whether vacuum is applied

directly to the transformer or the complete transformer is placed in an auxiliary vacuum tank.

1. Apply and maintain continuously a vacuum of at least 28 inches of mercury for at least one-half hour to units rated 25KV and below, or for four hours to units above 25KV.

2. While retaining the vacuum, slowly fill with Inerteen to the normal 25°C level or with approximately 90% of the required amount where it is impossible to gauge properly.

3. Maintain the specified vacuum for at least one-half hour after filling.

4. Adjust Inerteen to normal level and seal the transformer tank. Do not reopen until the temperature at the top of the fluid is equal to or higher than the ambient temperature in order to avoid condensation on the surface of the Inerteen.

In those cases where the transformers are not filled under vacuum, full voltage should not be applied to the windings for at least 24 hours after the Inerteen has been put into the case. This time is necessary to allow the air bubbles to escape.

PLACING IN SERVICE

Pressure Testing. All Inerteen transformers are pressure-tested at the factory and shipped free of leaks. After installations and before voltage is applied, it is desirable to pressure-test each transformer, especially if any fittings or covers have been removed and replaced during installation. Compressed dry nitrogen or dry air may be used for the purpose. It is recommended that the space above the Inerteen be blown out with dry nitrogen, then close all vents and apply a pressure-test of five pounds per square inch for a period of six to eight hours. The test pressure can best be limited by the use of a pressure regulator attached to the nitrogen cylinder. A check for leaks of joints above the Inerteen level may be made by painting them with a solution of soap and glycerin and watching for gas bubbles. At the conclusion of the test the internal pressure should be returned to normal by momentarily venting the gas space.

High Altitude. Where transformers are to be used at a high altitude (more than 3000 feet above sea level) a fitting above the liquid level should be opened to equalize the internal and external pressures at a temperature of approximately 25°C before placing the transformer in service.

Grounding Transformer Tank. Regardless of the type of foundation or floor on which a transformer is to rest, the tank should be definitely and permanently grounded to eliminate the possibility of obtaining static shocks or being injured by accidental grounding of a winding to the case. A ground pad or lug is always provided near the bottom of the tank for the purpose of connecting the grounded lead.

CAUTION: A good low-resistance ground is necessary for adequate protection — a poor ground may be worse than none at all.

Grounding Low Voltage Winding. Every effort is made in insulating transformers to guard against any chance of breakdown between high voltage and low voltage windings; however, in order to be absolutely safe, it is advisable that low voltage circuits with which persons may come in contact be grounded. The maximum voltage that can be obtained to ground is then limited to the normal voltage that exists between the grounded point and the line; this is true even though the high voltage and low voltage windings become connected electrically.

In grounding the winding, the neutral point should be used if it is available. When transformers operate on single phase circuits with the middle point of the low voltage, the maximum voltage that can exist between any part of the low voltage circuit and ground is one-half of the low voltages.

MAKING CONNECTIONS

A diagram, usually on the metal instruction plate attached to the side of the case, shows the proper

power terminal connections to be made for various voltages. Care should be taken to see that all connections and only those shown are properly made, for a wrong connection may cause severe damage.

Some installations require an auxiliary source of power or control leads to be wired to terminals at the transformer; a wiring diagram, either a separate drawing or included as part of the outline drawing, shows the connections to be made.

Voltage Application. When voltage is first applied to the transformer, it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be disclosed before damage can result. After full voltage has been applied successfully, the transformer should be operated without load for a few hours. It should be kept under close observation during this time and also during the first few hours while loaded.

INSPECTION

It is desirable that periodic inspections of Inerteen apparatus be made and that samples of Inerteen be taken from each and from all compartments of any apparatus and tested after a short period of service. See section on Sampling and Inspection.

Any increase in operating temperature at normal load should be investigated and if the cause cannot be determined, the transformer should be taken out of service and given a thorough inspection.

Any symptoms, such as unusual noises, high or low Inerteen levels, operation of relief device, etc., should be investigated at once.

Transformers which have been subjected to unusually severe operating conditions, such as overloads, frequent short circuits, or special units should be inspected at least once a year. This can usually be done adequately by lowering the Inerteen level and inspecting with a light through the manhole. Before this inspection is made, the Inerteen should be allowed to cool to reduce the amount of Inerteen fumes given off which are quite objectionable and should not be inhaled.

During periodic inspection, all accessories should be inspected to see if they are operating properly.

CAUTION: Never enter a vault or any other confined area in which a transformer relief device has been known to operate or in which a transformer has failed, until the area has been thoroughly ventilated. Then enter cautiously, with another person in attendance. The pungent, somewhat irritating fumes of hydrogen chloride are easily detected and can serve as a guide in entering the enclosure.

Memorandum

162429

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

Manufacture by Serial Number

Year	Serials
1916	404 400– 435 299
1917	435 300– 514 457
1918	514 458– 526 174
1919	526 176– 549 169
1920	549 170– 604 799
1921	604 800– 631 683
1922	631 684– 674 000
1923	674 001– 774 799
1924	1040 043–1113 030
1925	1113 031–1222 330
1926	1222 331–1345 312
1927	1345 313–1464 708
1928	1464 709–1572 334
1929	1572 335–1727 703
1930	1727 704–1861 640
1931	1861 641–1931 900
1932	1931 901–1939 000
1933	1939 001–1970 875
1934	2026 231–2062 299
1935	2062 300–2103 800
1936	2103 801–2210 799
1937	2210 800–2363 999
1938	2364 000–2448 000
1939	2448 001–2547 500
1940	2547 501–2884 850
1941	2884 851–3195 000
1942	3195 001–3324 800
1943	3324 801–3500 818
1944	3500 819–3659 400
1945	3659 401–3809 130
1946	3809 131–4122 772
1947	4122 773–4740 745
1948	4740 746–5163 189
1949	5163 190–5342 915
1950	5342 916–5809 997
1951	5809 998–6201 599
1952	6201 900–6709 642
1953	6709 643–7163 016
1954	7163 016–7255 585
1955	55A00001 and Up
1956	56A00001 and Up
1957	57A00001 and Up
1958	58A00001 and Up
1959	59A00001 and Up
1960	60A00001 and Up
1961	61A00001 and Up
1962	62A00001 and Up
1963	63A00001 and Up
1964	64A00001 and Up
1965	65A00001 and Up
1966	66A00001 and Up
1967	67A00001 and Up
1968	68A00001 and Up
1969	69A00001 and Up
1970	70A00001 and Up
1971	71A00001 and Up
1972	7211 - - - - and Up
1973	7311 - - - - and Up
1974	7411 - - - - and Up
1975	7511 - - - - and Up
1976	7611 - - - - and Up
1977	7711 - - - - and Up
1978	7811 - - - - and Up
1979	7911 - - - - and Up
1979	17900001 and Up (Pinetops Production)

Classes of Purchasers

Class	Discount Schedule
User Government: State, county and municipal governments, all Federal Government agencies	44-001
Electric Utility and Industrial Customers Contractors And all unclassified buyers purchasing for their own use.	
Manufacturers ① Electrical equipment manufacturers ② purchasing for resale with or as a part of their product who have Headquarters approval and for whom Form 7119 has been executed.	44-004

① Educational institutions use this schedule
② These manufacturers make and sell equipment for which transformers become component parts, losing their identity as separate pieces of apparatus.

Westinghouse Electric Corporation
Medium Power Transformer Division
Sharon, PA 16146 USA

Meter and LVIT Division
Raleigh, N.C. 27611 USA

...ing Policy
...300

...de Identification; Sharon, Sunnyvale, Athens

...el Numbers	Year of Manufacture
...A1	©1965
...SM10	©1965
...AD10	©1965

...	Code	55	56	65
	Year	1955	1956	1965
...e of ...facture	Code Location	Blank Sharon	S Sunnyvale©	A Athens

...nth	Code	A	B	C	D	E	F	G	H	J	K	L	M
	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.

...facturing Serial ...ber (Maximum of ...Digits): 1 to 99,999

...mples: 55A1, 55SM10, 65AD10

...el	Location	Month	Manufacturing Serial Number	Description
	..	A	1	First Transformer Manufactured at Sharon in January, 1955
	S	M	10	Tenth Transformer Manufactured at Sunnyvale in December, 1965
	A	D	10	Tenth Transformer Manufactured at Athens in April, 1965

...de Identification: Jefferson City (Effective 1/1/72 through 12/31/77)

	Code	72	73
	Year	1972	1973

...uction ...	Code	A	B	C	D	E	F	G	H	J	K	L	M
	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Code	250	255	260									
	Date	Refer to Sales Department, Jefferson City											

...al ...ber ...uction ...: 1 to 999

...mple: 72L250001

...	Month	Production Date	Serial
	L	250	001

...transformer manufactured at Jefferson City ...g production week 250 in November, 1972.

...tive January 1, 1978, all transformers manufactured ...fferson City (including some overheads) will have ...l numbers on the nameplate as follows:

Jefferson City Manufacture	Month	Schedule Date	Sequence No.
J	A	630	001

Some overhead distribution transformers were made in 1976-1977 in Jefferson City. The letter "J" between year and month identifies these units.

Example: 77JA250001

Year	Month	Production Date	Serial
77 J	A	250	001

...de identification began late in 1954.
...tribution transformer manufacturing ...discontinued in December, 1964.
...anged or added since previous issue.

Printed in U.S.A.

...inghouse Electric Corporation
...rtion Transformer Division
...round Distribution Transformer Dept.
...son City, Missouri USA 65101

The Epidemiology of PCBs

by William R. Gaffey

Monsanto Company

September 15, 1981

I. Summary

Twenty four published and unpublished reports covering 21 epidemiologic studies of human exposure to PCBs were reviewed and evaluated. The studies showed that high occupational exposures to PCBs have resulted in chloracne and dermatitis. Alterations in liver and fat metabolism were found in most studies that examined these functions, but there was no clinical illness associated with these alterations or with level and duration of exposure to PCBs. Studies of mortality rates in exposed populations have shown no pattern of cancer deaths related to PCB exposure.

II. Introduction

This is a review and evaluation of the epidemiologic evidence concerning the health effects of exposure to PCBs, particularly at levels that do not cause acute toxic effects. A study is considered "epidemiologic evidence" if it measures, directly or indirectly, the differences in the risk of ill health among populations with different exposures to PCBs.

In the past several decades there have been many clinical studies of the effects of heavy exposures to PCBs (e.g. Von Wedel et al [1], Schwartz [2]). Such studies are extremely useful in identifying the kinds of effects that should be investigated. However, they do not address the question of the risk of incurring such effects, and are therefore not included in this review.

The studies reviewed here fall into three categories. First, there are studies of accidental heavy exposures and the resulting acute and chronic effects. In each case the study was prompted by an outbreak of illness or the occurrence of a death in an exposed population, after which the population was studied.

Second, there are studies of the relationship between exposure to PCBs and the resulting body burden of PCBs in serum or adipose tissue. Strictly speaking these are not epidemiologic studies since they do not deal with health effects. However, if a relationship between level of exposure and body burden cannot be verified, the interpretation of epidemiologic studies becomes difficult if not impossible.

The third category is studies that were done because the populations in question were known or suspected to be exposed to PCBs, rather than because some untoward health outcome had been observed first.

Many published reports combine some or all of these types of investigations. In the sections that follow, we consider first the studies of accidental overexposure, second the studies of PCB exposure versus body burden, and third the epidemiologic studies of exposed populations. In the latter section the discussion will be organized with respect to the health effects that were investigated. These are (a) dermatologic symptoms, (b) biochemical alterations, (c) other symptoms and illnesses, (d) carcinogenicity.

III. Accidental Heavy Exposures

Two epidemiologic studies of accidental exposure have been reported. The first, by Meigs et al [3] in 1954, described an outbreak of chloracne in a plant in which a process change had introduced an unspecified PCB compound into the work environment. Breathing zone levels of PCB were stated to be 0.1 mg/cum. Seven of 14 exposed workers developed chloracne, but liver function tests were normal in six of these, with some borderline abnormalities in the seventh. The chloracne disappeared after treatment, and the single borderline liver function abnormality improved, but did not disappear after 13 months. Improved process control prevented any recurrence.

Although the estimated PCB level must be accepted with reservation because of the state of the art at that time, it is clear that the chloracne resulted from the PCB exposure. Given the lack of controls and the small rate of abnormal liver function, it is unlikely that the PCB exposure had any connection with the liver function findings.

The second incident is the now famous Yusho incident in 1968 which has been documented in many reports (Kuratsune et al [4], Urabe et al [5]), in which some thousand Japanese became ill after eating cooking oil which had been contaminated with Kanechlor 400, a PCB compound of Japanese manufacture.

The most common acute symptoms observed were hyperpigmentation and acne-like lesions, discharge from the eyes, central nervous system symptoms, and vomiting and diarrhea. There was a

dose-response relationship between the amount of oil ingested and the proportion of persons reporting symptoms. Three years later about half the patients had improved, but still had symptoms. Six years later many patients still reported such symptoms as headache, stomach pain, numbness of the extremities, joint pain and respiratory symptoms [5].

Out of ten live births to women affected by Yusho, nine showed hyperpigmentation and most had increased eye discharges. These symptoms later disappeared. Although there have been reports of premature eruption of teeth (two children out of a series of 13) and unusually wide fontanelles and sagittal sutures (three out of 13) it is not at all clear that these findings represent any more than the normal variation to be expected, since no control observations were made (Funatsu et al [6]).

In general, laboratory tests of the Yusho victims showed elevated serum triglyceride levels, low serum chlolesterol in serious cases, and elevated SGOT and SGPT levels in serious cases (Higuchi [7]).

As of the end of 1977, 51 deaths among Yusho patients had been identified [5]. The percentage of cancer deaths (35.4) exceeded that of the prefecture in which the deaths occurred (21.1). However, the figures do not appear to be very useful for several reasons. First, after the original incident, the criteria for diagnosis of Yusho had been changed, so that it is impossible to determine the denominator which produced this number. The completeness of ascertainment of the deaths is unknown. In addition, no adjustment for age appeared to have been made in the

above comparison. Finally, the average elapsed time from exposure to death was less than ten years, and cannot be calculated precisely because the dates of death are not provided. This may well be too short a period for cancers resulting from the exposure to show up.

Although the Yusho incident represented a massive ingestion of PCBs, recent reanalysis of the cooking oil and of the estimated intake by the patients shows that the exposure to polychlorinated dibenzofurans (PCDFs) and polychlorinated quater-phenyls (PCQs) was about equal to the exposure to PCBs, and current determinations of PCQs in blood and other tissues of Yusho patients have shown levels similar to that of PCBs [8]. It is therefore doubtful whether any generalization can be made from this incident to lower level environmental or occupational exposures to PCBs.

IV. Environmental Levels and Body Burdens

Two studies of the relationship between ingestion of PCBs and blood levels of PCBs have been reported (Michigan Dept. of Public Health [9] and Kreiss et al [10]). In each case the study was concerned with ingestion of fish known to contain relatively high levels of PCBs. In the first, an association was found between blood PCBs and exposure level as estimated by the amount of Lake Michigan sport fish consumed. In the second the relationship between blood PCBs and a complex of factors was examined in a population in an area with high levels of environmental contamination. Age, sex and fish consumption, in that order of importance, were associated with blood levels of PCBs. To the extent that fish consumption measures ingestion of PCBs, these studies confirm that blood PCBs are a function of ingestion of PCBs as well as of age and sex. Other associated variables were examined in [10] but will be discussed in the following section.

A number of studies of blood PCBs and exposure to atmospheric PCBs have been made, most of them in conjunction with studies of health effects. The portions of the studies relevant to this section are reviewed here.

There are three types of studies. The first compares groups which have had different exposure levels as estimated from process considerations or environmental measurements. For convenience such a study design will be called Type A. The second, which we will designate Type B, measures the change over time in a single group after PCBs have been removed from the environment (or after

the group has left the environment). The third, Type C, compares groups that have had different durations of exposure. Often the same report will contain more than one type of study. For example, an exposed group may be compared with an unexposed group (Type A) and within the exposed group long term exposed workers may be compared with short term workers (Type C).

The measure of body burden has in most cases been a single number representing, depending on the study, blood PCBs, plasma PCBs, serum PCBs (all of which are called "blood" PCBs in this review), or level of PCBs in adipose tissue. Analytic methods have varied over time and among investigators. More recently measures of body burden have sought to determine separately the levels of higher chlorinated biphenyls (5 or more chlorine atoms per molecule) and lower chlorinated biphenyls.

Table 1 lists the studies considered in this section, with the type of design and whether or not separate determinations of higher and lower chlorinated biphenyls were made. All of the studies except Baker et al are occupational.

All of the Type A studies agree in showing a higher body burden of PCBs in populations with higher environmental exposure, except for one anomaly in Baker et al. There, persons exposed to sludge containing PCBs had slightly lower blood levels than the controls, on the average. However, the sludge exposed persons and the controls were not matched for age, which Kreiss et al showed to be the most important factor associated with blood PCB level. It therefore appears unequivocal that higher exposure to PCBs means a higher body burden, all other things being equal.

The Type B studies appear at first glance to be more equivocal (Table 2). Two studies show a decrease when exposure ceased or decreased and two do not. However, the studies showing no decrease remeasured their study groups within a month or two after exposure changed. The ones showing a decrease remeasured after three months and one year.

The fact that Ouw et al found no decrease after two months while Kitamura et al found over a 50 percent decrease after three months gives rise to some uneasiness. However, in the former study exposure was decreased but still present, while in the latter study PCB use had ceased. Ouw et al also suggest that after exposures in their study plant had decreased, workers did not wear gloves as recommended, so that the blood PCB levels may have resulted from skin contact.

Table 3 shows the findings for the Type C studies other than Maroni et al and Smith et al that is, for those that compared duration of exposure with a single measurement of blood PCB level. The results are not consistent. The study of Baumgarner et al found very low levels (average 4 ppb) in exposed workers, which may have accounted for their failure to find a relationship with duration. On the other hand the exposed workers in Hasegawa et al had an average level of 370 ppb and still showed no relationship with duration.

The studies of Maroni et al and Smith et al suggest a possible explanation. Maroni et al made separate comparisons of high chlorinated PCBs and low chlorinated PCBs between workers with present and past exposures. They found differences in the

low chlorinated PCBs but not in the high chlorinated compounds. Even though their analysis did not adjust for age, it suggests that the relationship between blood PCB levels and duration and recency of exposure may be a function of the level of chlorination of the PCBs. Smith et al however, in an elaborate analysis of high and low chlorinated blood PCBs versus present and past exposure, found no "evidence either to support or refute different accumulation kinetics in humans for the lower and higher chlorinated biphenyls". Nevertheless, they found a significant correlation between current personal air PCB levels and low chlorinated blood PCBs, but no significant correlation with high chlorinated blood PCBs.

In summary, body burdens of PCBs are clearly related to the level of exposure to environmental PCBs. Observations of a decrease in the burden of PCBs after exposure is eliminated or decreased are not consistent. The lack of consistency may be due to the short periods of observation of some of the studies, or possibly to differences in the average chlorination of the PCBs involved. Studies of the relationship of PCB burden to duration of exposure again are not consistent. There is a suggestion that this may be due to the confounding effects of age and sex, or to differences in the metabolism of high and low chlorinated PCBs, with the higher PCBs being more likely to accumulate in adipose tissue.

V. Epidemiologic Studies of PCBs and Health

Excluding mortality studies, there are 17 epidemiologic studies of health effects related to PCB exposure. The accident repprt of Meigs et al is included since it did not differ in design from many of the studies that were not motivated by accident reports.

These studies are listed in Table 4 with a summary of the findings by major category. Five of the reports are in Japanese [13,14,15,16,18]. The details of those studies are taken from the NIOSH criteria document for PCBs [34].

Two of the studies, Kappanen and Kolhol and South Carolina Department of Health and Environmental Control are not specific as to health effects. The first of these is a comparison of groups with different work exposures and different blood PCB levels (74-1900 ppb in the 12 persons with the greatest exposure) in which the authors simply state that all persons studied were in good health. The second is a study of 32 workers in a capacitor plant, 10 of whom were exposed regularly to PCBs. The authors state that there is "no evidence of physical harm resulting from working with PCBs".

The remaining 15 studies in Table 4 are reviewed below with respect to their findings in each major category of health effects. The studies are considered in the order of their publication.

Dermatologic effects. There are 11 studies of dermatologic effects associated with PCB exposure. The first is Meigs et al

described in Section II above, who found that 7 of 14 exposed workers got chloracne where the PCB concentration in their breathing zones averaged 0.1 mg/cum. Hasegawa et al reported an unstated number of cases of hyperpigmentation of the hands, and acne-like lesions of the jaw, back and thighs in exposed workers. The average blood PCBs in the workers was 370 ppb. However, the authors state that skin complaints were unrelated to blood PCB levels and appeared to be due to skin contact. Kitamura et al reported a range of skin disorders in 10 of 13 exposed workers with an average blood level of 820 ppb. The disorders occurred on parts of the body not normally in direct contact with PCBs. Hara et al reported that about 45 percent of 118 capacitor workers complained of blackheads and other acne-like symptoms while working with PCBs. The complaints were not related to blood levels of PCBs, and virtually disappeared within a year after exposure had ceased.

Inoue et al reported one case of chloracne in an exposed worker whose blood PCBs were in the 190-210 ppb range, but no symptoms in the rest of a small work force whose blood PCBs ranged from 130 to 520 ppb. The Michigan Department of Public Health reported no relationship of any Yusho symptoms to consumption of fish with high levels of PCBs. Ouw et al reported 14 cases of dermatitis, eye irritation or burning sensations on the skin out of 34 exposed workers, where air levels of PCBs ranged from 0.32 to 2.22 mg/cum. The complaints appeared to occur more often in those with higher blood PCB levels. Fischbein et al reported that about 50 percent of 326 capacitor manufacturing workers reported a

history of dermatological symptoms, the most common symptom being a rash. Those with symptoms had higher blood levels of high chlorinated PCBs. Baker et al reported no chloracne in 18 exposed workers (average blood PCBs 75.1 ppb) or 19 members of their families (average blood PCBs 33.6 ppb). Maroni et al reported 10 cases of dermatitis (5 diagnosed as active or past chloracne) out of 80 exposed workers. The average blood PCB level in the study was 342 ppb. Smith et al found no chloracne in a study population of 324 exposed workers in capacitor manufacturing and transformer repair, whose average blood PCBs ranged from 38 to 546 ppb. However, there was a significant association of skin rash or dermatitis with blood levels of high chlorinated PCBs.

Interpretation of this mass of data is complicated by the difficulty of diagnosing chloracne, the uncertainties of blood PCB determinations, and the changing technology for making such determinations. Nevertheless, the data suggest strongly that when PCB blood levels exceed about 150-200 ppb chloracne can occur. However, most studies have shown that the occurrence of chloracne is not further associated with blood PCB levels. This suggests that (a) personal idiosyncratic factors may be involved and/or (b) that the high blood levels are an indicator of the existence of environmental contamination which actually produces chloracne by skin contact.

The reports of dermatitis other than chloracne suffer from an additional complication. According to the National Health Survey, about one-third of all Americans of working age have at least one current skin condition serious enough to warrant evaluation by a

physician [25]. Clearly, substantially more than one-third must have either a current condition or a history of such a condition in the past. The prevalence figures reported by Maroni et al and Fischbein et al are therefore not in themselves remarkable, but the agreement of Fischbein et al and Smith et al on the relationship between dermatitis and high chlorinated blood PCBs suggests that this association may be real.

Liver Function. Nine studies examined liver function. Meigs et al found one borderline abnormal liver function in 14 exposed workers. Hasegawa et al found mild disturbances in exposed workers (increased SGOT, SGPT, SAP, decreased serum cholinesterase) which they did not consider to be clinically significant. Ouw et al, Kitamura et al, Fischbein et al and Baker et al (a non-occupational study) found no abnormalities associated with exposure, except that Ouw et al found a high BSP retention in 4 out of 7 workers with blood levels above 500 ppb.

Maroni et al found 16 out of 80 workers with abnormalities in GGT, OCT and transaminases. Their blood PCB levels were higher than those in the workers with normal liver function. Kreiss et al (non-occupational study) found no relation between liver function and blood PCBs when age and alcohol consumption were taken into account. Smith et al found elevated SGOT and GGT levels in persons with higher blood PCB levels.

In summary, 5 studies of the 9 found some mild liver function abnormalities, none of which were associated with any measurable adverse health effects. The two non-occupational studies, Baker et al and Kreiss et al, found no abnormalities associated with

blood PCB level. Fischbein et al, in their study of capacitor manufacturing workers, noted that "there was a paucity of abnormal results in the biochemical studies".

Fat Metabolism. Six studies considered fat metabolism. One, Bumgarner et al, found no relationship between blood cholesterol and blood PCBs. One of the remaining 5, Hasegawa et al, found a decrease in cholesterol, glycerides, phospholipids and beta-lipoprotein in exposed workers. Of the remaining 4, Hara et al, Baker et al (non-occupational study), and Smith et al found increased triglyeride levels with increased blood PCBs. Kreiss et al found no association of triglycerides and blood PCBs when cholesterol level was taken into account. Smith et al and Kreiss et al also present contradictory findings with respect to HDL cholesterol levels; the former found an inverse relationship of HDL to blood PCBs; the latter found no relationship, but found a positive association between total cholesterol and blood PCBs.

Most studies, including one non-occupational study (Baker et al) have associated increased tryglycerides with PCB exposure. The data on cholesterol are not consistent; an increase, a decrease and no change were found (one study each). HDL cholesterol either decreased or was unchanged (one study each). Even if PCB exposure has some effect on fat metabolism, it appears to be without any apparent clinical significance.

Blood and Blood Pressure. There are five studies of blood chemistry; Bumgarner et al, Kitamura et al, Fischbein et al, Baker et al, and Maroni et al. None of them report any relationship of blood chemistry to PCB levels.

Bumgarner et al and Kreiss et al measured blood pressure in exposed persons. Bumgarner et al found no association with PCBs, but Kreiss et al found a statistically significant association between diastolic blood pressure and blood PCBs. Since there was no control group and since Kreiss et al are the only investigators to report this finding, its significance is not clear at this time.

Symptoms, Illness and Other Conditions. Six studies investigated reported symptoms in persons exposed to PCBs. Two of them reported allegedly increased symptoms of various kinds. Fischbein et al reported a history of gastrointestinal symptoms in 18 percent of 326 capacitor manufacturing workers, a prevalence of from 3.0 to 15.2 percent of various musculoskeletal symptoms, and a prevalence of from 4.8 to 27.8 of various neurological symptoms. These were, however, unrelated to duration of employment or to level of blood PCBs. Maroni et al reported 8 cases of gastrointestinal complaints in 80 exposed workers, with no indication of whether there was a relationship to duration of employment. They also reported two bleeding haemangiomas and one case of chronic myelocytic leukemia. These findings do not appear to have any significance, since they apparently are unrelated to the circumstances of exposure, and since the following 4 studies reported no symptoms related to PCBs.

The Michigan Department of Public Health compared a group of persons who consumed sport fish contaminated with PCBs to a group of unexposed controls. The incidence of 18 conditions, many of them the ones reported for Yusho disease, was measured in the two

groups. There were no health conditions that could be correlated with blood PCB levels or fish consumption. Baker et al reported that none of the following conditions were associated with blood PCB levels in a community study; fever, weight loss, anorexia, fatigue, headache, eye irritation, cough, shortness of breath, nausea, vomiting, diarrhea, abdominal pain, arthralgia, and persistent skin rash. The community study of Kreiss et al reported the same thing for prevalence of illness or weight loss in the preceding year, use of medication, use of medical care, history of heart disease, and percentage of pregnancies ending in miscarriage, stillbirth or infant death. Finally, Smith et al reported an increased prevalence of general malaise and possibly altered peripheral sensation with increased blood PCB levels among occupationally exposed workers, but found no clinical abnormalities on physical examination.

The weight of evidence, as Smith et al conclude, is that no studies to date "have shown that occupational exposure to PCBs is associated with any adverse health outcome, to be distinguished from demonstrable subclinical biochemical alterations".

Two studies considered other conditions in persons exposed to PCBs. Warshaw et al reported decreased vital capacity in capacitor manufacturing workers. However, the pulmonary function values in the study population, most of whom were current or ex-smokers, were evaluated in comparison with a standard population of non-smokers, so that the effect of smoking as a confounder was not allowed for.

Alvares et al reported that in 5 workers occupationally exposed to PCBs, the rate of drug metabolism was significantly higher than in a group of controls matched for age, sex, and smoking and drinking habits.

There appear to be no significant clinical effects associated with the occupational or environmental exposures studied in these reports.

Carcinogenicity. It is generally agreed that epidemiologic evidence for carcinogenicity should fulfill certain requirements in order to be acceptable. These requirements deal with the study design, the logic of the observed pattern, and the repeatibility of the results. Table 5 lists these requirements as given by Doll [28].

There are four studies directed solely or primarily to the question of the carcinogenicity of PCBs. Table 6 lists the studies and their findings. They are reviewed here keeping in mind Doll's requirements.

The most obvious feature of Table 6 is that no study agrees with any other. That is, the requirement of repeatibility is not met.

The first study, by Bahn et al, observed three melanomas in a group of 92 research and development and refinery workers. These workers had an unknown exposure to other possible carcinogens, so that there could have been confounding. In any case the study was withdrawn for revision in the definition of the exposed population, and has not yet been released [34].

Zack and Musch studied 89 workers exposed for at least six months between 1945 and 1965 inclusive. There were no deaths from cancer of the liver or cirrhosis. The excess in respiratory cancer was based on four deaths and was not statistically significant. As with Bahn et al there was confounding because of other chemical exposure at the plant and, in this case, possibly cigarette smoking.

Brown and Jones studied 2,567 workers in a capacitor plant. About half the cohort had a latency period of 20 years or more. Although there was an excess of liver cancer deaths, it was inversely related to duration and latency of exposure, which does not support an occupational explanation. There was also an excess of rectal cancer. However, the two plants studied are located in an area whose mortality from rectal cancer is greater than the U.S. average [35]. Since U.S. population rates were used as a basis for comparison, the rectal cancer excess is at least partly an artifact.

Bertazzi et al studied 1,310 workers with at least six months employment in capacitor manufacturing between 1946 and 1970. Although excess digestive cancer was observed, there were no liver cancer deaths. The total number of deaths was small (27) and the excess cancer observed was based on two or three deaths for each of the two major sites involved. There is no indication of the duration or latency of exposure for the cancer deaths. The authors state that there were no other major exposures at the plant, and propose to continue the study with a larger cohort. In spite of the statistical significance of the excesses from all

cancers, this study must be considered a preliminary report, particularly since it shares with the other studies a failure to agree on any particular pattern of mortality.

The existing mortality studies of occupational exposure do not show the agreement that would lead one to infer an excess risk of cancer. Much of the conflicting findings can be attributed to the possible effect of confounding exposures, and to the "noise level" of sporadic excesses which would be expected in the absence of any occupational hazard.

VI. Summary and Conclusions

The epidemiologic studies of exposure to PCBs show that the body burden in exposed persons, whether the exposure is by ingestion, inhalation or skin contact, is related to the environmental levels and distribution of PCB. The relation of body burden to duration of exposure is less clear, and appears to differ depending on the degree of chlorination of the PCBs. Nevertheless, the evidence is clear that higher exposures mean higher blood PCB levels, and that persons with occupational exposures have blood PCB levels that may be an order of magnitude greater than that of environmentally (that is, non-occupationally) exposed persons.

Occupational exposure to PCBs at high levels has been associated with the occurrence of chloracne, but the relationship is not straightforward, suggesting that the actual risk of chloracne is also a function of individual susceptibility and personal work habits, as well as possible exposure to other contaminants.

Dermatologic problems other than chloracne are associated with occupational exposure, and may be related to exposure to high chlorinated PCBs.

Alterations of liver function and fat metabolism associated with PCB exposure have been observed in several studies, but are characterized by investigators as mild and of no clinical significance.

The one fact on which all occupational studies of health effects agree is that there has been no clinical illness associated with PCB exposure other than dermatitis. Studies of non-occupationally exposed populations have found neither dermatitis nor other clinical evidence of exposure-related effects, with the exception of a single study which suggests that diastolic blood pressure may be related to blood level of PCBs.

Mortality studies concerned primarily with cancer present problems of interpretation due to the small sample size of some of the studies, and to the confounding effect of other exposures. However, they do exhibit a pattern, which is that none of the studies agree on the cancer sites at which an excess mortality was found, and the excesses that were found are in general not statistically significant. One must conclude that the findings of the mortality studies reflect a sporadic pattern of excess mortality at different sites which is not consistent with a carcinogenic effect of PCBS. In addition, where an examination of duration and latency of exposure was possible, no association with these variables was found [32].

Taken as a whole, the epidemiologic studies find that high occupational exposures to PCBs may cause dermatitis of various kinds, but that there are no other clinically observable effects, including the occurrence of cancer.

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Table 1

Studies of Environmental Levels and Body Burden of PCBs by Type of Body Burden Measure

Study	Study Type*	High & Low Chlorinated PCBs	Adipose PCBs
Baker, E et al [11]	A	No	No
Bumgarner, JE et al [12]	C	No	No
Hara, I et al [13,14]	B,C	No	No
Hasegawa, H et al [15]	A,B,C	No	No
Inoue, Y et al [16]	A,C	No	No
Karppanen, E, Kolho, L [17]	A	No	Yes
Kitamura, M et al [18]	B	No	No
Maroni, M et al [19]	A,C	Yes	No
Ouw, HK et al [20]	A,B	Yes	No
Smith, AB et al [21]	A,C	Yes	No

* A = comparisons of groups with different exposure levels
  B = evaluation of results of decreasing or removing exposure
  C = comparisons of groups with different durations of exposure.

Table 2

Studies of Blood PCB Levels Before and After Exposure Levels Changed, and Interval from Exposure Change to Remeasurement

Study	Exposure Change	Interval to Remeasurement	Decrease in Blo PCB Level
Hara et al [13,14]	Ceased	1 year	~75%
Hasegawa et al [15]	Ceased	1 month	None
Kitamura et al [18]	Ceased	3 months	>50%
Ouw et al [20]	Decreased	2 months	None

Table 3

Studies of PCB Levels by Duration of Exposure

Study	Relationship of Blood PCB to		
	Duration of Exposure	Age	Race
Bumgarner et al [12]	No	No	No
Hara et al [13,14]	Yes		
Hasegawa et al [15]	No		
Inoue et al [16]	Yes		

Table 4

PCB Epidemiology Studies (other than mortality) and Summary of Findings*

	Dermatologic Findings	Physiological Parameters	Symptoms and Illness	Other
Alvares et al [27]		Y		
Baker et al [11]	N	Y	N	
Bumgarner et al [12]		N		
Fischbein et al [23]	Y	Y	Y	
Hara et al [13,14]	Y	Y		
Hasegawa et al [15]	Y	Y		
Inoue et al [16]	Y			
Karppanen, Kolho [17]				N
Kitamura et al [18]	Y	N		
Kreiss et al [10]		Y	N	N
Maroni et al [24]	Y	Y	Y	
Meigs et al [3]	Y	Y		
Michigan Dept of Public Health [9]	N		N	
Ouw et al [20]	Y	N		
Smith et al [21]	N	Y	Y	
South Carolina Dept. of Health and Environmental Control [22]				N
Warshaw et al [26]		Y		Y

* Y = Findings associated with exposure
N = No findings associated with exposure

Table 5

REQUIREMENTS FOR ESTABLISHING CARCINOGENICITY FROM EPIDEMIOLOGICAL EVIDENCE

- Positive associations in groups of individuals with known exposure (case-control or cohort studies).
- That are not explained by bias in recording or detection.
- That are not explained by confounding.
- That are not explained by chance.
- That vary appropriately with dose.
- That vary appropriately with period of exposure.
- That are observed repeatedly in different circumstances.

Table 6

Inconsistencies in Studies of Cancer in PCB Exposed Populations, with Findings

Study	No. Studied	Findings
Bahn et al [29,30]	92	Melanoma**
Zack, Musch [31]	89	Lung
Brown, Jones [32]	2,567	Liver Rectum
Bertazzi et al [33]	1,310	Digestive* Lymphatic and hematopoietic

* Significant at 5 percent level

** Significant at 1 percent level

APPENDIX D

Occurrence, Transfer, and Cycling of PCBs in the Environment

Table of Contents

Tables

TABLE 1
PCB MANUFACTURING AND SALES
DATA FROM MONSANTO INDUSTRIAL CHEMICALS CO.
1957 THROUGH 1971
(Thousands of Pounds)

	1957	1958	1959	1960	1961	1962
TOTAL PRODUCTION (For Domestic Sales)(1)				37919	36515	38353
DOMESTIC SALES	32299	26061	31310	35214	37538	38043
DOMESTIC SALES BY CATEGORY						
Heat Transfer	-	-	-	-	-	157
Hydraulics/Lubricants	1612	1549	2685	2523	4110	3915
Misc. Industrial	704	755	1569	1559	2114	1681
Transformer	12955	5719	5984	7921	6281	7984
Capacitor	17028	14099	16499	16967	15935	15382
Plasticizer Applications(2)		3939	4573	6244	9098	8924
Petroleum Additives	-	-	-	-	-	-
Total	32299	26061	31310	35214	37538	38043
DOMESTIC SALES BY PCB GRADE						
Aroclor 1221	23	16	254	103	94	140
Aroclor 1232	196	113	240	155	241	224
Aroclor 1242	18222	10444	13598	18196	19827	20654
Aroclor 1248	1779	2559	3384	2827	4023	3463
Aroclor 1254	4461	6691	6754	6088	6294	6325
Aroclor 1260	7587	5982	6619	7330	6540	6595
Aroclor 1262	31	184	359	326	361	432
Arcolor 1268	-	72	102	189	158	210
Total	32299	26061	31310	35214	37538	38043

NOTE: (1) Production amounts prior to 1960 are not available.
(2) Amounts for plasticizer applications prior to 1958 are not available.

estimated that one-third of the PCBs released to the air and one-half of those released to water have now been degraded. The PCBs in dumps probably have undergone less degradation.

Given the diversity of uses of PCBs and their chemical stability (greater stability in the higher chlorine species), it is not surprising that residues are now widespread. While satisfying quantitative estimates of the contribution of various pathways into the environment are not possible with existing data, there are enough data to be certain that they do reach the environment at least from the following sources:

-- Open burning or incomplete incineration (at usual temperatures) of solid wastes, municipal and industrial. Incineration at 2000° F or above for two seconds will destroy PCBs, but poorly operated incinerators or open burning may result in PCBs being released to the atmosphere unchanged.

-- Vaporization from paints, coatings, plastics, etc. (Nisbet and Sarofim, 3) estimate that as much as 20 percent may be vaporized.

-- Municipal and some industrial sewers (present in treated as well as untreated wastes). Tables 2 and 3.

-- Accidental spills or improper waste disposal practices.

-- Formerly, direct application to the environment as ingredients of pesticides or as carriers for pesticides (such uses are now prohibited).

-- Dumping of sewage sludge, municipal and industrial solid waste, and dredge spoil at sea.

-- Sewage sludges disposed of on land.

-- Migration from surface coatings (paints, etc.) and packaging materials into foods and feeds.

Probably the largest amounts of PCBs circulating in the environment reach it through industrial and municipal discharges to inland and coastal waters. Tables 2, 3, and 4 present data on such discharges. Based on Table 4, we can estimate 6,000 tons per year may reach these environments.

In addition, PCB residues occur in sludge from municipal sewage systems. Table 5 presents results of analyses from several such sludges. Sewage sludge is disposed of by incineration, landfill, spreading on the land, and dumping at sea. Four million tons per year reach the Atlantic Ocean and Gulf of Mexico, which would include only 10 or so tons of PCBs (4). Analysis of the waste water from the effluent scrubbers of three sludge incinerators showed no detectable residues of PCBs (level of sensitivity 0.1 part per billion), suggesting that most PCBs had been destroyed by incineration. The total amount of PCBs contained in the sludges would not be more than ~70 tons per year.

TABLE 3. PCB CONCENTRATIONS IN INDUSTRIAL EFFLUENTS

Location	Kind of Industry	Date	Aroclor Compound Detected	Concentration in Effluent (ppb)	Source of Data
Saukville, Wisc.	Chemical Plant	3/70	1242	2.50	Vleth and Lee, 1970
Ohio- Great	Paper Coating Co.	1/71	1242 & 1248	27	EPA data- Analytical Quality Control Lab.
Miami River	Paper Treatment	1/71	1242	430, 470*	"
	Appliance	1/71	1254	5	"
	"	1/71	1254	18	"
Florida- Escambia River	Chemical Plant	4/69-10/69	1254	2.5-275	Duke, et al., 1970

*Samples from treatment lagoon

TABLE 5. CONCENTRATION OF PCBS IN SEWAGE SLUDGES

Collection Site	Date	Aroclor Detected	Concentration (ppb)	Sludge per day tons/day	Est. PCB Content Day (lbs.)	Source
California						
Hyperion (Los Angeles)	12/70	1254	85 (78.5-92.1)	20,000[1/]	3.2	Schmidt, et. al., (13)
Barstow	7/21/71	1254	1400	1.4	.004	EPA Unpublished data
Ohio						
Dayton (Miami River)		1254	105,000	47.9	10.1	EPA Unpublished data
Little Miami (Cincinnati)		1254	32,000	20.2	1.3	" " "
Mill Creek (Cincinnati)		1254	12,700	88.3	2.2	" " "
Lebanon (Turtle Creek)		1254	2,500	1.0	.005	" " "
Shayler Run		1254	3,200	-	-	" " "
Virginia						
Lorton		1254	1,200	-	-	" " "
Indiana						
Indianapolis		1254	3,500	126.1	1.03	" " "

1/ This number is based on outfall discharge and represents a relatively dilute sludge. The estimated PCB content in lbs./day is the important figure here.

Assumptions: Each million gallons of sewage contains about 1 ton of sludge. The daily output of sludge, then is 150,000,000 sewered population x 130 gal. sewage per day = 19,500,000,000 gallons per day and 19,500 tons of sludge per day.

At 10 ppm of PCBs (highest level found), the daily output would be 19,500 tons x 2000 lbs. = 39 million lbs. x 10 ppm = 390 lbs. per day, at 1 ppm, 39 lbs./day. These would be respectively 70 and 7 tons/year.

TABLE 6. A SAMPLING OF MEASURED OCCURRENCES OF PCBS IN THE ENVIRONMENT

	Location	No. Samples	Date	Aroclor Compound Detected	Concentration (ppb)	Source of Data	Remarks
Air							
Precipitation	United Kingdom		1968	N.S.	Detected but not quantified	Tarrant and Tatton, 1968	
	Florida		1971	N.S.	Below level of quantification	USGS- Unpbl.	
	Sweden		1970	N.S.	Present in snow	Smithsonian Inst. CFSLP- 1970	
Suspended Particulate	4 U. S. cities		1968-1970	N.S.	~27-230 ppm on suspended solids	EPA- Unpbl.	Quantification questionable
Water							
	Great Miami River, Ohio	19	11/70	1242	ND to 15.8 $\bar{x}$ = 5.7	EPA- Unpbl.	3 samples above Dayton below level of detection. Mean of 16 samples 5.7
	Ohio River	2	11/70		ND	"	
	Big Suamico River, Wisc.		-		<0.01	Veith, 1972	
	Pestigo River, Wisc.		11/70	1254	0.31	"	
			4/71	"	0.38	"	
			Summer '71	"	<0.01	"	
	Oconto River Wisc.		11/70	1254	0.45	"	
			4/71	"	0.16	"	
			Summer '71	"	<0.01	"	
	Milwaukee River	10	1970	1242 1260	0.03-2.07, $\bar{x}$ 0.29 0.02-0.13, $\bar{x}$ 0.08	Veith and Lee, 1970	

TABLE 6 (Continued)

	Location	No. Samples	Date	Aroclor Compound Detected	Concentration (ppb)	Source of Data	Remarks
Biota							
Marine Plankton	North Atlantic		1971	N.S.	$\bar{x}$ 200	Harvey in Nesbit & Sarofim, 1972	
Zooplankton	Irish Sea	7	10/69	N.S.	10-30	Holdgate in Nesbit & Sarofim, 1972	
Invertebrates							
Mussels	Irish Sea	(about 200)	10/69	N.S.	50-500	"	
"	Baltic Sea	40	1965-1968	N.S.	4300 (1900-8600)	Jenson, et al., '69	
"	Stockholm Archipelago	15	"		5200 (3400-7000)	"	
Oysters	Escambia Bay, Fla.	18	1971	1254	650 (100-1400)	EPA- Gulf Breeze, Unpbl.	
"	"	2	1970	"	840 (710-970)	"	
"	"	2	1969	"	1050 (1000-1100)	"	
	Florida	8	1964-1970	"	1400-2700	"	
	Georgia	12	1967-1970	"	2000	"	
	S. C.	3	1965-1969		Present but not quantified	"	
Blue Crab	Florida	10	2-3/70		"	"	
Crabs	S. C.		1969	N.S.	<100	Duke, et al., '70	
"	Escambia Bay, Fla.		1969	1254	1000-7000	"	
Shrimp	"		1969	1254	1500-2500	"	
Norway Lobster	Irish Sea	33			10-100	Holdgate 1970 in Nesbit & Sarofim, 1972	

	Location	No. Samples
Biota (continued)		
Birds - Land		
Starlings	Continental U. S.	124
Woodcock	N.S. - Nothern U. S.	
Bald Eagle	25 states	69
Birds - Water		
Guillemot Eggs	Baltic Sea	9
White-tailed Eagle	Stockholm Archipelago	4
Heron	"	4
Double-crested Comorant (eggs)	Bay of Fundy	
Abdominal fat		
Herring Gull Fat	Bay of Fundy	

TABLE 6 (Continued)

Date	Aroclor Compound Detected	Concentration (ppb)	Source of Data	Remarks
11-12/70	N.S.	$\bar{x}$ 660 (50-24,300)	Bureau of Sport Fisheries & Wildl., Unpubl.	
Fall 1971	N.S.	4000-9000	"	
1966-69	N.S.	Not quantified	"	
5/68		250,000	Jensen, et al., 1970 (22)	
3/65-6/66		14,000,000, 8,400,000-17,000,000	"	
4/67		9,400,000	Jensen, et al., 1969 (19)	
1971?	1254	17,200	Zitko, et al., 1972 (20)	
"	1254	52,000	"	
"	1254	75,000	"	

million in some fish and birds near the top of the food chain (1/8 of an inch is about one trillionth of the distance to the moon; and a part per million is about 5 steps on a walk from Washington to San Francisco). Man, who is also at the top of a food chain, carries residues ranging up to 2 parts per million or occasionally more.

II. BEHAVIOR IN THE ENVIRONMENT

A. Air - The relative importance of the atmosphere as a transport mechanism is not known. While PCBs have been identified in air, the residence time, transformations, and movement from air to land or water surfaces through fall-out or rainout, or return to the atmosphere are virtually unknown. There are at least two observations that suggest substantial aerial transport; data on residues in fish in Lake Minto in a remote part of northern Quebec (7), and residues in woodcock which feed almost exclusively on earthworms, which in turn pick up residues from the soil. Only by invoking aerial transport can we account for residues in arctic lakes or in more or less wilderness areas of the North where woodcock summer. Nisbet and Sarofim (3) suggest airborne PCBs will have been adsorbed on particles and have a relatively short residence time--thus most will have been redeposited on the U. S. continent, but some will have reached the oceans.

B. Water and Sediment - The water environment is probably the principal sink and transport mechanism for PCBs. Calculations based on measured occurrences in municipal and industrial outfalls, in the receiving waters, and the downstream reaches of the waterways demonstrate transport through the aquatic system. Measured residues in fishes from various environments suggest accumulations at the downstream ends of the drainageways.

There are few data on removal, disappearance, and sequestering of the substances in soils or bottom sediments of rivers, lakes, estuaries, or the ocean. Table 6 includes some data that indicate presence in bottom sediments, and suggest that sediments may be a major reservoir of PCB residues. Work by Mimmo and his colleagues at Gulf Breeze (8) has shown that at least pink shrimp and fiddler crabs are able to take up PCB residues from this source. Fiddler crabs and pink shrimp exposed to clean flowing sea water in aquaria containing sandy silt with initial residues of 61 parts per million (dry weight basis) of Aroclor 1254 accumulated an average of 80 ± 25 parts per million in the whole crab and 240 parts per million (one pooled sample) in the hepatopancreas of the shrimp. Accumulation was much less, 17 ± 9 parts per million and 6.1 parts per million, respectively, with silt initially containing 30 parts per million. Some accumulation took place 3.2 ± 0.9 parts per million (in crabs) and 1.1 parts per million (shrimp hepatopancreas) from silt initially containing 2.5 parts per million. The same investigators have shown transfer of residues from sediments to overlying water. Effluent water from the aquarium with 61 parts per million Aroclor in sandy silt contained 3.5 parts per billion; from the aquarium with 30.0 parts per million in silt, effluent water contained 0.5 parts per billion.

III. EXPOSURE AND BIOLOGICAL ACCUMULATION

Experimental work on biological accumulation by individual species of vertebrates and invertebrates has been conducted by a number of laboratories in the United States and elsewhere. Table 7 presents selected data that demonstrate accumulation factors of up to 75,000 in whole organisms, and in the

hepatopancreas of pink shrimp. The data reported in the preceding section demonstrate that pink shrimp are able to accumulate PCB residues from environmental levels as low as 0.5 parts per billion; and Table 7 shows accumulation by fish from levels as low as 1 part per billion.

Evidence from environmental samples (Table 6) suggests uptake of PCB residues from exceedingly low environmental concentrations. Thus the plankton samples from the North Atlantic contain something like 200 parts per billion, yet PCB levels in marine waters are believed to be exceedingly low--certainly less than 0.01 parts per billion.

PCBs, like many of the organic insecticides, are fat soluble, and are stored in the lipids of animals. Like the insecticides, they resist metabolic changes, and tend to be concentrated (at least to some extent) at succeedingly higher levels as they pass through various steps in the food chain.

The data presented in Table 6 suggest that there are two components of movement through the biota. One is the familiar pattern of food chain accumulations. The other involves direct uptake from the environment by various trophic levels; e.g., soil to earthworms; water to phytoplankton, zooplankton, larger invertebrates, and fish. The fish and plankton data from the North Atlantic reported by Nisbet and Sarofim (3) are consistent with the hypothesis, in that plankton residue levels are higher than fish levels, suggesting direct accumulation rather than food chain transfers. So, too, is the evidence from feeding studies reported by Stalling and Mayer (9) that suggest accumulations of no more than a factor of 2 over dietary intake levels in fish. It seems reasonable that food chain transfers are the principal route of accumulation in warm blooded vertebrates, and possibly in the highest levels of carnivorous fish. Conversely, direct environmental uptake is probably the most important for aquatic invertebrates and fish.

That humans are exposed to PCBs is evident from the data in Table 6. There are a number of possible routes: air, water, food. Fish and shellfish through uptake from water would be expected to provide the principal continuing source in the diet. Sampling of fish to keep those containing more than the FDA interim action level from the market is carried out by FDA and the various States where fish are known to have substantial PCB contamination. Other foods have been found to contain PCB residues, but these residues are for the most part traceable to accidents; e.g., residues in eggs and poultry whose diet included fishmeal contaminated by leakage of PCBs from processing equipment (Monsanto reports they no longer sell PCBs for this purpose); residues in milk traceable to silage stored in silos painted with PCB-containing paints; residues in dry food packaged in PCB-contaminated packaging materials. Aside from the occurrences traceable to incidents such as the above, residues have been found in only 479 of 15,000 food samples by FDA during November 1969-June 1971 (200 of the 479 were followups on samples found to contain PCBs). In the FDA diet studies during FY 70 and 71, only 22 of 720 composite samples contained PCB residues. It is clear that only a small fraction of the U. S. food supply contains detectable levels of PCBs.

The effluents from such installations should be regulated and closely monitored to assure that no more than 0.01 parts per billion results in the receiving water. (So, too, should the manufacturing and disposal facilities of Monsanto.) Good housekeeping should permit this level to be achieved. An educational campaign aimed at users to assure proper disposal will also be necessary--so long as the materials are referred to as transformer oils, cutting oils, hydraulic oils or fluids, etc., care in disposal will be hard to assure. After all, oils in moderate quantities aren't regarded as troublesome substances.

V. RESEARCH NEEDS AND OPPORTUNITIES

1. Data provided by Kuratsune and Masuda (11) suggest that PCB-containing carbonless copy paper may have been an important source of PCB residues in man. An epidemiological study, involving a group of regular users of such copy paper (airline ticket salesmen; clerical workers; etc.), would shed much light on this question.

2. The detection of high levels of PCBs in house dust by Price (10) suggests that inhalation may be an important source of PCB levels in man. Both the question of occurrence in dust and of respiratory uptake from such dust should be explored.

3. Residues of PCBs have not been determined in soils, though by inference they must be present. A set of samples from the program of pesticides monitoring in soils should be analyzed for PCBs; the set should be drawn with care to illuminate distribution patterns in, near, and remote from industrial areas.

4. Data on pesticides in air are unsatisfactory. A few samples, including both vapor and particulates, should be collected from industrial areas and analyzed. If the methodology proves satisfactory, a small-scale survey should be undertaken to determine the importance of the atmosphere as a transport mechanism.

5. The presumption that PCBs do not move to ground water should be tested. The volume of water in this reservoir, coupled with its relatively long residence time, suggests that even very low levels of contamination may be significant.

6. Dumps and landfills are thought to be the principal reservoir of PCBs, but there are virtually no data on behavior of PCBs in these locations. Small-scale sampling should be undertaken to determine the concentrations brought to dumps, the fate of PCBs from open burning, and into leachate and gases from sanitary landfills. Degradation in place should also be investigated.

7. The presumption that submerged sediments contain a large amount of PCBs should be examined. Such questions as vertical distribution, degradation, movement, transfer of water, should be explored as well as the current distribution of residues beneath inland and inshore marine waters.

8. The reported finding of PCB residues on the order of 0.2 parts per million in marine plankton of the mid-North Atlantic requires elaboration.

FOOTNOTES

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APPENDIX B

Use and Replaceability of PCBs

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APPENDIX B

Use and Replaceability of PCBs

I. DIELECTRIC FLUIDS

Dielectric (electrically insulating) liquids are important to the electrical industry for filling agents or impregnants in transformers, capacitors, and other devices. Besides their electrical functions, the liquids may also be used for cooling and arc quenching functions. Detailed discussions of dielectric fluid applications are available (1-4).

A. CAPACITORS

Generally, industrially important capacitors use liquid impregnated cellulose paper as a dielectric. The required properties of the liquid are:

1. Non-flammability (important for preventing fires, particularly in indoor use).
2. Dielectric constant matching that of paper. A good match reduces electric field inhomogeneities, increases dielectric strength and lifetime, and allows decrease in capacitor size.
3. Low dissipation factor (reduces energy loss and destructive heating in a capacitor).
4. High dielectric strength (prevents breakdown and allows decrease in capacitor size).
5. High chemical stability (increases capacitor lifetime and stabilizes its performance).
6. Low vapor pressure (increases physical stability).
7. Inert decomposition products in an electric arc (prevents explosion or corrosion following breakdown).
8. Low toxicity of the material and its decomposition products.
9. Low cost.

1. Advantages and Disadvantages of PCB in Capacitors

The PCB capacitor liquids, commonly called askarels, are mixtures of chlorinated biphenyls and chlorinated benzenes. Several standard mixtures are specified by ASTM (5). The askarel capacitor liquids and their decomposition products are non-flammable. Thus their use in capacitors greatly reduces fire and explosion hazards. This characteristic permits economies where safety codes require fireproof enclosures for capacitors containing flammable liquids.

The dielectric constant of the askarels is high compared to other common dielectric liquids. Doubling the dielectric constant of the dielectric allows a reduction by half in the area of the capacitor electrodes, and a significant saving in the cost of construction and installation. The dielectric constant of askarels closely matches that of the capacitor paper.

TABLE 1

TYPICAL PROPERTIES OF LIQUIDS

	Mineral Oil				Polybutenes			Alkarels				
	Uninhibited transf. oil	Capacitor oil	Pipe cable oil	Heavy cable oil	Pipe cable liquid	Paper impregnant	Capacitor liquid					
Viscosity, SUS 25°C					1,200[a]	8,000	200,000[a]					
37.8°C	58.2[a]	103[a]	763[a]	2365[a]				50-42	41-51	62-42	105-240	1500-2500
99-100°C		38[a]	60[a]	101[a]	63[a]	176[a]	2,200[a]	30-31	31-32	36-37	56-57	61-63
Viscosity, cs, 25°C												
37.8°C	9.79	21						4.6	6.9	17.2	45.3	46.4
99-100°C		3.5	10	21				<1.8	<1.8	2.5	3.2	6.1
Flashpoint open cup, °C	146[b]	154.4[b]	196.1[b]	243.3[b]	154[b]	160[b]	252[b]	146.1[b]	153.3[b]	182.2[b]	182.8[b]	none
Acidity, max. KOH/gm	0[c]	0	0[c]	0[c]	0.01[c]	0.01[c]	0.01[c]	0.010 max	0.010 max	0.010 max	0.010 max	0.010 max
Pour point, °C	−45.6[c]	−45.6[c]	−26.1[c]	−17.8[c]	−14[c]	−23[c]	1.7[c]	1.1	−35.5	−19.0	−7.9	10.0
Specific gravity, 15.6°C	0.898[d]	0.907[d]	0.928[d]	0.926[d]	0.862[c]	0.870[c]	0.905[c]					
25°C								1.18	1.26	1.38	1.45	1.54
Coef. of expan., cc/cc/°C	0.00063				0.00078	0.00076		0.00071	0.00073	0.00068	0.00070	0.00066
Thermal conduc., (g-cal/sec)(cm²)(°C/cm)	0.00031[e]	0.00031[e]	0.00030[e]	0.00030[e]								
(BTU/Hr)(ft²)(°F)	0.076[e]	0.076[e]	0.072[e]	0.072[e]		0.062[c]	0.062[c]	0.067	0.063	0.058	0.057	0.054
Boiling point at 760 mm, °C								275.0	290.0	325.0	340.0	365.0
Volatility, weight loss												
Dielectric strength kv/1" (0.254 cm)	32.5[c]	>30[c]	>30[c]	>30[c]	>35[c]	>35[c]	>35[c]	>35	>35	>35	>35	>35
Dielectric constant, 60 Hz												
10^3 Hz, 25°C								4.5	5.7	5.8	5.6	5.0
10^6 Hz					2.14[c,f]	2.16[c,f]	2.22[c,f]					
Dissipation factor 60 Hz	0.001[c,f]	0.001[c,f]	0.001[c,f]	0.001[c,f]	0.0005[c,f]	0.0005[c,f]	0.0005[c,f]					
10^3 Hz, 100°C								0.001	0.001	0.001	0.001	0.001
10^6 Hz												
Volume resistivity, ohm-cm					>1x10[c,g]	>1x10[c,g]	>1x10[c,g]	>5x10[h]	>5x10[h]	>5x10[h]	>5x10[h]	>5x10[h]

Table 2

Physical and Other Properties of Lubricating Oils, Engine Oils, and Hydraulic Fluids

Fluid	Chemical Class or Compound	Viscosity, cs 100°F	Viscosity, cs 210°F	Specific Gravity (Water=1)	Flash Point °F	Fire Point °F	Autoignition[1] Temperature °F	Decomposition Temperature °F
			Mineral Oils					
MIL-2190	Mineral Oil	32.2	5.8	0.86	~450	--	665(5)	--
Harmony 44 (Gulf)	" "	87.6	9.8	0.88	~460	--	680(5)	--
MLO-5731	" " - Naphthenic	--	--	--	--	--	--	640(28)
MLO-7277	" " "	--	--	--	--	--	464(50)	725(30)
MLO-60-294	" " - Paraffinic, deep dewaxed	14	3.15	0.88	385	430	700(27)	~620(30)
Mobil DTE-103	Mineral Oil	124	8.74 to 10.2	0.92	390	--	702, 675(50)	--
MIL-H-6083B	" "	--	--	--	255	--	470(50)	--
MIL-H-5606A	" "	--	--	--	--	--	437(4)	--
MIL-O-5606(Esso Univis J-43)	" "	--	--	--	195	225	437(2)	--
			Glycols and Water Glycols					
Ethylene Glycol	Glycol	8.7	--	--	240	--	856(38)	--
Propylene Glycol	"	19.6	--	--	230	235	835(38)	--
Ethylene Glycol + 50% Water	Water-Glycol	2.2	--	--	--	--	903(38)	--
Houghto-Safe 271	" "	~43	~16(150°F)	1.045	--	--	767(5)	--
" " 520	" "	43.2	25.1(130°F)	1.075	--	--	--	--
" " 620	" "	43.2	29.8(150°F)	1.055	--	--	--	--
Nyvac 20(Mobil)	Water-Glycol and additives	41	--	1.07	--	--	750(51)	--
Irus 902 (Shell)	Water-Oil Emulsion	97.4	51	0.93	--	--	709(51)	--
Ucon 50HB-260	Polyalkylene Glycol	56	--	--	455	500	743(38)	--
Ucon 50HB-280-X	" "	--	--	--	500	600	743(20)	--
Ucon LB-60	" "	10.7	--	--	310	325	653(38)	--
Ucon LB-400-X	" "	--	--	--	--	--	752(20)	--
			Phosphate Esters					
Houghto-Safe 1010	Triaryl Phosphate Ester	18.2	3.9	1.20	505	670	>1200(51)	--
" " 1055	" " "	13.0	8.0	1.145	505	680	1020,810(50)	--
" " 1115	" " "	32.2	4.1	1.165	--	680	>1200(51)	--
" " 1120	" " "	49.8	5.0	1.15	485	690	1020(5)	--
" " 1130	" " "	62.8	6.0	1.145	490	680	>1200(51)	--

Table 2 (Cont)

Fluid	Chemical Class or Compound
MLO-56-582	Octadecyl tridecyl Silane
MLO-56-610	Dodecyl tridecyl Silane
MLO-56-611	Didodecyl dioctyl Silane
MLO-57-9	Tetra undecyl Silane
Tetra (2-ethylhexyl)Silicate	Ethyl hexyl Silicate
Oronite B.F.1	(2-ethylhexyl) Silicate
Oronite 8200	Silicate Ester
Oronite 8515	" "
MLO-54-645	85% Oronite & 15% Plexol
MLO-54-540 (Monsanto OS-45)	Silicate Ester
MLO-54-856 (Hollingshead, 720730)	" "
Versilube F-50	Silicone
Versilube F-44	"
Dow Corning 190	Polymethyl Siloxane
Dow Corning 400	Polymethyl Siloxane
Dow Corning 500	Polyethyl Siloxane
Dow Corning 550	Silicone
Dow Corning 700	Poly (methyl, phenyl) Siloxane
Dow Corning 710	Methyl Phenyl Silicone
MLO-59-98	50% Methyl Phenyl Silicone (DC 550) plus 50% TKP Adipate Tetracoproate
MLO-53-446 (GE 81406)	Chlorinated Silicone
MLO-59-287 (GE F-50)	Chlorophenyl Methyl Silicone
Fluoroluba F-3	Polytrifluorochloroethylene
Pydraul A-200	Chlorinated Hydrocarbon
Arochlor-1248	Tetrachlorodiphenyl
Arochlor-1242	Trichlorodiphenyl
Arochlor-1254	Chlorinated Hydrocarbon

Viscosity, cs 100°F	Viscosity, cs 210°F	Specific Gravity (Water=1)	Flash Point °F	Fire Point °F	Autoignition[1] Temperature °F	Decomposition Temperature °F
	Silanes (Cont)					
33.9	6.8	--	545	595	750(17)	--
26.4	5.6	--	535	575	750(17)	--
23.1	5.0	--	520	555	750(17)	--
29.26	6.11	--	545	600	760(17)	--
	Silicates and Silicones					
--	--	--	--	--	--	638(28)
--	--	--	--	--	~570(12)	--
31.75	11.14	--	385	440	716(2)	--
24.3	8.11	--	390	450	710(50)	--
--	--	--	340	455	716(2)	--
--	--	--	325	430	703(2)	--
--	--	--	315	440	716(2)	--
52	16	1.045	550	640	900(51)	≥600(51)
55	17	1.045	550	640	900(51)	≥600(51)
22.6	--	--	240	--	860(38)	--
10.9	--	--	255	280	610(38)	--
44.9	--	--	470	--	900(38)	--
65 to 87	--	1.065	600	--	--	740(28)
2.8	--	--	305	325	940(38)	--
220	--	1.112	520	--	--	583(15)
61.8	13.5	--	--	--	--	625(30)
	Halogenated Silicones and Hydrocarbons					
--	--	--	380	710	786(2)	514(15)
--	--	--	--	--	--	630(30)
5	--	1.86	--	--	~1205(12)	≥623(51)
49.8	5.0	1.42	350	680	1200(51)	--
43.0	3.2	1.41	380	None	~1185(12)	--
17.7	--	--	350	633	1230(30)	--
--	--	--	--	--	~1085(12)	--

exercized through companies which insure against fire, utilities which supply electrical power, and building codes.

3. Extent of Capacitor Use

Almost all industrial capacitors contain PCBs. In 1968 95 percent of the U. S. production of capacitor liquids (2.46 million gallons) were PCBs (9). Two important types of capacitors are phase correction capacitors on power lines and ballast capacitors for fluorescent lighting. Non-ballast industrial capacitors produced in 1967 had a value of $112 million (10), and fluorescent lamp ballast capacitors produced that year numbered 21.7 million units with a value of $15.5 million (10). In 1970 there were 50.9 million ballast units produced with a value of $163 million (11). These ballast units are in extensive use inside buildings where non-flammability is important.

Phase correction capacitors are necessary on power circuits to correct for the inductive loading of much electrical power equipment. The amount of phase correction capacitance is ordinarily specified in kilovolt amperes of reactive current or kvars. Most power capacitors are rated at from 1/2 to 25 kvars so that the number of capacitors is very roughly the kvar value divided by 10 (12). As examples of the extent of power capacitor use, TVA has 2-1/4 million kvars (13), and a power company serving suburban New Jersey has 3.6 million kvars on their power lines with 1/2 million kvars on order (14). The value of these capacitors is roughly $5 per kvar (14). More than 20 million kvars of power capacitors were produced in 1970 (16).

The procurement lag for these capacitors is 1-1/2 to 3 years, and estimates for redesigning new systems range from 3 to 10 years, according to power company representatives to ASTM Committee D-27 (14,15). Extensive re-designing is anticipated if distribution capacitors were required to use presently available non-PCB liquids. Askarel capacitors have been developed to the point that failures are considered negligible (13, 15).

Several private sources reported extensive efforts to find replacements for PCB capacitor fluids, but none reported having a good substitute.

B. TRANSFORMERS

Most power transformers contain a liquid to electrically insulate and remove heat from the core and windings. The properties required of these liquids are:

1. Non-flammability (required for indoor use and desirable in remote location use).
2. High dielectric strength (prevents breakdown and allows transformer size reduction).
3. Low viscosity (promotes convective heat transfer).
4. High chemical stability (allows higher temperature operation and reduces degradation of the transformer).

flammable liquid. An annual report on such failures is compiled by the Edison Electric Institute (19).

II. INDUSTRIAL FLUIDS FOR HYDRAULIC, GAS TURBINE, AND VACUUM PUMP USES

A. HYDRAULIC

Hydraulic fluids are liquids used as force transmitters (20, 21). The characteristics of a good hydraulic fluid are (20):

1. High lubricity (lowers heating and increases lifetime of moving components).
2. Stability (increases lifetime of use).
3. Appropriate viscosity and high viscosity index (24).
4. Low pour point (necessary for material to flow at low temperatures (25).
5. Compatibility (prevents interactions with other components, for example, rubber seals).
6. Good heat transfer (reduces local heating and large temperature gradients).
7. High bulk-modulus (important for extreme pressure applications).
8. Low volatility (necessary to prevent malfunctioning due to "vapor lock").
9. Low foaming.
10. Low thermal expansion. Aside from the implication of a more constant volume over a wide temperature range, a low thermal expansion implies a high viscosity index and the constancy of certain other properties with respect to temperature.
11. Good demulsibility.
12. Inhibitor (necessary to prevent oxidation of metals or rusting).
13. Good fire resistance (very important in high temperature environments).
14. Low density (desirable in transportation, particularly airborne, applications).
15. Good dielectric properties (reduces arcing or short circuiting should the fluids come in direct contact with electrical components).
16. Non-toxicity (reduces the danger to human beings from rupture of hydraulic equipment or improper disposal and to maintenance personnel during transfer of these fluids).

Since most commercial hydraulic fluid mixtures are proprietary, it is difficult to obtain information with respect to their composition. The results from inquiries with respect to PCB content have been somewhat contradictory. No definite knowledge is available that PCBs are present in commercial hydraulic fluids. Since composition specifications of these fluids are usually not available to the public, PCB content should be established by chemical analysis.

PCBs are useful in hydraulic fluids as lubricating additives in extreme pressure applications (26) and as pour point depressants. Although it is true that the pour point of oils may be lowered by extensive dewaxing, the use of additives is much cheaper. There are other inexpensive additives which are often used for these applications and which appear to be adequate. For

viscosity index, low pour point, and oxidation and foaming resistance. Sample U. S. and U. K. military specifications are given in Table 3 (36). Usually, dibasic acid esters containing appropriate additives meet the above requirements. In the case of the turboprops, the same lubricant is usually used for both the turbine and prop-drive gear.

PCBs would seem to be useful as additives in gas turbine lubricants, but there is no evidence that PCBs are currently used for this purpose. Research along these lines has been done, and there is some indication that some PCBs have on occasion been added to gas turbine lubricants. The objection to PCBs and other chlorinated hydrocarbons is that they tend to be corrosive at the high temperatures reached in gas turbines. This corrosion is accelerated by decomposition of the PCBs and the formation of hydrochloric acid at high temperatures. The corrosiveness of PCBs is a major deterrent against their use in these lubricants. TCP also has the desirable property of reacting with metallic surfaces at high temperatures to form a protective coating.

Jet engines are run for approximately 18,000 hours (37) between overhauls. The lubricants are not usually changed during this period; however, the appropriate "oil level" is maintained at frequent intervals. Immediately before engine overhaul the lubricant is drained and discarded. Unlike the situation with respect to hydraulic fluids used in commercial aircraft, there appears to be no general recycling facility for gas turbine lubricants (37). As a result of their increase in acidity and viscosity during use, recycling of gas turbine fluids would demand expensive redistillation and reblending.

C. VACUUM PUMP APPLICATIONS (22, 23)

Both mechanical and diffusion pump applications require fluids of one highly fractionated component. Accordingly, additives generally are not used. However, PCBs are used in pure form as a diffusion pump oil in commercial applications.

The characteristics (38) of a good diffusion pump fluid are:

1. Relatively high vapor pressure at operating temperatures.
2. Low vapor pressure at room and lower temperatures. (The vapor pressure imposes a lower limit on the ultimate vacuum).
3. Heat resistance (prevents cracking or molecular degradation at operating temperatures).
4. Narrow vapor pressure range and freedom from contaminants such as absorbed gases and liquids with higher vapor pressures. (This requirement often implies the necessity of a narrow fraction).
5. Oxidation resistance (important because air may enter a diffusion pump during operation either accidentally or through slow leakage).
6. Nonhydroscopic (absorbed water increases pump maintenance and may contaminate the vacuum system).
7. Compatibility (must be compatible with pump and vacuum system components).
8. Stability in the presence of the vapor being pumped.

Some of the pertinent properties of many diffusion pump fluids are given in Table 4 (39). The stability, oxidation resistance, appropriate vapor pressures, and, in particular, the relatively low cost of PCBs make them a desirable choice for many industrial applications. Although the ultimate vacuum using

Table 4

Some Properties of Pumping Fluids

Fluid	Proprietary names	Chemical nature	Molecular weight	Specific gravity (room temp.)	Flash point (open °C)	Viscosity (centistokes) at 20°C	Approx. pour point (or freezing point) °C	Approx. boiling point at 1 torr °C	Estimated true vapour pressure (torr)
Apiezon A	As under 'fluid'	Paraffinic hydrocarbons	414	0·872	218	69	−12	190	10^{-9} (20°C)
Apiezon B	" "	" "	465	0·873	235	100	−12	220	5×10^{-9} (20°C)
Apiezon BW	" "	" "	472					225	$\sim 10^{-7}$ (20°C)
Apiezon C	" "	" "	534	0·880	265	295	−9·5	255	4×10^{-9} (20°C)
Apiezon G	" "	" "	445	0·873	232	86	−12	210	2×10^{-7} (20°C)
Apiezon HW	" "	" "	360					165	5×10^{-6} (20°C)
Convoil 10	" "	" "	250	0·91	191	147	−23	150	$6–7 \times 10^{-5}$ (20°C)
Convoil 20	" "	" "	400	0·86	218	320	−8·9	195	$2–3 \times 10^{-7}$ (20°C)
Di-n-butyl phthalate	—	$C_6H_4(COOC_4H_9)_2$	278	1·044	159	19	−71	102	$1·5 \times 10^{-4}$ (20°C)
Di-2-ethyl hexyl phthalate	Octoil	$C_6H_4(COOC_8H_{17})_2$	391	0·983	196	75	−52	204	10^{-7} (20°C)
Di-2-ethyl hexyl sebacate	Octoil-S Narcoil-20 Viacoil-20	$C_8H_{16}(COOC_8H_{17})_2$	427	0·912	209	24	−56	215	10^{-6} (20°C)
Di-nonyl phthalate	Narcoil-40 Viacoil-40	$C_6H_4(COOC_9H_{19})_2$	419	0·973	215			215	10^{-7} (20°C)
Tri-cresyl phosphate	—	$(CH_3C_6H_4)_3PO_4$	368	1·17	240	105		219	5×10^{-6} (25°C)
Tri-xylenyl phosphate	—	$[(CH_3)_2C_6H_3]_3PO_4$	414	1·14	243	160		245	
Glycerol	—	$(CH_2OH)_2CH(OH)$	92	1·26		1180		123	$5·6 \times 10^{-4}$ (15°C)
Mixed chlorinated diphenyls	Aroclor 1248 Convaclor 8 Clophen A-40	Approx. $C_{12}H_5Cl_5$	292	1·45	193	400	−7	137	$1·5 \times 10^{-6}$ (20°C)
Mixed chlorinated diphenyls	Aroclor 1254 Edwards Booster fluid A Narcoil-10 Viacoil-10 Convaclor-12 Clophen A-50	Approx. $C_{12}H_5Cl_5$	326	1·54	none	~6000	10	150	8×10^{-9} (20°C)
Silicone D.C. or M.S.702	As under 'fluid'	Methyl polysiloxanes $(CH_3)_3SiO[(CH_3)_2SiO]_2(CH_3)_2Si$	530	1·071	194	38	−40	173	
Silicone D.C. 703	" "		570	1·039	227	40	−36	206	
Silicone D.C. or M.S. 704	" "	Tetraphenyl tetramethyl trisiloxan	484	1·066	216	47	−38	223	10^{-8} (20°C)
Silicone D.C. or M.S. 705	" "	Pentaphenyl trimethyl trisiloxane	546	1·095	243	170 (25°C)	−15	254	5×10^{-10} (25°C)
Convalex 10 or V.R.T. fluid E	" "	Mixed 5-ring polyphenyl ethers	447	1·198	288	2500 (25°C)	4·5	285	$1·3 \times 10^{-8}$ (25°C)
Mercury	—	Hg	200·6	13·6	—	1·15	−38·9	127	$1·1 \times 10^{-3}$ (20°C)

toxicity, a tendency to decompose to form highly corrosive HCl, a lower decomposition temperature than some alternate liquids (43) and relatively poor radiation resistance (44).

B. REPLACEABILITY OF PCBs AS HEAT TRANSFER FLUIDS

Increased risk from fire and explosion is a major disadvantage with most PCB replacement fluids. Other non-flammable fluids are: 1. fluorocarbons, which have low toxicity, high thermal stability, and in spite of high cost are used as convective or evaporative coolants (1), 2. water, which is quite corrosive, has a high temperature limit of 374°C and requires extremely expensive high pressure systems for its use above the atmospheric boiling temperatures and 3. molten salts and metals which, because of their resistance to radiation damage, are useful in reactor applications.

Several liquids are more stable at high temperatures than the PCBs. Table 5 (42) shows the decomposition point range of liquids in a variety of chemical classes. Few of these liquids are non-flammable, however, as can be seen from Table 2. The phosphate esters, silanes, and aromatic ethers have high fire points (around 600°F), but they are flammable and it is not clear how high the fire point must be for a fluid to be safe in a high temperature system, especially in the event of leakage into a furnace. The details of specific heat transfer applications are necessary to evaluate the suitability of PCB replacement fluids.

IV. PLASTICIZER AND MISCELLANEOUS USES +

A plasticizer is a material incorporated in a plastic to increase its workability and flexibility (45,46). The addition of a plasticizer may lower the melt viscosity and flow temperature (increasing the ease with which the plastic can be made to flow),or lower the elastic modulus (making the plastic softer) (46). Plasticizers are generally non-volatile liquids or low-melting solids. A major requirement of a plasticizer is that it have high compatibility* (mixes will to form a homogenous composition with useful properties) (42) with the material being plasticized. Figures are given in Table 6 for the compatibility of some common plasticizers with some common synthetic thermosetting or thermoplastic resins (45). Other properties which are important when considering plasticizers are specific gravity, refractive index, color, odor, moisture sensitivity, vapor pressure (volatility), boiling range, stability (to light and heat) toxicity and cost (47). Of course, the properties of the final plasticized material are of prime importance. Certain plasticizers provide formulations with specific properties such as:

1. phthalate esters - general purpose.
2. adipates and ozelates - low temperature flexibility.
3. highly aromatic esters - fast processing, strain and extraction resistance.
4. epoxies - heat stabilization during processing.
5. phosphate esters and PCBs - fire retardant materials.

+ The information in this section about specific uses was obtained from Chemical Abstracts (1928-1969) and patent claims. The Task Force has no knowledge whether or not specific applications are in current production or use.

* Note that the term "compatibility", used here, has a meaning very different from its use earlier in this appendix. In the earlier case, compatibility meant that two materials could coexist without either being affected by the other. The present meaning is quite the opposite.

Table 6. Approximate Maximum Compatibility, phr[+], of Plasticizers with Various Resins

	Phthalates						Adipates		Phosphates				Phthalyl glycolates			Polyesters				Epoxides	Sulfonamides		Miscellaneous		
	Dimethyl	Dibutyl	Di-2-ethylhexyl	Ditridecyl	Dicyclohexyl	Butyl benzyl	Di-2-ethylhexyl	Diisodecyl	Triphenyl	Tricresyl	2-Ethylhexyl diphenyl	Tri-2-ethylhexyl	Tributoxy ethyl	Methyl phthalyl ethyl glycolate	Butyl phthalyl butyl glycolate	Santicizer 405	Santicizer 409	Paraplex G-25	Paraplex G-54	Paraplex G-62	N-Ethyl-o,p-toluene sulfonamide	o,p-Toluene sulfonamide	Chlorinated biphenyl	115–40	Polyethylene glycol di-2-ethylbutyrate
poly(vinyl chloride)	100	100	100	100	30	100	100	50	20	100	100	100	60	20	100	100	100	100	100	100	40	1	35	40	100
poly(vinyl acetate)	100	100	1	1	50	100	1	1	80	40	50	1	40	100	100	75	100	11	11	3.1	1	100	50	50	1	25
poly(vin. chloride chloride)	50	75	25	10	20	75	15	10	20	75	75		50	75	75	10	25					50	20	50	20	
polystyrene	100	100	50	100	20	100	100	25	20	15	50		100	50	30	1	50					20	10	100	100	
ethylcellulose	100	100	100	100	50	100	100	100	30	50	100	100	50	75	75	10	35	1	1	<1	100	60	75	75	100	100
cellulose nitrate	60	100	100	100	50	100	35	35	75	100	100	100	100	100	100	100	100	100	100	100	100	80	50	100	10	100
cellulose acetate	80	25	1	1	1	10	1	1	35	15	20	<1	10	100	50	1	1	1	1	1	1	90	30	1	1	1
cellulose acetate butyrate	100	100	50	50	20	100	25	50	50	30	80	<25	25	100	50	100	100	1	1	100	1	50	25	50	30	
chlorinated rubber	25	100	30	100	20	80	100	100	50	100	100		100	100	80	50	50		100	100	100	50	25	100	100	
high styrene-butadiene copolymer	20	50	50	50	20	50	20	20	20	50	50		50	50	50	15	25					25	25	50	25	
protein-based plastics	20	20	1	1	1	10	1	1	10	30	25		10	20	40	1	1					50	40	1	1	
shellac	5	1	1	1	1	1	1	1	1	1	1		1	10	30	1	1					40	60	1	1	
acrylic resins	100	70	25	25	25	75	10	1	25	25	100	100	25	60	70	1	1	1				25	25	10	20	25
polyamides	1	25	25	20	10	25	25	25	10	25	25		15	1	20	1	1					50	25	25	1	
polyesters	5	20	20	15	20	20	1	1	10	20	20		20	5	20	5	10					10	5	25	1	
epoxy resins	1	25	1	1	10	25	1	1	10	25	25		25	25	25	1	1					50	50	50	1	
phenolic resins	25	50	25	25	25	50	25	25	50	50	50		50	50	50	15	25					50	50	25	25	
alkyd resins	25	50	25	25	25	50	50	25	50	70	70		50	70	70	20	25					25	25	25	15	
melamine formaldehyde resins	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1					50	80	1	1	
polyurethan	25	25	25	25	10	25	15	15	10	25	25		25	25	25	10	15					20	10	25	15	
nitrile and neoprene rubber	100	100	50	33	50	100	20	33	50	55	40		50	50	50	25	50		33			50	50	50	50	

* Trademark Monsanto Co.
* Trademark Union Carbide Corp.
* Trademark Rohm and Haas Co.

[+] parts per hundred

Table 7.

Material	Form and color	Specific gravity
Aroclor 1221[a]	colorless, mobile oil	1.182-1.192 (25/15.5°C)
Aroclor 1232	almost colorless, mobile oil	1.270-1.280 (25/15.5°C)
Aroclor 1242	almost colorless, mobile oil	1.381-1.392 (25/15.5°C)
Aroclor 1248	yellow-green tinted, mobile oil	1.405-1.415 (65/15.5°C)
Aroclor 1254	light yellow, viscous oil	1.495-1.505 (65/15.5°C)
Aroclor 1260	light yellow, soft, sticky, resin	1.555-1.566 (90/15.5°C)
Aroclor 1262	light yellow, sticky, clear resin	1.572-1.583 (90/15.5°C)
Aroclor 1268	white to off-white powder	1.801-1.811 (25/25°C)
Aroclor 1270	white crystalline powder	1.911-1.960 (25/25°C)
Aroclor 4465	transparent, yellow, brittle resin	1.670 (25/25°C)
Aroclor 5442	yellow, transparent, sticky resin	1.470 (25/25°C)
Aroclor 5460	clear, yellow-to-amber, brittle resin	1.670 (25/25°C)
Aroclor 2565	black, opaque, brittle resin	1.734 (25/25°C)

[a] ASTM D-20 (modified). [b] Cleveland open [c] ASTM E-28. [d] Saybolt Universal, ASTM D-88. [e] Hold point on solidification.

General Properties of Some Aroclors (PCB)

Distillation range,[a] °C (corr)	Flash point,[b] °C	Fire point,[c] °C	Pour point,[d] °C	Softening point,[e] °C	n_D^{20}	Viscosity,[f] sec	
						37.8°C	98.9°C
275-329	111-150	176	crystals at 1°C		1.617-1.618	28-40	30-31
290-325	152-154	218	−35.5		1.620-1.622	44-51	31-32
325-366	170-180	none	−19		1.627-1.629	62-92	34-35
340-375	193-196	none	−7		1.630-1.631	185-210	36-37
365-390	none	none	10		1.639-1.641	1890-2500	44-48
385-420	none	none	31		1.647-1.649		72-78
395-425	none	none	35-38		1.6501-1.6517		86-100
435-450	none	none		150-170[g]			
450-460	none	none		240-300[g]			
230-320 (4 mm Hg)	none	none		60-66	1.664-1.667		90-150 (130°C)
215-390 (4 mm Hg)	247	>350	46	46-52			300-400
280-345 (5 mm Hg)	none	none		98-105.5	1.600-1.665		
	none	none		66-72			

[a] Cleveland open cup; none indicates no fire point up to boiling temperature. [b] ASTM D-92. [c] Last two digits indicate approximate chlorine content, ie, Aroclor 1221 contains about 21% Cl, etc.

D. SEALANTS

Sealing and caulking compositions include a wide range of compounds which can be used to seal joints or voids against water and water vapor, air and other gases, dust, sound, vermin, heat and cold (88). Specialized applications require resistance to certain chemicals or atmospheric environments. PCBs can be used as plasticizers in the formulation of putties from copolymers or ethylene-vinyl acetate or styrene (89). The products are non-hardening, and resistant to moisture and frost and show good weatherability A non-sticky, non-hardening putty was also prepared from polysulfide mixtures which employs PCB as the plasticizer. This putty gave good bonding to building materials and had good extrudability and shape retention (90). Elastic pavement or concrete sealing compositions, used for traffic markings, were prepared from coal-tar-polysulfide mixtures which are plasticized with PCB (91). A sealant, effective for concrete and asphalt applications, can be formulated from a mixture of polysulfide, chlorinated rubber, and polyisocyanate, and plasticized with PCB (92).

E. PRINTING

Chlorinated biphenyls have been employed as part of the formulations used to prepare pressure-sensitive record (93, 94) and colored copying papers (95, 96, 102, 103). They have been used to coat papers used in thermographic duplicating processes (97-101) as well as in xerographic transfer processes (104, 105). Solvent-free printing on polyolefin plastics can be accomplished by heating a mixture of low molecular weight material, chlorinated biphenyl or terpene resin, and suitable pigments and dyes. Durable prints can be made on the surface of the polyolefin at the time of their thermoplastic shaping (106). Printing plates, hard enough for high quality letterpress printing, and sufficiently flexible for use as flexographic plates, can be prepared from compositions containing a liquid resin such as epoxy, polyester, urethan, acrylic or vinyl with an excess of curing agent and PCB as the plasticizer (107). The extent, if any, of current uses of PCBs in printing application is unknown.

F. FIRE RETARDANT AND FLAME-PROOFING COMPOSITIONS

When PCBs are used as plasticizers, they impart a certain degree of non-flammability to the objects as described previously. However, for increased effectiveness in flame retardant applications, the PCBs can be admixed with various metal oxides. Some flame retardant compositions based upon these mixtures are: polyolefin yarns (108); organopolysiloxane sealants (109); thermoplastic poly (hydroxylethers) (110); fireproof panels made from starch which can be used for doors, floors, ceilings, and partitions (111); polyamides (112); and in fireproof fiberboards (113). Rigid polyurethane foams (114-116) and hardboard compositions (117), when treated only with PCBs do not show any significant increase in flame retardance.

G. MISCELLANEOUS APPLICATIONS

The wide range of chemical and physical properties exhibited by the PCBs (see Tables 6 and 7) make them desirable for an assortment of miscellaneous uses. Some of the more interesting and non-conventional uses are as follows:

transformers would require considerable time and money for reengineering, manufacture, and application of substitute equipment.

PCBs are useful in hydraulic systems where leakage onto hot metal surfaces could cause a dangerous fire. Hydraulic fluids can also be made with phosphate esters which are toxic and which will burn at high temperatures. Replacement of PCBs in some hydraulic systems could increase loss of life due to fire. Gas turbines require lubrication at high temperatures. PCBs can be used but tend to be corrosive. Phosphate ester lubricants seem better in this respect. Chemical stability is more important for high temperature lubricants than is non-flammability. PCB fluids are useful in diffusion booster pumps to produce moderately high vacuums with relatively poor fore vacuums. Non-flammability is not especially important for diffusion pump liquids, and with a few possible exceptions alternative liquids are available.

Flammable heat transfer fluids present a fire hazard if they leak into a furnace or onto hot surfaces. The use of PCBs can prevent this danger. In some cases water is a suitable substitute at moderately high temperatures. Other heat transfer fluids are commercially available and in use. Replacement of PCBs is satisfactory in some, but may be dangerous in other heat transfer uses.

The PCBs are good plasticizers for use with adhesives, textiles, surface coatings, sealants, and copy paper. In some cases the PCBs act as fire retardants. There are no particularly unique properties of PCBs for plasticizer uses, and equally effective alternatives are generally available (e.g. phosphate esters are often used as fire retardants). The extent of current use, if any, in such applications has not been determined.

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APPENDIX C

The Need For Continued Use of PCBs As Electrical Insulating Liquids

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Tables

TABLE 2

Composition of Different Liquid Chlorinated Biphenyls

Components - given as % -	Monsanto Aroclors							
	1221	1232	MCS 1043	1242	MCS 1016	1248	1254	1260
Chlorine	21	32	32	42	42	48	54	60
Biphenyl	14.8		.04	.02	.02			
Mono-chlorobiphenyl	56.5		22.2	.72	.93			
Di-chlorobiphenyl	26.9	~ 55	74.4	15.6	19.4			
Tri-chlorobiphenyl	1.42		3.3	54.5	64.5			
Tetra-chlorobiphenyl	.06			22.5	15.0	~ 55		
Penta-chlorobiphenyl				6.7*	.16*		60	
Hexa-chlorobiphenyl								70

*Includes higher than penta-chlorinated isomers.

III. THE NEED FOR PCBs IN CAPACITORS

PCBs are used in more than 90 percent of the electric utility (large power) type and smaller industrial type capacitors made today. They are needed for safety, reliability and long life, and to achieve sizes compatible with equipment and installation requirements.

The principal types of PCB-impregnated capacitors and their applications are high voltage power capacitors used primarily for power factor correction in the distribution of electric power; low voltage power capacitors installed in industrial plants at the load (typically large motors); ballast capacitors to improve the efficiency of lighting systems; and small industrial capacitors for power factor improvement in such equipment as air conditioning units, pumps, fans, etc. Almost 80 million such capacitors are manufactured annually, most of them for first-time use.

Capacitors used in lighting and air conditioning applications contain 0.005 to 0.09 gallons of PCB per unit. The largest power capacitors contain about 6.7 gallons of askarel. The most popular size contains about 3.1 gallons. The National Electrical Code requires that any installation of capacitors in which any single unit contains more than 3 gallons of combustible liquid shall be in a vault like that required for transformers. During 1968, the last complete "normal" year for the electrical industry, the total amount of PCBs used in capacitors was approximately 14.4 thousand tons.

Possible alternatives to PCB-impregnated capacitors are capacitors impregnated with mineral oil, or certain other liquids.

A. MINERAL OIL

1. Size

The single most important property of a liquid to be used in a capacitor is its dielectric constant (the ratio of its ability to store electrostatic energy relative to air). The dielectric constant of the capacitor-grade PCB (Aroclor 1242) is 5.85 while that of mineral oil is 2.25. (See Table 3) Reverting to an oil-paper dielectric system would increase the average capacitor volumn(size) by approximately 600 percent the weight by 500 percent, and the cost by approximately 400 percent. At the present levels of demand for capacitor KVAR, there would be a shortage of electrical grade paper and a shortage of capacitor factory facilities further tending to increase the cost to the utility, and ultimately to the consumer.

2. Reliability and Life

PCBs are thermally and oxidatively more stable than mineral oils, and discharges, which can occur in capacitors, are less likely to generate gases from askarels than from mineral oils. The chemical stability of PCBs in the presence of capacitor tissue and plastic films and the favorable stress distributions between solid and liquid have made it possible to design low-cost capacitors with a life expectancy of more than 10 years life in lighting applications and more than 20 years in electric utility applications. In each application the first-year failure rates are less than 0.2 percent. This level of life and reliability had not been achieved prior to the introduction of PCBs.

3. Safety

The relative non-flammability of PCBs significantly reduces the fire hazard that might otherwise accompany those failures that result in rupture of the case.

B. OTHER LIQUIDS

1. Castor Oil. The dielectric constant of castor oil is 4.5, and this material is useful as an impregnant in D.C. energy storage capacitors. However, A.C. capacitors filled with this liquid have relatively short lives and are not very stable under A.C. discharges and in the presence of water derivable from the cellulosic paper.

2. Dibutyl sebacate. This ester is especially useful in high frequency parallel plate capacitors because of its low, flat loss characteristics over a broad frequency range. In this type of construction the liquid is the sole dielectric material. When used in conjunction with paper, this ester is also unstable.

3. Silicone Fluids. These materials have a dielectric constant of 2.7 and would generally be subject to the same disadvantages as mineral oil.

In the interest of achieving a higher degree of environmental compatibility the capacitor industry switched during 1971 from Aroclor 1242 to Aroclor MCS 1016, from which the higher-chlorinated persistent fractions have been substantially removed.

IV. ENVIRONMENTAL PROTECTION

The advantages to the public in terms of safe, reliable, and efficient electrical equipment made possible by the use of PCBs have been documented in the body of, and especially Appendix B to, this report. It is also clear that there are no present or prospective substitutes for these materials, and that the functions they perform are essential. Thus the continuing need for PCBs in closed electrical system applications is conclusive. The electrical industry well understands, however, that continued use of these materials requires unusual protective measures. These measures were the subject of recommendations made by a previous NIPCC Sub-Council report (The Use and Disposal of Electrical Insulating Liquids, June 1971) and are judged to be well on their way toward implementation: witness the introduction of the new capacitor dielectric, the provision of facilities for the incineration of liquid and solid wastes, and the instructions to operating personnel and users regarding the need for care in waste disposal, an activity now being further formalized and strengthened by ANSI's committee C107. The annual residual leakage to the environment from the continued use in transformers and capacitors has been estimated between one part in a thousand and one in ten thousand of the existing environmental PCB burden.

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1. The above paper was prepared by the Electric and Nuclear Sub-Council, National Industrial Pollution Control Council: Chairman, D. C. Burnham, Westinghouse Electric Corporation; Vice Chairman, Fred J. Borch, Chairman and Chief Executive Officer, General Electric Company; Members: A. P. Fontaine, President and Chairman, The Bendix Corporation; Raymond H. Giesecke,

APPENDIX H

Regulatory Action on PCBs

Table of Contents

Tables

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Shrimp are very sensitive to PCBs and most will die as a result of 20-day exposure to a concentration of 5 parts per billion. PCBs also inhibit shell growth of oysters. Crabs are less sensitive; all accumulate residues to many times the concentrations in the water, and a test with crabs showed that they lost the residues very slowly.

Growth of certain species of marine diatoms was experimentally inhibited by PCBs, but algae were not affected.

The small marine crustacean, Gammarus, is sensitive to PCBs in concentrations of thousandths to tenths of a part per billion.

Exposure to 5 parts per billion of Aroclor 1254 caused mortality of two species of fish in 14-45 days. Onset of death was delayed and was accompanied by fungus-like lesions.

Rainbow trout were quickly killed by polychlorinated terpheryls at 10 parts per billion under normal oxygen conditions and at 2 parts per billion with reduced oxygen.

Metabolic changes of PCBs have been suggested by environmental observations of different isomeric patterns in animals of different trophic levels. Quantitative differences also are pronounced, with magnifications of hundreds to thousands of times.

Laboratory studies have shown no metabolic changes of PCBs by crabs and shrimps, minimal changes by fish, and pronounced changes by birds.

PCBs induce microsomal enzyme activity in birds. Exposure to PCBs increased the susceptibility of mallard ducklings to duck hepatitis virus.

Offspring of pheasants whose parents received high dosages of PCBs made poor choices in visual cliff tests. Egg production and hatching after pipping also were affected. Migratory restlessness was increased in English robins exposed to PCBs.

Long-term studies of the reproductive effects of Aroclor 1254 on mallards and bobwhite quail and of Aroclor 1254 plus DDE on quail showed no significant differences from controls. In studies of chickens, however, egg production and hatchability were impaired by high doses of Aroclor 1254 and by low doses of Aroclor 1242.

Statistical evaluations of the role that different chemicals may play in thinning eggshells of brown pelicans showed that DDE residues correlate better with shell thinning than do residues of dieldrin or PCBs, confirming observations with cormorants and white pelicans.

IV. CONCLUSIONS

PCBs are man-made biologically active substances that are dispersed throughout the environment and stored in the tissues of animals. They are lethally toxic to fish and aquatic invertebrates in concentrations measured

Mallard ducklings demonstrated the possibility of interacting effects between PCBs and disease organisms (Friend and Trainer, 28). Thirty-five to 44 percent of the 10-day-old ducklings exposed for 10 days to a dietary dosage of 25, 50, or 100 parts per million of Aroclor 1254 died upon subsequent exposure to duck hepatitis virus in contrast to only 14 percent of the birds exposed only to the virus.

Swedish robins (Erithacus rubecula) given 5 micrograms of Clophen A50, for 11-13 days showed a greater migratory restlessness than controls (Ulfstrand and Södergren, 29).

Pheasant hens absorbed 94 percent of the Aroclor 1254 given as a single capsule dose, a very efficient entry of this chemical into the system (Dahlgren, et al., 30). Residues in muscle declined 82 percent in 28 days after dosage. Residue were excreted in both eggs and feces.

Residues in the milk of cattle inadvertently exposed to PCBs declined at the rate of 1.3 percent per day when uncontaminated feed was restored (Fries, et al., 31). The rate of loss of DDE residues was identical. PCBs in milk fat decreased from 12.6 parts per million to 5.8 parts per million in about 3 weeks and to 2.1 parts per million in about 4 months.

A cow given 10 mg/kg of Aroclor 1254 in a single dose released an average of 3.9 parts per million into the whole milk during the next 4 days' milking. A dosage of 100 mg/kg produced 36 parts per million in the milk of another cow (Platonow, et al., 32). The gas chromatographic pattern of the Aroclors in the milk was very similar to that of the fed compound.

B. REPRODUCTION

Pheasants given a capsule dose of 50 mg of Aroclor 1254 weekly for 17 weeks produced fewer eggs than controls, and a higher percentage of chicks pipped the shell but did not hatch (Dahlgren and Linder, 33). Chicks that hatched weighed less and survived more poorly than controls. Eggshell thickness was not affected. In behavioral tests of the offspring on a visual cliff, more of the chicks from the dosed parents made the undesirable choice of jumping to the deep side, or made no choice, in the 5-minute test period. None of these effects occurred among the groups whose female parents were dosed with 12.5 mg.

Mallards fed a dietary dosage of 25 parts per million of PCBs from about 11 weeks before their first breeding season and through their second year laid eggs with shells of normal thickness (Heath, et al., 1). The number of eggs laid, hatchability, and survival of young did not differ significantly from the untreated controls. In another test, mallard ducks fed 10 or 500 parts per million of Aroclor 1254 in the diet for about 5 weeks laid eggs with normally thick shells. Bobwhite quail fed diets containing 50 parts per million of PCBs, or 30 parts per million of DDE, or a combination of 25 parts per million of PCBs plus 15 parts per million of DDE for about 11 weeks before their first breeding season reproduced as well as controls.

Ring doves (Streptopelia risoria) fed 10 parts per million of Aroclor 1254 for 6 months laid eggs no lighter than those laid by control birds. (Peakall, 34). Fourteen birds fed 10 parts per million of PCBs before and after dosage and nine birds injected intraperitoneally with 160 mg/kg 1-4 days before egg laying confirmed the lack of effect of PCBs on shell weight.

faster than those with more chlorines, so that the latter were subject to greater increase in the food chain (Jensen, et al., 19).

In two simple food chains, fish to eagles (Haliaeetus albicilla) and fish and mussels (Mytilus edulis) to seals (Phoca vitulina and Pusa hispida), concentrations increased hundreds to thousands of times from prey to predator (Jensen, et al., 19). Fish contained hundredths to tenths of parts per million; fresh mussels contained hundredths of parts per million; seal blubber contained 5-21 parts per million; and the muscle of the white-tailed eagle contained 150-240 parts per million.

In Great Britain, birds that feed on birds or mammals contained the highest concentrations of PCBs, those that have a mixed diet contained the next highest, and those that feed on insects had the lowest (Prestt, et al., 3). The fish-eating herons from the southeast of England contained higher residues of PCBs than birds of any other area.

Many species of California birds contained hundredths to tenths of parts per million of PCBs; peregrines (Falco peregrinus) contained greater amounts, one as high as 98 parts per million in muscle (Risebrough, et al., 20), while fish in the same area contained only thousandths of parts per million.

Residues of PCBs in the industrially polluted Escambia Bay increased in the expected order. Water contained a maximum of 275 parts per billion, and sediment a maximum of 486 parts per million. Oysters (Crassostrea virginica) contained 2-3 parts per million, shrimp (Penaeus duorarum) 1.5-2.5 parts per million, blue crabs (Callinectes sapidus) 1-7 parts per million, and pinfish 6-12 parts per million (Duke, et al., 15).

Subsequent samplings from three stations in the Bay showed little change in concentrations of PCBs in sediments even after 9 months (Nimmo, et al., 21). Experiments were then undertaken that showed that shrimps (Penaeus duorarum) and fiddler crabs (Uca minax) could accumulate Aroclor 1254 from the sediments. Relationships between concentration of PCBs in sediment and concentration in crabs and shrimps were variable. The maximum accumulation was from sandy silt containing 61 parts per million (dry weight) of Aroclor 1254; fiddler crabs accumulated 80 parts per million (wet weight) in their bodies; shrimp accumulated 240 parts per million (wet weight) in the hepatopancreas. Some PCBs were present in the water and a portion of the accumulation could have been from that source. The ratio of individual PCB isomers maintained integrity in the sediments and tissues of test animals throughout the investigation, indicating no pronounced metabolic changes of the PCBs.

Spot (Leiostomus xanthurus) exposed to 1 part per billion of Aroclor 1254 for 56 days attained maximum concentrations in 14-28 days, although absolute amounts continued to increase as the fish grew (Hansen, et al., 17). Maximum concentration in whole spot was 37,000 times that in the test water. These results were very similar to those for DDT reported earlier from the same laboratory. The PCBs were lost slowly from the tissues of spot after they were placed in clean flowing water. After 84 days of flushing, the concentration had dropped 73 percent and the absolute amount had dropped 61 percent. Isomers of Aroclor 1254, with the exception of one peak, maintained their integrity in spot.

1. Residues in Birds Killed by PCBs. Chickens killed by PCB dosage in the studies of(Vos and Koeman, 8) generally contained from 120 to 420 parts per million in the brains, but the overall range was from 40 to 700 parts per million. Residues in livers were 120 to 2,900 parts per million.

Coturnix quail poisoned by PCBs (Phenoclor DP6) contained residues of 342-1710 (av. 1158) parts per million in the brain and 1079-8350 (av. 3280) parts per million in the liver (Koeman, 11).. Bangales finches killed by PCBs had residues of 70 to 697 parts per million in the livers; those sacrificed at the end of the experiment contained 3 to 634 parts per million (Prestt,et al., 8). Residues in brains were somewhat lower; the proportional amount in the brain in comparison with the amount in the liver averaged higher in the birds that died than in those that were sacrificed.

A bald eagle found sick in the field contained high residues of both DDE and PCBs in its brain, suggesting that PCBs may have contributed to its death. Residues of DDE in the brain were 385 parts per million, which is within the lethal range for DDE (Stickel et al., 12). However, the brain also contained 230 parts per million of PCBs, 6 parts per million of DDD, 2.2 parts per million of dieldrin, and 0.4 parts per million of heptachlor epoxide.

B. INSECTS

The toxicity of PCBs to insects also is related to the chlorine content, but in the reverse order to the result with birds. PCBs with lower amounts of chlorine were more toxic to flies than PCBs with higher chlorine content, and the toxicity of mixtures with more than 48 percent chlorine was very low (Lichtenstein et al., 11). Toxicity of dieldrin and DDT was enhanced beyond an additive effect by the addition of the lower chlorinated PCBs.

Topical applications of Aroclor 1254 to a grasshopper (Clorthippus brunneus) produced delayed mortality that occurred at the time of molt (Moriarty, 14).

C. FISH AND AQUATIC INVERTEBRATES

Shrimp (Panaeus duorarum) are sensitive to low concentrations of PCBs (Duke,et al., 15). All individuals died as a result of a 48-hour exposure to flowing seawater containing 100 parts per billion of Aroclor 1254; 80 percent died in 24 hours. These shrimp accumulated 3.9 parts per million in their tissues. Shrimp exposed to 10 parts per billion did not die, but accumulated 1.3 parts per million of PCBs in their tissues.

Seventy-two percent of the juvenile shrimp died from a 20-day exposure to 5 parts per billion of Aroclor 1254 and the tissues accumulated 16 parts per million. Crabs (Callinectes sapidus) were less sensitive, but accumulated an average of 23 parts per million in a 4-week exposure at 5 parts per billion and still contained 22 parts per million after a week in clean water and 11 parts per million after 4 weeks in clean water.

The small crustacean,(Gammarus oceanicus) had a lethal threshold in 30-day tests between 0.001 and 0.01 parts per billion in colloidal solution and between

APPENDIX G

Biological Data On PCBs In Animals Other Than Man

Polychlorinated biphenyls have become ubiquitous in the world ecosystem in quantities similar to those of DDE. Their presence has caused concern and stimulated research to evaluate their role in the biosphere.

The significance of PCBs to wild animals depends upon both their lethal toxicity and their sublethal physiological effects. These are the subjects of the present paper. Coordinate knowledge of level of exposure, as shown by frequency and levels of occurrence of PCBs in the environment, is essential to complete the understanding. These are summarized elsewhere in this report.

I. TOXICITY

Outright mortality of wild animals can affect populations, particularly those of long-lived species. Measurements of direct toxicity are therefore important first steps in evaluation of a chemical. Other laboratory studies also are needed for proper interpretation of field observations. These include studies to diagnose cause of death by behavior of poisoned animals, tissue changes, and concentrations of chemical in critical tissues.

A. BIRDS

The toxicities of different PCBs to pheasants (Phasianus colchicus), mallards (Anas platyrhynchos), bobwhite quail (Colinus virginianus), and coturnix quail (Coturnix coturnix) were compared with the toxicities of DDT, dieldrin, and other insecticides (Heath, et al., 1). Tests of six PCB mixtures, containing 32 to 62 percent chlorine, showed that the toxicity increased with the percentage of chlorine. In general, toxicities were similar to those of DDE. There were some differences in sensitivity of the species. Bobwhite were most sensitive, followed in turn by pheasants, mallards, and coturnix quail. Bobwhite were 3-4 times as sensitive as coturnix. Special tests with coturnix quail showed that the toxic effects of DDE and Aroclor 1254 were additive but not synergistic.

In other studies, Aroclor 1254 was approximately as toxic as DDE to four species of blackbirds: grackles (Quiscalus quiscula), cowbirds (Molothrus ater), starlings (Sturnus vulgaris), and redwings (Agelaius phoeniceus) (Dustman, et al., 2). Redwings were somewhat more susceptible to DDE than to PCBs. Signs of poisoning were sluggishness with slight tremors of moderate amplitude, much as with chemicals of the DDT group. Internally, livers frequently had hemorrhagic streaks or spots, and the gastrointestinal tract commonly contained blackish fluid, but these signs were not sufficiently consistent for distinctive diagnosis.

Aroclor 1254 was approximately 1/13 as toxic as DDT to Bengalese finches (Lonchura striata) (Prestt, et al., 3). Tremoring and other signs were similar to those observed among blackbirds; the finches had enlarged kidneys and some had hydropericardium.

62. Aulerich, R. J., R. K. Ringer, H. L. Seagran and W. G. Youatt, Can. J. Zoology 49 (1971) 611.

63. Wilson, W. E. and C. Sharp, NIEHS (1971); Studies in progress.

64. Spalding, J. W., NIEHS (1971), Studies in progress.

65. Courtney, D. C. and Chernoff, N., Personal Communication, Nov. 15 (1971).

66. Fujita, S., H. Tsuji, K. Kato, S. Saeki and H. Tsukamoto, Fukuoka Acta Medica 62 (1971) 30; C. A. 75 (1971) 3797.

Dr. G. J. Love (61) of EPA has reported that 72 sets of specimens (blood, urine, and hair) collected from 36 workers occupationally exposed to burning automobiles or refuse dumps and from an equal number of controls are to be collected and analyzed for PCB levels.

It is of interest to note the analysis of PCB in human adipose tissue. Biros and co-workers (48) examined two human adipose tissue samples by combined GLC-mass spectrometry and found substantial quantities of PCBs ranging from pentachlorobiphenyl to decachlorobiphenyl and including at least 14 isomers and chlorine homologs. The samples were estimated to contain 200 parts per million and 600 parts per million total PCB, respectively, as determined by electron-capture gas chromatography.

IV. STUDIES IN PROGRESS

Curley and co-workers (37) have described results in a study with Aroclor 1254 to determine placental transfer, rates of excretion in milk and consequent tissue distribution and storage levels in fetuses and weanling rats following oral dosage to the mother daily on the 7th through the 15th day of gestation at 10 mg/Kg, respectively, by stomach tube. Table 11 lists the experimental protocol for the above studies. This is summarized as follows:

Fetus Analysis: Samples were taken by Caesarian section on the 20th day of pregnancy. The mean concentrations of Aroclor are given for the respective dosages as parts per million.

	Controls	10 mg/Kg	50 mg/Kg
Mother 1	0	1.42	2.42
Mother 2	0	1.24	2.90
Mother 3	0	1.14	2.93

10 mg/Kg

	Wt. at onset (gms)	Age (days)
Mother 1	254	90
Mother 2	265	90
Mother 3	258	90

50 mg/Kg

Mother 1	242	90
Mother 2	244	90
Mother 3	261	90

TABLE 4 - OBJECTIVE SAMPLES - CY 1971
for PCB's

SUMMARY
PPM - fat Basis

ANIMAL AND POULTRY TISSUE CY 1971

Class	N.D.	.01-.1	.11-.50	.51-1.5	1.51-3.0	3.01-5.0	5.01-7.01	7.01-15	Over 15
Animals	2379	1	9	11	4				
Poultry	1664	4	25	53	23	4	5	15	11

PCB RESIDUES IN ANIMAL AND POULTRY
TISSUES COLLECTED IN OBJECTIVE PHASE
DURING CY 1971

Animal or Poultry	Number of Samples Analyzed	Number of Samples with A Residue	Percent of Samples with A Residue	Number of Samples Exceeding Guidelines	Percent of Samples Exceeding Guidelines
Cattle	722	9	1.2	0	0.0
Calves	66	4	6.1	0	0.0
Swine	1436	7	0.5	0	0.0
Sheep	180	5	2.8	0	0.0
Young Chickens	1637	127	7.8	2	0.1
Mature Chickens	69	5	7.2	0	0.0
Turkeys	88	8	9.0	0	0.0
Ducks	10	0	0.0	0	0.0
	4208	165	3.9	2	0.04

packaging material was identified as the source of PCB in the food. The manufacturer of the packaging material used about 95 percent recycled paper to manufacture paperboard containers. FDA analysis of different types of the firm's paperboard showed PCB levels ranging from about 2 to 433 parts per million. Various types of packaged food products, some of which used this firm's paperboard, were also analyzed as part of FDA's investigation. Nine samples of the 28 packaged foods examined contained PCBs in the food portion.

As a result of this limited investigation, FDA initiated a nationwide survey in September 1971, to determine the extent of the PCB food packaging problem. The survey included analysis for PCBs in all paper packaging components and the packaged food portions of 15 different representative food categories. This survey was completed in late December 1971. A detailed statistical analysis of the results of the survey is currently being compiled. Sixty-seven percent of the packaging portion of the samples contained PCB residues as high as 338 parts per million; 19 percent of the food portions of the samples contained PCB residues, with an average PCB concentration of 0.1 parts per million. The maximum PCB level found in food was 5 parts per million.

The FDA survey, as well as other studies by the paper and food industries, show a significant correlation between the presence of PCB residues in the food component and the packaging component. The mechanism of PCB migration from the packaging to the food probably occurs through both the vapor phase and abrasion or physical contact. The level of PCB contamination is dependent upon many factors -- levels of PCBs in the packaging materials, type of food, length and conditions of storage, and others. The extent of migration of PCB from paperboard packaging to the food contents is being investigated (Trout. 5). There is also significant correlation between the presence of PCB residues in packaging and the presence of recycled paper components in the packaging. The occurrence of PCBs in recycled paper materials is attributed primarily to the recycling of the so-called "carbonless" carbon paper (contains 3-5 percent PCB -- use of PCBs for this purpose has been discontinued) and to a lesser degree, the use of certain printing inks. PCB residues also were found in some packaging components that appeared to be composed entirely of virgin paper material. This source of PCBs probably occurs in the packaging manufacturing processes.

Industry has taken steps to reduce the levels of PCBs in food packaging materials by avoiding the recycling of carbonless carbon paper. Although it is not know if this practice has been instituted industry wide, data provided by the Grocery Manufacturers of America, Inc., does reflect a change. For example: recycled board manufactured during the period June 1970 - January 1972 shows that only 18 percent of the samples contained less than 5 parts per million PCB; the same type of recycled board manufactured from November 1971 through January 1972 shows that 95 percent of the samples to be below 5 parts per million PCB.

IX. SPECIAL SURVEYS

FDA is currently conducting a national survey to determine the extent and levels to which complete animal feeds are contaminated with PCBs.

million. Approximately 1 million turkeys approaching market weight were withheld from market until residue levels were reduced to less than 5 parts per million.

5. Oklahoma Incident. On August 20, 1971, USDA informed FDA of excessive PCB findings in chickens in Mississippi during routine sampling. Investigation revealed that the birds came from a grower in Oklahoma and the feed from a mill also in Oklahoma. FDA analysis of eggs and feeds from these firms showed no PCBs.

6. California Incident. USDA examined turkeys after slaughter in warehouse storage in California. PCBs were found in the amount of 1.41 to 28.0 parts per million in the fat tissue. There were 100,000 pounds of turkeys detained until testing was completed. The turkeys had originated from flocks raised in four counties in California. The source of the PCBs could not be determined.

B. MEAT BY-PRODUCTS

National By-Products, Inc., Mason City, Illinois Incident - On July 28, 1971, FDA inspection of this firm revealed that PCBs were used in heat treatment equipment. Sampling showed the pasteurized meat meal to contain PCBs. The firm initiated recall of the contaminated product.

C. MILK

1. West Virginia Incident. In July 1969, FDA's Baltimore District found PCBs in milk samples collected in the routine food surveillance program. Baltimore District investigated possible routes of contamination, and by February 1970, the investigation pointed to spent transformer fluid used as a vehicle for herbicide sprayed along power right-of-ways in the Martinsburg, West Virginia area. Through this route, PCBs contaminated dairy cattle grazing areas. The dairy farms involved were taken off production by State officials.

2. Ohio Incident. In April 1970, the State of Ohio notified FDA's Cincinnati District of unidentifiable residues in milk. FDA identified the residues as PCBs and advised the State of a guideline of 0.2 parts per million (whole milk). The State of Ohio and FDA investigated the problem and determined that the dairy farms were using a PCB-containing sealant in silos that migrated to the silage. The State of Ohio banned milk from some producers and destroyed an undetermined amount of milk.

3. Florida-Georgia Incidents. The States of Florida and Georgia reported findings of PCBs in milk to FDA's Atlanta District in August 1970. A PCB-containing sealant in silos was found to be the source of contamination in this incident. FDA found approximately 11 percent PCB in the silo coating.

VIII. PAPER FOOD PACKAGING

FDA first learned of the PCB food packaging problem in July 1971. The total diet market basket samples showed low level PCB residue in a grain and cereal composite (Table 3). The PCB was traced to the Shredded Wheat

distribution of poultry containing less than 5 parts per million. This level was applicable to the edible tissue on a whole tissue basis or to the separate fat removed during slaughter or processing and intended for use as a food or feed ingredient.

The regulatory control action extended from December 1970 until August 1971, when all samples submitted for testing prior to slaughter were found to be below the 5 parts per million guideline. To support this control activity and determine disposition of the fowl scheduled for slaughter the following samples were analyzed for PCBs: 1,566 dozen eggs, 198 feed, and 5,790 chicken samples. Most of the analytical work was done in the New York State chemical laboratory. On the results of these samples, 140,450 chickens were killed on the farm and buried, 75,740 chickens were passed for restricted slaughter, and 409,000 chickens were released for normal slaughter.

The alleged source of the PCBs in this incident is believed by State officials to be plastic bakery wrappers. Bakery goods were used as a feed ingredient for the poultry and the plastic wrappers which may have contained high PCB levels were ground with the bakery goods.

2. East Coast Terminal Incident (FDA Actions). The Monsanto Chemical Company informed FDA in July 1971 that large amounts of fish meal might have been contaminated with Aroclor 1242 leaking from a heating system during pasteurization of fish meal at East Coast Terminal, Wilmington, North Carolina. Aroclor 1242 was used as the heat exchange fluid. FDA inspection revealed PCB contamination of processed fish meal on hand at the firm. Investigation indicated the leak began in April 1971 and continued through July.

The fish meal on the premises was embargoed and the firm initiated a voluntary recall of fish meal processed since April 1971. An estimated 12,000 tons were distributed. Over 2,000 tons were recalled. Individual fish meal samples examined contained from 14 to 30 parts per million PCB.

FDA also initiated follow-up sampling of fish feeds, catfish from fish farms, and eggs when the contaminated fish meal was implicated. USDA was informed when investigation indicated eggs were being distributed to commercial egg breakers. As of September 1971, 224 samples of eggs had been analyzed with 71 containing residues in excess of 0.5 parts per million.

FDA seized 3 lots of eggs. The samples representing these lots contained from 0.7 to 1.9 parts per million PCB.

FDA seized 5 shipments of fish feeds that were manufactured from contaminated fish meal. These seizures were in the States of Louisiana, Georgia, and Mississippi, and were on feeds that contained from 0.6 to 4.5 parts per million PCB. In addition, a shipment of the contaminated fish meal from East Coast Terminal that had not been recalled was seized. The analysis of this seized product showed levels in excess of 350 parts per million PCB. Catfish sampled from commercial fish farms contained less than 3.0 parts per million PCB.

Arochlor 1260 light yellow sticky resin	Arochlor 1268 white to off-white powder	Arochlor 1254 light-yellow, clear, brittle resin	Arochlor 5442 Yellow trans-parent sticky resin	Arochlor 5460 Clear, Yellow-to-Amber, brittle resin	Arochlor 1262 Black, opaque brittle resin
50 Max. (APHA)	1.0 Max. APA (molten)	1 Max. APA (molten)	1 Max. APA (molten)	1 Max. APA (molten)	
1.2114	1.05	1.05	1.05	1.05	1.05
1.3552 (25°,66°C)	1.30067 (20°,130°C)	[illegible] (25°,66°C)	[illegible] (25°,130°C)	[illegible] (25°,132°C)	[illegible] 25°,132°
1.372-1.383 (99°/15.5°C) 11.72	1.362-1.371 (25°/25°C) 15.05	[illegible] (25°,35°C) 11.71	[illegible] (25°/25°C) 10.04	[illegible] (25°,35°C) 11.91	[illegible] 11.94
190°-,20°	[illegible]	230°-,330° At 5 mm. Hg.	210°-,320° At 5 mm. Hg.	280°-,335° at 5 mm. Hg.	-
0.6 to 0.8 0.1 to 0.2	0.1 to 0.2 0.0 to 0.06	0.2 to 0.3 0.0 to 0.02	0.2 0.021	0.03) 0.6 to 0.7 (at 25°-5 hrs.)	0.2 to 0.3 -
None	None	None	[illegible]	None	None
None	None	None	[illegible]	None	None
35°-,38° 60°	- -	- -	40° 60°	- -	- -
-	[illegible] (acid acid) [illegible]	[illegible] 60° 80°-,85°	140°-,42° 110°-,126°	180°-,110°,0° 200°-,222°	60°-,0° 140°-,162°
1.4601-1.4611	[illegible] -	1.4604-1.4667	-	1.464-1.466	-
50-120	-	70-150 (20-39F or 130°C)	300-400	-	-
200-300 [illegible] - -	- -	- -	- -	- -	- -
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	- -	[illegible]

Based on available monitoring data and reports, one route of human exposure to PCBs currently in the environment is through food. The PCB contribution made by other routes of exposure has not been sufficiently measured.

The FDA has issued a proposal which will prohibit the use of PCBs in and around food processing plants and will establish limitations on the use of salvaged paper containing industrial chemicals for food packaging. These proposed actions should prevent occurrences such as the Wilmington incident and the problem of PCBs in food packaging materials. However, there will still be problems, as evidenced by the Coho Salmon contamination, the mysterious Minnesota turkeys, and the discovery of high levels of PCBs in cardboard food containers. The solution to these problems seems to lie in a better understanding of the path which PCBs follow through the environment and on full use of existing regulatory authorities. Even with better understanding we can probably expect future isolated incidents of PCB contamination.

Existing regulatory authority is generally inadequate to prevent more PCBs from entering the environment. The Monsanto Company has reported voluntarily limiting the distribution of PCBs to "closed systems" but this limit has no force of law behind it. The government has no power to restrict imports of PCBs by foreign manufacturers, and if it disagreed with Monsanto's judgment on allowable uses it could not impose more stringent limitations on Monsanto or on any other potential manufacturer.

This regulatory gap would be filled by the Administration's proposed Toxic Substances Control Act. The proposed Act, sent to the Congress in February 1971, would authorize the Administrator of EPA to restrict or prohibit the use or distribution of a chemical substance if such restriction were necessary to protect health and the environment, and it would also authorize him to issue standards for tests to be performed and for results to be achieved from such tests for various classes and uses of new substances. Thus, in addition to providing the regulatory authority needed to deal with the PCB problem, it would also establish a system for preventing new chemicals from becoming similar problems. Action by the Congress to approve the Toxic Substances Control Act is the most important step which can be taken to deal with PCBs and similar problems.

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materials be established permitting unavoidable PCB residues in such materials for a period of one year. This will provide an opportunity for the orderly elimination of PCB-containing raw materials used in the manufacture of food packaging materials.

EPA recently has proposed regulations which would prohibit all intentional discharges of PCB into the water, and would limit PCB levels in the water to .01 parts per billion. These regulations probably would be enforced through use of the Refuse Act.

III. APPLICATION OF REGULATORY AUTHORITIES

Within the past two years there have been several incidents involving PCB contamination. These include the following:

In September 1969 FDA detected PCBs in West Virginia milk. The source of PCBs was suspected to be the use of spent transformer fluid as a solvent for herbicide spray. Grade A milk shippers involved were taken off production by the State.

In April 1970 FDA identified the presence of PCB residues in milk sampled by the Ohio State Department of Agriculture. The Department removed a large quantity of milk from the market. The chemical was traced to a material used as a sealant in the silos where dairy feed was stored. Similar occurrences of PCB contamination of dairy herds have been reported in several Southeastern States.

Since June 1971, the Meat and Poultry Inspection Program (MPIP) and the Poultry Division, Consumer and Marketing Service, USDA, have been surveying specifically for PCBs. Prior to that time, the MPIP's ongoing survey of chlorinated hydrocarbons should have detected any PCBs present in animal or poultry fat at a level of 1 parts per million or above. None was detected in the fat of poultry, swine, cattle, or sheep prior to December 1970. Since that time, there have been five separate incidents of contamination of poultry with PCBs. Each appears to be a single-source, one-time occurrence. The Poultry Division's egg sampling program in the Southeastern U.S. and in Minnesota has not detected levels of PCBs which are significant--most values falling below the sensitivity of the method.

Contamination of hens slaughtered on December 2, 1970, led to placing all laying hens in Orange, Sullivan, and Ulster Counties, New York, under quarantine through August 30, 1971, requiring pretesting for PCBs prior to slaughter. Levels up to 26.8 parts per million PCBs were found in the fat. Approximately 137,100 hens were condemned and buried on the farms. Flocks containing less than 5 parts per million PCBs were sold in commercial channels, frequently at drastically reduced prices. Eggs from contaminated flocks were destroyed. The source of contamination was feed containing returned bakery product wrappings.

Frozen turkeys produced on farms from Modesto, Fresno, Stockton, and Santa Rosa, California, were found to contain up to 28 parts per million of of PCBs in the fat. The source of contamination is unknown. All turkeys

II. STANDARDS, TOLERANCES, OR GUIDELINES ESTABLISHED

The most important limits which have been established for PCBs have been those established by FDA to deal with particular instances of food or feed contamination.

Standards or, more accurately, tolerances for products such as for PCBs may be established under Section 406 or Section 409 of the Food, Drug, and Cosmetic Act, which require a finding that the substance is required in the production of the food or cannot be avoided by good manufacturing practices or a showing of safety and a need for use. No permanent tolerances for PCBs have been established, since all the safety data necessary and the need for use to support such tolerances are not available at this time. In the absence of tolerances, the Food and Drug Administration, in order to respond to accidental contamination, has set interim guidelines for levels of PCB in some foods at which it will take action under the Food, Drug, and Cosmetic Act. It is now proposing to establish temporary tolerances for permitting unavoidable PCBs in several categories of food.

FDA has taken action to remove from the market shell eggs containing more than 0.05 parts per million PCBs and feeds containing more than 0.5 parts per million PCB where the PCBs present appears to be from accidental contamination of feed. The U.S. Department of Agriculture has also taken action to remove poultry from the market containing 5.0 parts per million PCBs where such contamination was the result of accidental contamination of feed fed to poultry. The action level of 5 parts per million (whole tissue basis) was established in 1971 by FDA. This level was reduced to 3 parts per million on a fat basis in 1972.

The Food and Drug Administration has taken no action against any other products for PCB contamination but has informed the States and others that it would consider action on milk if PCBs exceed 0.2 parts per million (whole basis) and on fish if PCBs exceeds 5 parts per million. Some States have taken action to remove milk from the market that contained more than 0.2 parts per million PCBs.

The temporary tolerances recently proposed by FDA are listed in Table 1.

The guidelines and the temporary tolerances taken into account available toxicological data, the estimated amount and type of intake of PCB from food, and also the sensitivity of the methods used for detecting PCB. Thus more PCB is allowed in poultry than in eggs because children are fed egg yolk, and children are not considered to have as efficient detoxication mechanism for handling PCBs as adults. It should be noted that these limits were established to deal with particular incidents, and thus may be changed as new knowledge develops or as circumstances change.

Some food has been discovered to be contaminated because of migration from food packaging materials containing PCBs. Thus FDA also has proposed that a temporary tolerance of 5 parts per million in paper packaging ;

shipped in interstate commerce must be registered with the EPA. EPA can refuse to register a product if it will cause injury to man or the environment if used according to the label. The registration of a product can be suspended or cancelled if it is found to no longer meet the criteria for registration.

On October 29, 1970, the Pesticides Regulation Division (then in the Department of Agriculture; now in EPA) issued a notice (PR Notice 70-25) to all pesticide manufacturers, formulators, and distributors. The notice stated that, "Formulators and manufacturers of economic poisons containing polychlorinated biphenyls and polychlorinated terphenyls should change their formulations to eliminate such chemicals either as active or inactive ingredients. It is believed that a period of six months is a reasonable period of time within which to affect such formula changes." Assuming that the notice has been complied with, there should be no pesticides which currently contain PCBs.

B. FEDERAL WATER POLLUTION CONTROL ACT (33 U.S.C. 466 et.seq.)

The Federal Water Pollution Control Act (FWPC Act) authorizes the Administrator of EPA to enforce State water quality standards established by the States and approved by the Federal Government if the State is not adequately enforcing the standards. No States have established water quality standards relating specifically to PCBs. Thus the water quality standards part of the FWPC Act is not a useful tool for dealing with the PCB problem.

Section 12 of the FWPC Act applies primarily to accidential discharges of hazardous polluting substances. It requires the immediate reporting to EPA or the Coast Guard of any discharge of a hazardous substance from a vessel or an onshore or off-shore facility. The discharger is responsible for making the report and for clean-up, but EPA is authorized to remove or arrange for the removal of the hazardous substance if the discharger is unable or unwilling to do so. PCBs are being designated as hazardous substances under section 12, and the authority contained in the section could be used if an accidental spill of PCBs into water should occur.

C. THE REFUSE ACT OF 1899 (33 U.S.C. 407)

Another legal authority for controlling water pollution is section 13 of the 1899 Refuse Act which forbids discharge of any wastes (other than municipal wastes) into navigable waters without a permit, issued by the Army Corps of Engineers, which can limit the discharge of substances into water. EPA and the Justice Department are prepared to use the Refuse Act to prevent PCB discharges.

D. THE CLEAN AIR ACT (42 U.S.C. 1857 et. seq.)

The general authorities contained in the Clean Air Act are not, for the most part, applicable to PCBs because PCBs are not generally emitted into the air in the normal operations of a municipal or industrial facility. PCBs may become air contaminants through the burning of refuse, but such emissions usually could be controlled only by preventing the substance from initially getting into the refuse.

II. Problems in Analytical Chemistry - Comparison of Methods

II. 1 Separation

One of the primary and early problems in the identification of the polychlorinated biphenyls (PCBs) was that of possible interference in the GLC determination of organochlorine pesticides, where the PCB occurred along with the pesticide residue. During 1969 and 1970, various investigators worked on methods for separating PCB from pesticides (7-14). An excellent treatment of the subject of PCB as a contaminant in the environment, as related to its detection in the presence of other compounds, is covered by Jensen (15).

Jensen (15), in his review, has shown that some of the earlier studies of DDT and DDE in human fat by GLC must have been inordinately high. He first identified some GLC peaks in wildlife in 1964-66 that were not reconcilable but later identified chromatograph peaks from human fat that were not attributable to DDT or metabolites of DDT, which were more nearly comparable to peaks ascribed to PCB. The possibility that these peaks could be attributed to naturally occurring constituents in fish eaten by man was discarded when it was suggested that these same peaks could come from environmental pollutants.

To further establish the then uncertain composition of the chemicals causing the false DDT peaks, Jensen (15) separated out one of the chemicals by GLC and subjected this fraction to mass spectrometry. The mass spectrometry data showed compounds with molecular weights of 324, 358, 392, and 426. The molecular weight differences or differences of 34 mass units suggested one less chlorine atom per position on a carbon atom. In essence, through calculation, he deduced that these unknown chemicals could only be polychlorinated hydrocarbons, in this case having 5, 6, 7, and 8 chlorine atoms in the molecule. He verified his conclusion by introducing a synthetic or known PCB into the mass spectrometer. He also found that PCB standard chromatogram matched those with the same retention times as observed in various samples he analyzed, i. e., eagles, fish, or other wildlife.

It is interesting to point out that failure to recognize such interferences led to spurious results and data and obviously led to the overestimation of DDT in our environment, in man, in wildlife, and aquatic organisms. Jensen (15) referred to PCB as a new pollutant, but, as stated earlier, PCB was with us in the environment since 1930 and thus it would be an old pollutant only recently correctly identified by appropriate analytical chemistry.

In earlier work in the identification of some organochlorine pesticides such as p,p'-DDT; o,p-TDE (DDD), lindane, dieldrin, aldrin, heptachlor, and lindane, some unidentified spots and peaks in TLC and GLC interfered with the detection of these pesticidal chemicals. Jensen (15) in his work extracted the compounds from biological samples and, by appropriate cleanup of some contaminants, identified the pesticides and PCBs by thin layer and gas liquid chromatography followed by mass spectrometry. In 1964, Jensen used TLC to separate the fat soluble chlorinated hydrocarbons from the rest of the sample.

Some biological samples require more extensive pretreatment than for water or effluents from industrial plants. The measurement of PCB concentration of effluents is a simple procedure involving chromatogram of sample and then chromatograms of standard samples developed from known PCBs. For more accurate analysis, calibration graphs can be developed from known specific peaks in the standard samples (15).

In the following charts (Figures 1-6) some chromatograms of the various representative chlorobiphenyl Aroclors are presented according to Armour (18).

Some additional points might be made relevant to separation and quantitation of PCBs. First of all, in separation, the methods used prior to quantitation of residues in samples containing PCBs and chlorinated hydrocarbons fall essentially into two categories: (a) those which necessitate destruction or alteration of one or more of the compounds and (b) those which do not. Peakall and Lincer (19) have described in detail the procedures used for separation.

Briefly, the first group requires nitration ($HNO_3 + H_2SO_4$) treatment at 0°C for 5 minutes, which destroys or alters many of the organochlorine pesticides; thus PCB is left unaffected along with lindane and BHC. Some workers such as Armour and Burke (1) reported that complex chromatograms resulted after nitration, which could not be related to the unreacted DDT-PCB mixture. Thus, nitration was not pursued as a practical means of separating DDT and PCB for further analyses.

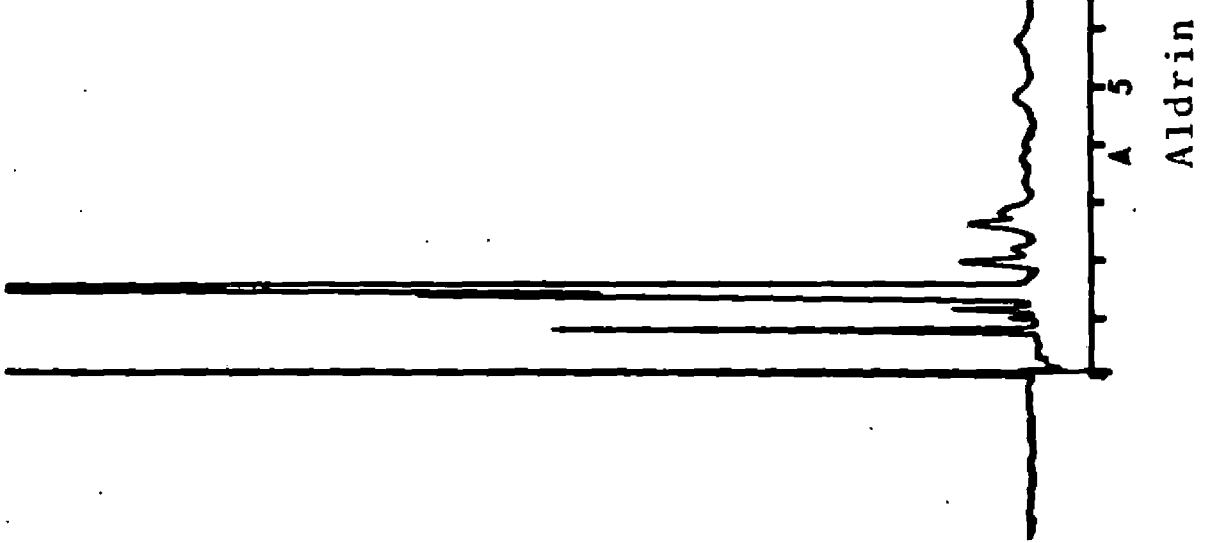
Saponification with alcoholic NaOH or KOH will dehydrochlorinate some pesticides such as Perthane, Toxaphene, DDD and DDT to their respective olefinic compounds (20).

Perhaps the more desirable technique allows for special separation of many chlorinated hydrocarbon pesticides from PCB. This involves using various columns and solvents. Another procedure is to use a series of differing polarity columns in the gas chromatograph at the time of determination (21).

II.2 Quantitation

Koeman, et al (2) measured residues in Japanese quail by using one of the peaks in a phenachlor DP6 mixture as standard. Risebrough (22) quantitated relative levels of PCBs by assuming that each PCB compound produced the same peak height with the electron capture detector as the same amount of weight by p,p'-DDE. After adding the heights of the individual peaks, the total was multiplied by a factor derived from measurements of standard solutions with EC and MC detectors. Jensen and co-workers (23) reported concentrations of PCB as the sum of all PCB components and based the estimation on several detection systems such as mass spectrometry and EC and MC detectors. In spite of all these techniques, these investigators consider the method approximate and correct only within a factor of 2.

There are other modifications of techniques, but with all the quantitation methodology available, relative estimates of concentrations of PCB are

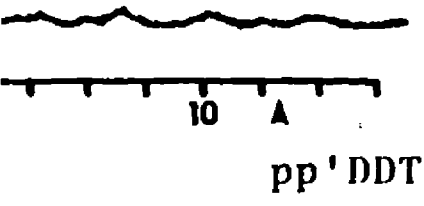


PLAINTIFF'S EXHIBIT 498

Figure 1.

Aroclor 1221

10% DC-200



pp' DDT

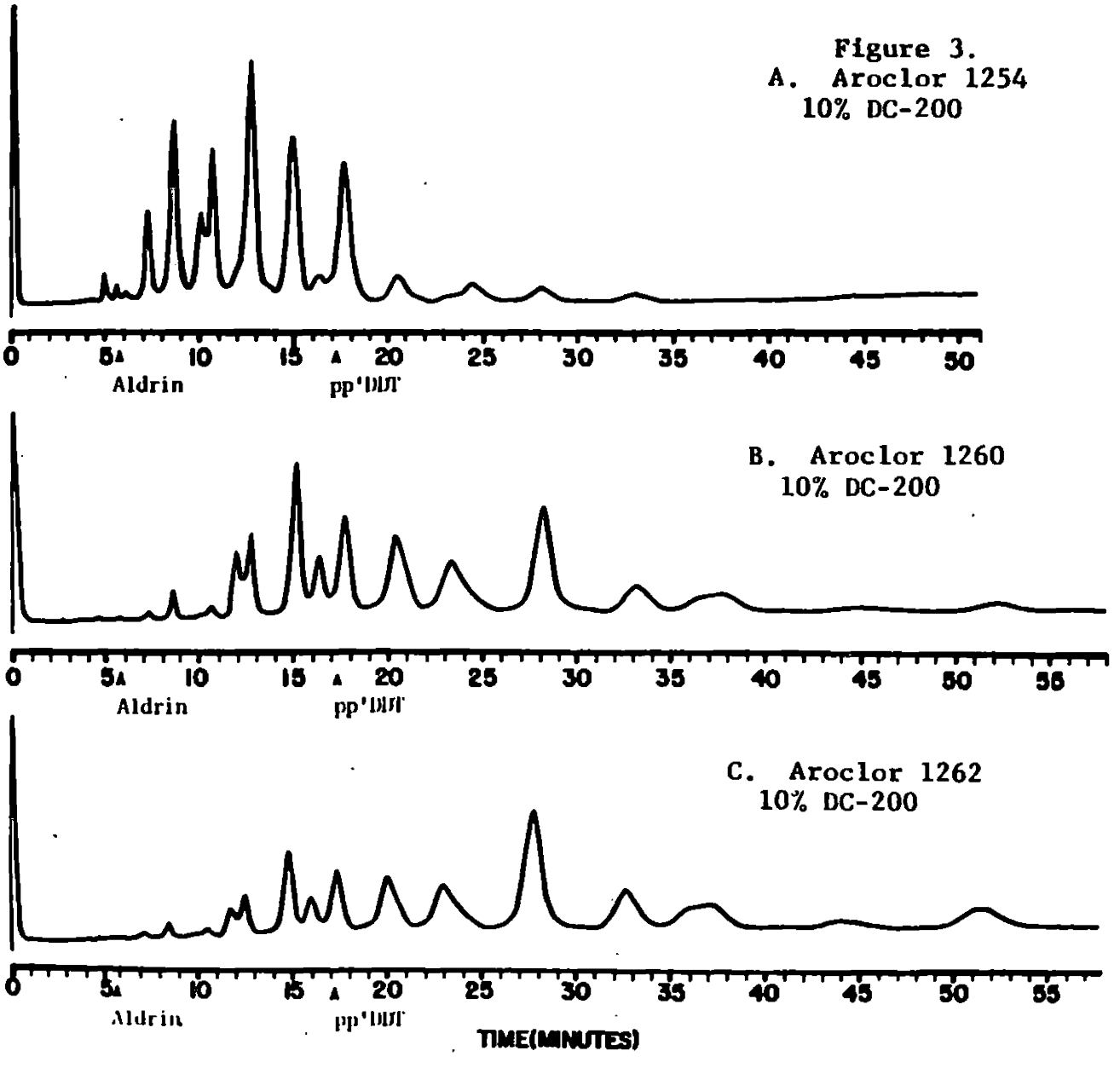


Figure 3.

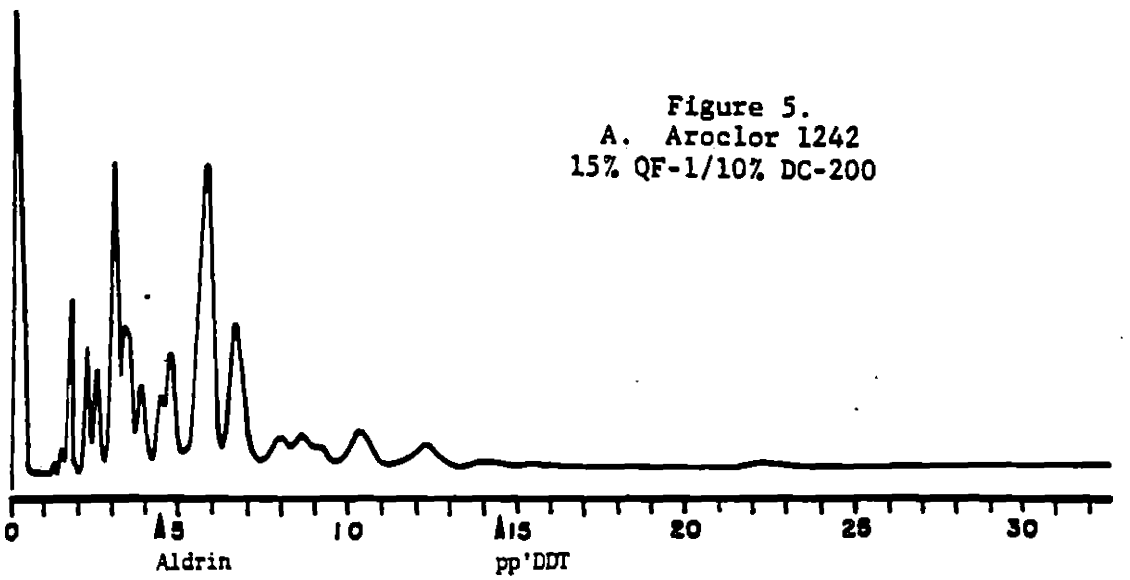
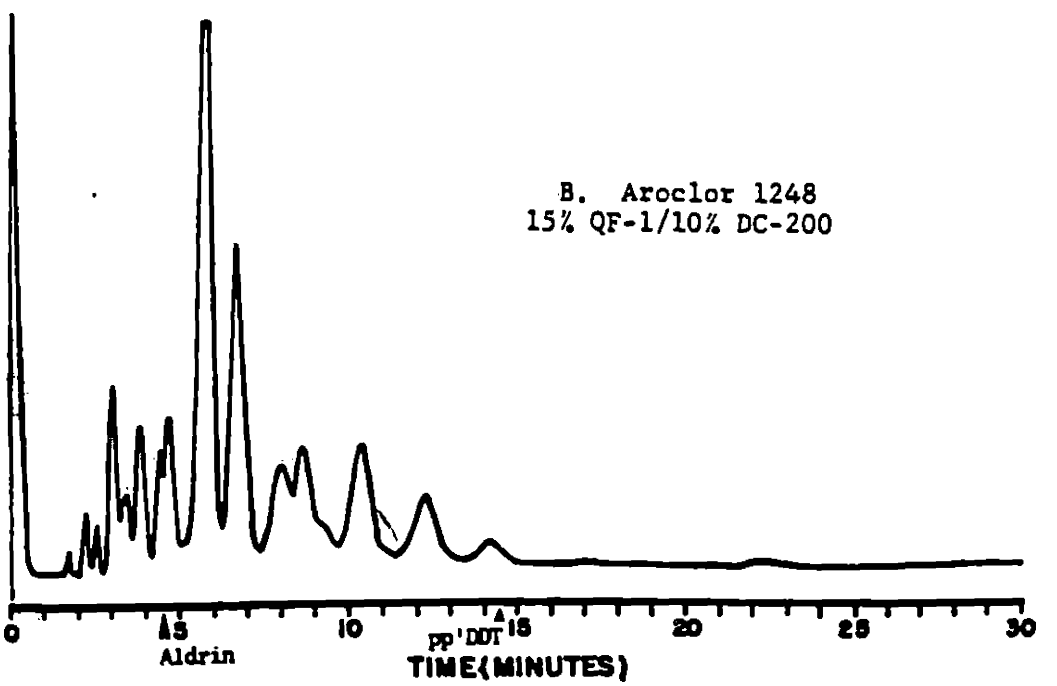


Figure 5.
A. Aroclor 1242
15% QF-1/10% DC-200



B. Aroclor 1248
15% QF-1/10% DC-200

only approximate. At such time, when one is able to synthesize the individual PCB components commonly found in the environment and identify them in terms of individual peaks, then the estimation remains, as stated, a relative concentration.

However, for most biological assessment work, the correct order of magnitude and accurate relative amounts of PCB provide the requisite information for this purpose.

III. Contaminants, Impurities, or Other Chemical Moieties in PCBs

In the analysis of the polychlorinated biphenyls, one encounters a problem similar to that of the polychlorophenols and 2,4,5-T in that certain contaminants or impurities prevail. These impurities arise from the basic starting materials or compounds used in the synthesis and also from the processing conditions used in the chlorination procedures. In this respect, the series of compounds identified through GLC and mass spectrometry are somewhat similar in nature to the spectrum of dioxins found in working with chlorinated phenols, hexachlorophene, 2,4,5-T and related synthetic organic chemicals.

It has been noted in the bioassay of various Aroclors for toxicity, usually testing on chickens, that there was a variance in toxicity of certain PCB preparations. Since the occurrence of lesions resembled those of chick edema in birds fed PCB, this prompted a comparative study between three compounds, Phenoclor DP6, Clophen A60, and Aroclor 1260 by Vos et al in 1970 (24). In this study, the specific PCBs were fractionated, analyzed, and bioassayed using the chick embryo assay.

These studies revealed the presence of certain polar compounds which are present as impurities in the various PCBs and thus explain the variance in toxicity of certain commercial PCB preparations. In Table 2 some of the retentions and mass spectrometric data of some of the peaks identifying the presence of some dibenzofurans, chlorinated napthalenes, and associated chlorinated biphenyls are indicated, proving the presence of impurities.

Table 2
Relative Retentions, Mass Spectrometric Data on PCB Fractionated Sample

Peak No.	Relative Retention	Mass Nos. and No. of Cl atoms per mol	Identity of Compound
1	1.40	304 (4 Cl)	Tetrachlorodibenzofuran
2	1.58	332 (6 Cl)	Hexachloronapthalene
3	1.74	358 (6 Cl) 392 (7 Cl)	Hexachlorobiphenyl Heptachlorobiphenyl
4	2.42	338 (5 Cl) 392 (7 Cl)	Pentachlorodibenzofuran Heptachlorobiphenyl
5	3.68	366 (7 Cl)	Heptachloronapthalene

FOOTNOTES

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18. Armour, J. (1970) FDA Laboratory Information Bulletin No. 918F FSCS/ACFC, pp. 1-17.

APPENDIX A

Chemical and Physical Properties of PCBs

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Tables

Figures

APPENDIX E

Occurrence And Sources Of PCBs In Food

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Tables

II. FDA TOTAL DIET STUDIES

The total diet program is designed to determine the levels of pesticides, PCBs, and trace heavy metals in the dietary intake on a geographical and seasonal basis. Market basket samples, representing the two-week diet of a 15-20 year old male -- which is approximately twice that of the normal diet -- are collected at retail stores, bimonthly, in five regions of the United States. Food items are cooked or prepared for table-ready use by dieticians and are divided into 12 food class composites, such as dairy products; meat, fish and poultry; and leafy vegetables. Each composite is analyzed for a variety of chemical contaminants, including PCBs. The limit of detectability as applied to total diet composites is approximately 0.05 parts per million PCBs. When abnormally high residues are detected in any composite, follow-up analysis is made of the individual food commodities of the composite to determine which food is contributing the excessive residues and to determine whether compliance action is warranted.

III. USDA SAMPLING PROGRAMS

The Consumer and Marketing Service, USDA, has primary responsibility for sampling and analyzing meats, poultry, and broken egg products for pesticide, environmental (PCB), and other chemical or biological contaminants. The USDA program involves all federally inspected slaughtering plants (about 1,200) and egg breaking establishments (about 140). The instructions for sampling request that the agricultural producer of the animal, bird, or eggs, be named so that the State of origin will be known. This facilitates follow-up if a violative sample is found and identifies those samples which originate from the same farm. Inspectors are instructed to collect objective samples from different agricultural producers. The time of sampling and the plant location are determined on a random basis, by computer, for this program.

IV. OTHER REGULATORY PROGRAMS

In addition to these routine sampling activities, FDA and USDA learn of PCB contamination of foods in other ways. As part of their enforcement responsibilities, they conduct in-plant establishment inspections; conduct special investigations and surveys to determine the cause and extent of specific PCB problems; and maintain close contact with State officials and industry who also monitor the occurrence of chemical contaminants in food.

When required, there is also a selective phase to these sampling programs and investigations. Selective sampling is used to determine the extent of violations when a violative sample is encountered or a report of possible harmful residues is received by the responsible agency. An increased number of samples is taken in the suspected area to determine

TABLE 1

FEDERAL ANALYSIS OF MARINE FOOD SPECIES
November 1969 through Jan. 1971
(15,000 Samples Analyzed --all prior to East Coast Termin.l Fish Meal Incident)
Number Positive Samples (Range-ppm) Average ppm

Examining District	Fish	Fish By Product	Cheese[a]	Milk[a]	Shell Eggs	Potato By Product	Oysters	Misc.	Total Positive All Products
Los Angeles	23(0.1-2.60).62	5(0.2-5.0)2.10		6(0.15-0.30).19	1(0.03).03				35
Minneapolis	2(.12-35.29)17.70								2
New Orleans	23(T-1.70)0.4[d]							Milled Rice 1(0.20)	24
New York	3(0.21-4.78)2.49								3
San Francisco					1(0.50).50				1
Seattle	1(0.40).40					8(0.10-4.20)1.16		Straw 1(0.30) Wheat 1(0.32)	11
Kansas City	19(0.60-13.30)3.41								19
Atlanta	1(0.53).53[e]		1(T)	2(0.94-0.97).96				Silage 1(0.82) Silo Coating 1(11.3)	6
Baltimore				22(T-12.58)2.69	5(T-T).00		12(T-T).00	Crabmeat 1(0.24)	40
Boston	1(6.08)6.08								1
Buffalo	19(T-13.00)3.26[d]	1(T).00							20
Chicago				1(0.23)0.23					1
Cincinnati	55(0.04-4.70)1.77			4(0.22-0.24).24					59
Denver						2(0.15-1.12).64			2
Detroit	49(0.25-15.5)2.96			4(0.49-1.86)1.27				Cat Food 1(6.49) Duck 1(0.70)	55
Dallas									0
Total Positive	196	6	1	39	7	10	12	8	279

[a]ppm fat basis [d]T=Trace; not incl. in ave. [e]marine species

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Polychlorinated biphenyls (PCBs) have been used in the United States and elsewhere over the past 40 years, for many industrial and consumer applications. During the past three years evidence has accumulated to indicate that PCBs are widely dispersed throughout the environment and that they can have adverse ecological and toxicological effects.

The principal uses for PCB fluids are in the electrical industry. PCBs have superior cooling, insulating, and dielectric properties and hence are widely used in various electrical devices. Transformers and capacitors filled with PCBs can be used in inside locations where failures of oil-insulated equipment would present a potential danger to life and property. Because PCBs are relatively nonflammable, apparatus containing them is essentially free from the fire and explosion hazards associated with oil-insulated and oil-cooled electric devices. Stability at high temperatures is another major factor in the attractiveness of these compounds. The principal advantage of PCBs over substitutes is the relative freedom from flammability in some applications that previously had been plagued by serious fires. PCBs also give electrical equipment the critical advantages of reliability, long life, and compactness. PCB impregnated capacitors, for example, are markedly more reliable and long-lived, and 1/6 the size, 1/5 the weight, and 1/4 the cost of comparable oil impregnated capacitors. Small capacitors with PCBs have a use-life expectancy of 10 to 15 years, and large capacitors 20 to 25 years. PCBs in transformers are replaced only every 25 to 30 years.

PCBs have been discovered to have a widespread distribution in the environment, and some environmental occurrences have been associated with adverse effects on certain forms of animal life. Beginning in 1971, the Monsanto Company, the sole U. S. producer, has reported taking voluntary actions to reduce the volume of PCB production and to limit its distribution to industries concerned with the manufacture of electrical apparatus. Similar restrictions have been put into effect by statute in Sweden and voluntarily in Great Britain.

A large use of PCBs had been in carbonless duplicating paper. This use has been discontinued. The Food and Drug Administration and the food industry have increased their surveillance to assure that PCBs are not used in food plants, products, or packaging.

The task force has reviewed all of the available scientific information on various aspects of the PCB problem. It has found much data that it regards as inadequate and many questions that remain unanswered. But on the basis of available information, the task force concurs on the following findings, conclusions, and recommendations:

5. Housekeeping is particularly important in the manufacture, use, and disposal of PCBs. Under a program of limitation on the sale of PCBs, the electrical industry will continue to be the principal user of PCBs; it, as well as industries now holding inventories of PCBs, have a special responsibility for monitoring and controlling their wastes. In this connection, the Environmental Protection Agency will restrict industrial liquid discharges of PCBs from PCB users. To keep levels in fish as low as possible, and in any case below FDA's interim action level of 5 parts per million, concentrations in rivers or lakes from all sources should not exceed 0.01 parts per billion.

6. The use of PCBs should not be banned entirely. Their continued use for transformers and capacitors in the near future is considered necessary because of the significantly increased risk of fire and explosion and the disruption of electrical service which would result from a ban on PCB use. Also, continued use of PCBs in transformers and capacitors presents a minimal risk of environmental contamination. The Monsanto Company, the sole domestic producer, has reported voluntarily eliminating its distribution of PCBs to all except manufacturers of electrical transformers and capacitors.

Pending passage of the Toxic Substances Control Act, the Federal Government does not have the legal authority to impose restrictions corresponding to the actions reported by Monsanto. Although some Federal enforcement authority is available, the Federal Government does not have the authority to control PCBs at their source.

7. Most capacitors presumably have been disposed of in landfills. PCB containing material buried in soil is not expected to migrate but should remain in place. In the past, many fluids containing PCBs have been disposed of in sewers. More appropriate means of disposal such as high-temperature (at least 970°C) incineration must be used instead.

8. PCBs are manufactured in countries other than the United States. Importation of PCBs as a chemical or as a component in products remains legally possible because the Toxic Substances Control Act has not yet become law. Electrical products imported from abroad may contain PCBs. The task force looks to international agreements to bring about some multi-national understanding on the sale and use of PCBs globally. Importation of PCBs for uses other than those singled out in the present pattern of voluntary limitations should be avoided by users.

As an additional measure, the United States has asked the Organization for Economic Cooperation and Development (OECD) through its Environment Committee to make a special review of member states' national policies concerning PCBs and also to identify products moving in international trade which contain PCBs. OECD, whose membership includes all major Western industrialized states plus Japan and Australia, has been giving priority attention to the problem of PCBs over the past year.

9. More scientific information about PCBs is needed, and several Government agencies are seeking it through research. The task force recognizes that the scientific basis of much of our knowledge must be

production and sales figures for 1971 were roughly half of those for 1970, when these volumes were at their peak (Table 1 and Figures 1 and 2). Projections for 1972 indicate an even lower volume.

Prior to 1971, about 40 percent of the PCB material in the United States was used in applications where containment was difficult and losses into the environment were probable. These uses included plasticizers, hydraulic fluids and lubricants, surface coatings, inks, adhesives, pesticide extenders, and microencapsulation of dyes for carbonless duplicating paper. The remaining 60 percent of domestic sales was used mainly in electrical applications (transformers and capacitors). In 1971, this fraction is expected to have reached approximately 90 percent of the total use, only about half of the total use in 1970.

In terms of the grade or family of PCB manufactured, the lower chlorinated species have generally made up the majority of the products produced. From the figures in Table 1 it can be seen that Aroclor 1242 and grades with lower percentages of chlorination characteristically composed one half or more of the total production between 1963 and 1970.

The largest categories of use of PCBs have been in capacitors and transformers and in certain "plasticizer" applications including carbonless duplicating paper. A large percentage of the production of Aroclor 1242 went into these three categories of products. (2) The major uses for PCBs prior to 1970 (in the order of importance as a reflection of the volume of material used) were:

Capacitors
Plasticizer applications
Transformer fluids
Hydraulic fluids and lubricants
Heat transfer fluids

II. CHEMICAL AND PHYSICAL PROPERTIES AND IMPURITIES

Chemical and Physical Properties of PCBs

Theoretically, there are 210 possible PCB compounds, but only about 100 are likely to occur in commercial products. The degree of chlorination determines the chemical and physical properties of the Aroclors; the first two digits of the numbered Aroclor represent the molecular type, the last two digits the average weight percent of chlorine. Their physical state thus varies from colorless, oily liquids to more viscous and increasingly darker liquids to, in the higher series, yellow and then black resins. The PCBs are not readily biodegradable. They resist breakdown by water, acids, and alkalis and have boiling points ranging from 278 to 475°C.

Analytical Techniques

Whereas in the past it was difficult to identify PCBs in the presence of other organochlorine compounds such as DDT and DDE, they can now be separated from interfering compounds and identified and measured by means of thin layer and gas liquid chromatography at levels less than 1 part

Electrical Uses

PCBs are used in fluids (known as askarels) for electrically insulating and cooling transformers when the transformers are used in or near buildings. Being virtually free of fire and explosion hazards, PCBs can be used where failures of oil-insulated transformers would present a potential danger to life and property. PCBs also are superior to oils in reliability, in making small equipment possible, and in assuring long life and reliability to equipment. Table 1 shows the flammability ratings of two PCBs compared to five other common materials.

Table 1

Underwriters' Laboratories Flammability Ratings

Fluid	Flammability Rating
Ether	100
Gasoline	90-100
Ethyl Alcohol	60-70
Kerosene (100° F.P.)	30-40
Mineral Oil	10-20
Aroclor 1242 and MCS 1016	2-3

PCBs are used in transformers wherever fire protection is particularly important--for about 5 percent of all transformers.

Most of these transformers are located inside public, commercial, or industrial buildings--or on the roof tops of, or in close proximity to, such buildings--and require no special enclosures other than those necessary to prevent accidental hazardous mechanical or electrical contact of persons with the equipment.

The amount of Aroclor used in various types of transformers ranges from 40 to 500 gallons (516 to 6,450 pounds) with an average of about 235 gallons (3,032 pounds). During 1968, the last complete "normal" year for the electrical industry, the total amount of PCBs used in new transformers or as replacement fluid was approximately 1.3 million gallons (8.4 thousand tons).

The only present alternatives to Aroclor-insulated transformers are mineral oil-insulated transformers or dry-type transformers (either those open to the atmosphere or those that are gas-filled and sealed). Mineral oils are the preferred fluids when fire does not create a hazard. Dry transformers also can be used when space is available to install them. Fluorocarbon liquids require a special transformer design.

PCBs are used in more than 90 percent of the electric utility (large power) type and smaller industrial type capacitors made today. They are needed for safety, reliability, and long life, and to achieve sizes compatible with equipment and installation requirements.

IV. OCCURRENCE, TRANSFER, AND CYCLING IN THE ENVIRONMENT

Given the diversity of uses of PCBs and their chemical characteristics (greater stability in the higher chlorine species), it is not surprising that the residues are widespread. While satisfactory quantitative estimates of the contribution of various pathways into the environment are not possible with existing data, there are enough data to be certain that PCBs do reach the environment at least from the following sources:

-- Open burning or incomplete incineration (at usual temperatures) of solid wastes, municipal and industrial. Incineration at 2000°F or above for two seconds will destroy PCBs, but poorly operated incinerators or open burning may result in PCBs being released to the atmosphere unchanged.

-- Vaporization from paints, coatings, plastics, etc. (Nisbet and Sarofim, 1) estimate that as much as 20 percent may be vaporized.

-- Municipal and some industrial sewers (PCBs present in treated as well as untreated wastes).

-- Accidental spills or improper wastes disposal practices.

-- Formerly, direct application to the environment as ingredients of pesticides or as carriers for pesticides (such uses of PCBs are now prohibited).

-- Dumping of sewage sludge, municipal and industrial solid waste, and dredge spoil at sea.

-- Sewage sludges disposed of on land.

-- Migration from surface coatings (paints, etc.) and packaging materials into foods and feeds.

Probably the largest amounts of PCBs circulating in the environment reach it through industrial and municipal discharges to inland and coastal waters.

The recommendation by the task force that "more scientific information about PCBs is needed" is illustrated by the sparsity of knowledge about PCBs in the environment. Only general statements can be made about how PCBs reach the environment, how they reach target organisms, and how much is present.

Nisbet and Sarofim (1) estimate that the total loss of PCBs into the U. S. environment over the last 40 years would approach 30,000 tons to the atmosphere, 60,000 tons to water and 300,000 tons to dumps. Of this total, remaining residues might be 20,000 tons from the air (which would be distributed on land or water), 30,000 tons in water, and perhaps 250,000 tons in dumps.

-- PCB residues in milk have resulted from the use of PCB in certain coatings on the inside walls of silos, which, in turn, contaminated the dairy feed silage.

-- The use of spent PCB transformer fluid as a herbicide spray vehicle allegedly contaminated dairy cattle grazing areas thereby causing residues in milk.

-- The grinding of bakery products along with their PCB-containing wrappers for use as poultry feed is suspected to have caused contamination of fowl.

These incidents, as well as others during the past several years, represent localized sources of contamination. Federal, State, and industry actions prevented most of the contaminated foods from being marketed.

Food Packaging

A significant percentage of food paper packaging materials contains PCBs and has resulted in the migration of low levels to the packaged food. This source of food contamination was identified in 1971. The origin of PCBs in packaging materials is not fully understood. Recycled waste paper containing PCB carbonless "carbon" papers is the prime source of PCB in paperboard product. Virgin paper products, however, have also been shown to contain PCB residues, probably as a result of the paper manufacturing processes. Data on current production of food packaging materials indicate that the levels are decreasing and are controllable so that the potential for PCB contamination of packaged foods can be minimized.

Dietary Intake

National monitoring data, and in particular FDA's total diet studies, indicate that the human dietary intake of PCBs is of a low order. For example: the dietary intake expressed as mg/kg body weight/day, and based on food consumption approximately twice as high as the normal diet, was less than 0.0001 in FY 1971 and 0.0001 in the first-half of FY 1972. As a point of reference, from 1965 to 1970 dietary intake of DDT was 0.0007 mg/kg body weight/day. Other investigations further disclose that except for unavoidable background levels in certain foods, the PCB contamination of food can be significantly reduced or eliminated through appropriate controls.

Man and the Ecosystem

In air and water away from immediate sources of waste discharge, levels of PCBs are low -- a few micrograms per cubic meter (parts per trillion; ppt) in air and less than a part per billion (ppb) in fresh water; soil or bottom sediments contain a few parts per billion, up to several hundred parts per million (ppm) near some industrial outfalls; from tenths of a ppm to tens of ppm in fish and up to hundreds of ppm in some fish and birds near the top of the food chain. To illustrate these relationships, 1/8 of an inch is about

Tables

(continued)

Tables

(continued)

[redacted]

AROCLOR SEMI-CONTINUOUS ACTIVATED SLUDGE PRIMARY DEGRADATION STUDIES

PLAINTIFF'S EXHIBIT 503

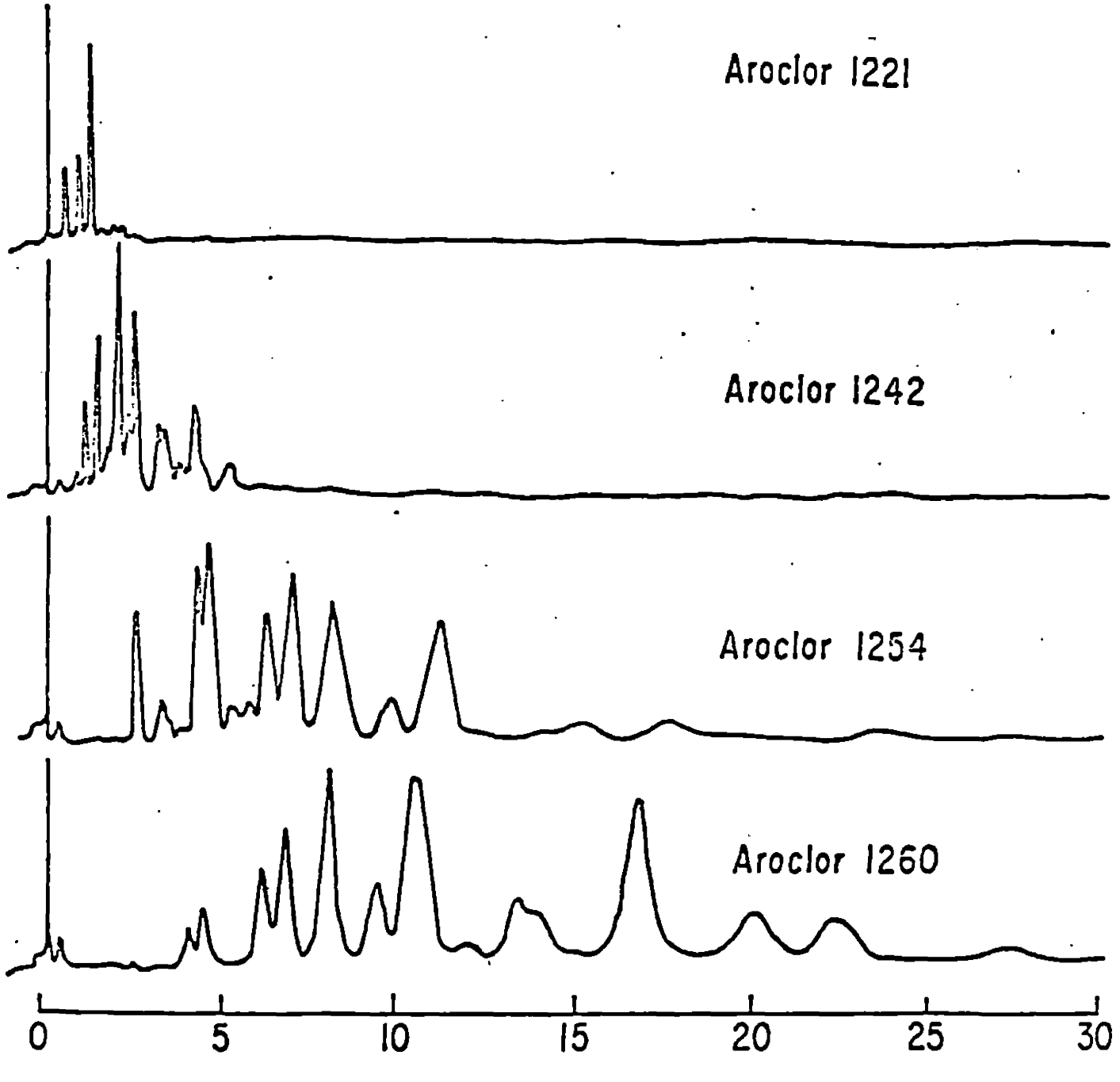
TYPICAL % COMPOSITION OF POLYCHLORINATED BIPHENYL PRODUCTS *

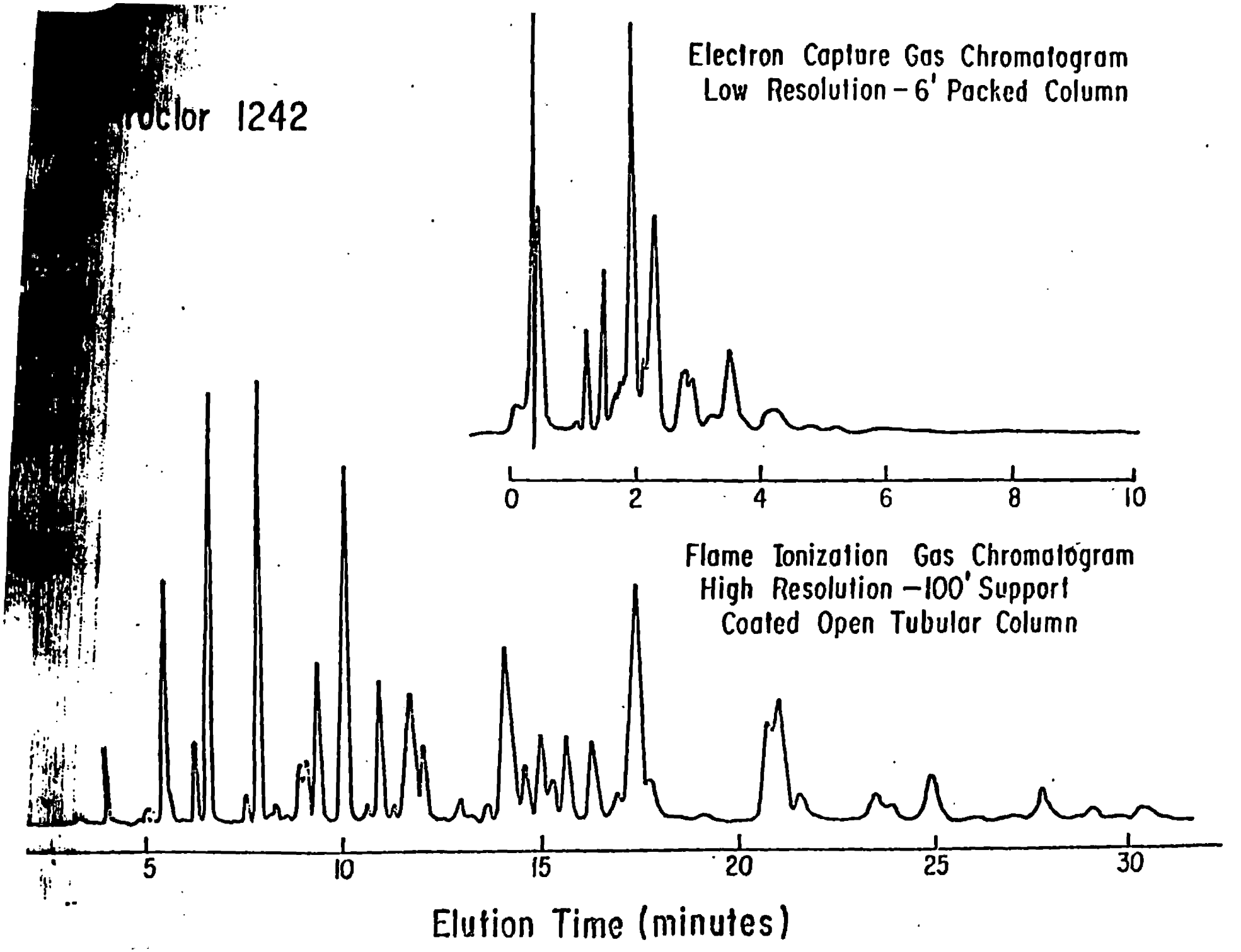
HOMOLOG # Cl/BIPHENYL	AROCLOR 1221	AROCLOR 1016	AROCLOR 1242	AROCLOR 1254
0	11	<0.1	<0.1	<0.1
1	51	1	1	<0.1
2	32	20	16	<0.5
3	4	57	49	1
4	2	21	25	21
5	<0.5	1	8	48
6	ND	<0.1	1	23
7	ND	ND	<0.1	6
8	ND	ND	ND	ND

*PER CENT (W/W) BY GC/MASS USING AREA CORRECTION FACTORS BY HOMOLOG RESPONSE

NONE DETECTED, <0.01% = ND

Electron Capture Gas Chromatograms




roclor 1242
Electron Capture Gas Chromatogram
Low Resolution – 6' Packed Column
0
2
4
6
8
10
Flame Ionization Gas Chromatogram
High Resolution – 100' Support
Coated Open Tubular Column
5
10
15
20
25
30
Elution Time (minutes)

- PCB PRODUCTS ARE NOT A SINGLE ENTITY, BUT COMPLEX MULTI-COMPONENT MIXTURES

- PCB RESIDUES FOUND IN WILD LIFE ARE DOMINANTLY PENTA-, HEXA-, HEPTA-, AND OCTA-CHLORO BIPHENYLS

- PCB RESIDUE ARE MOST SIMILAR TO AROCLOR 1254 AND AROCLOR 1260 PRODUCTS

PRIMARY BACTERIAL DEGRADATION STUDIES

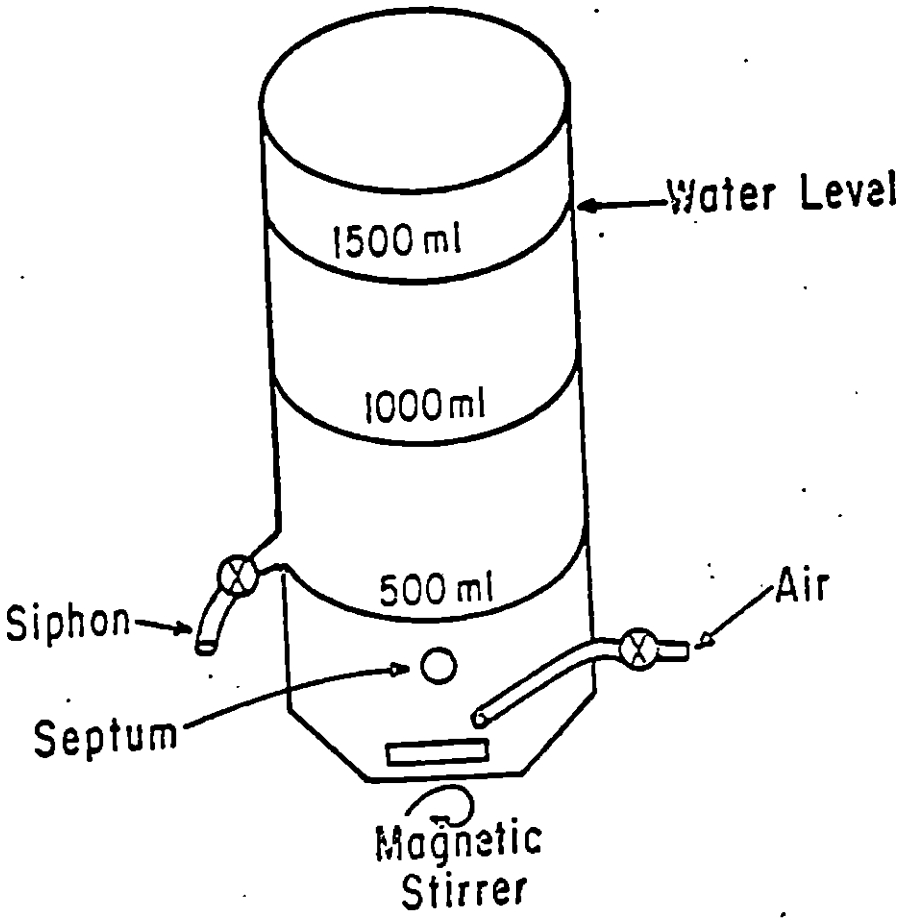
- SEMI-CONTINUOUS ACTIVATED SLUDGE DEGRADATION

RESIDUE ACCUMULATION STUDIES

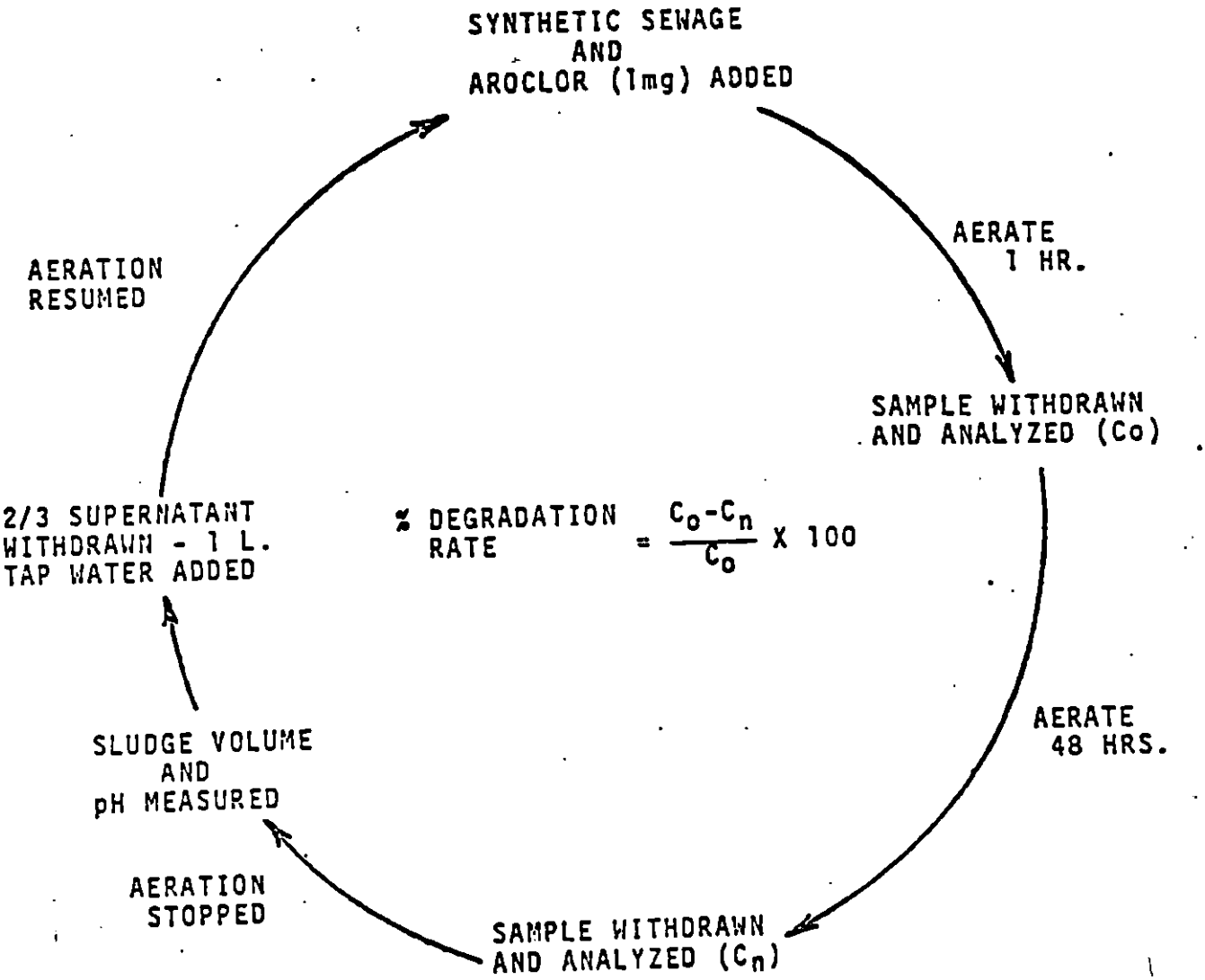
- FISH - CATFISH AND BLUEGILLS
- BIRDS - WHITE LEGHORN CHICKENS
- MAMMALS - ALBINO RATS AND BEAGLE DOGS

ASSESSMENT OF THE PERSISTENCE OF POLYCHLORINATED BIPHENYLS IN BIOLOGICAL SYSTEMS

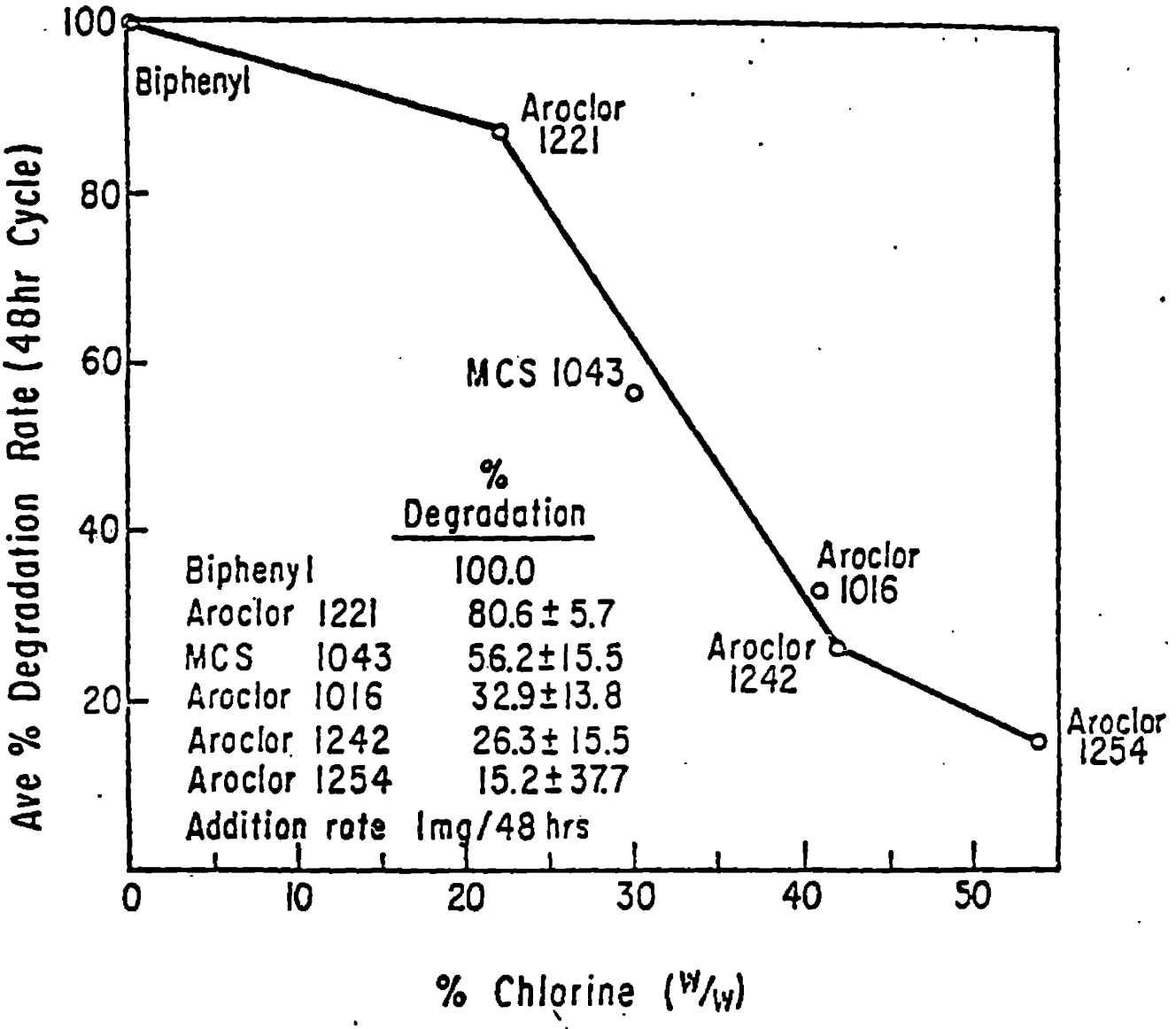
Semi-Continuous Activated Sludge Test Unit



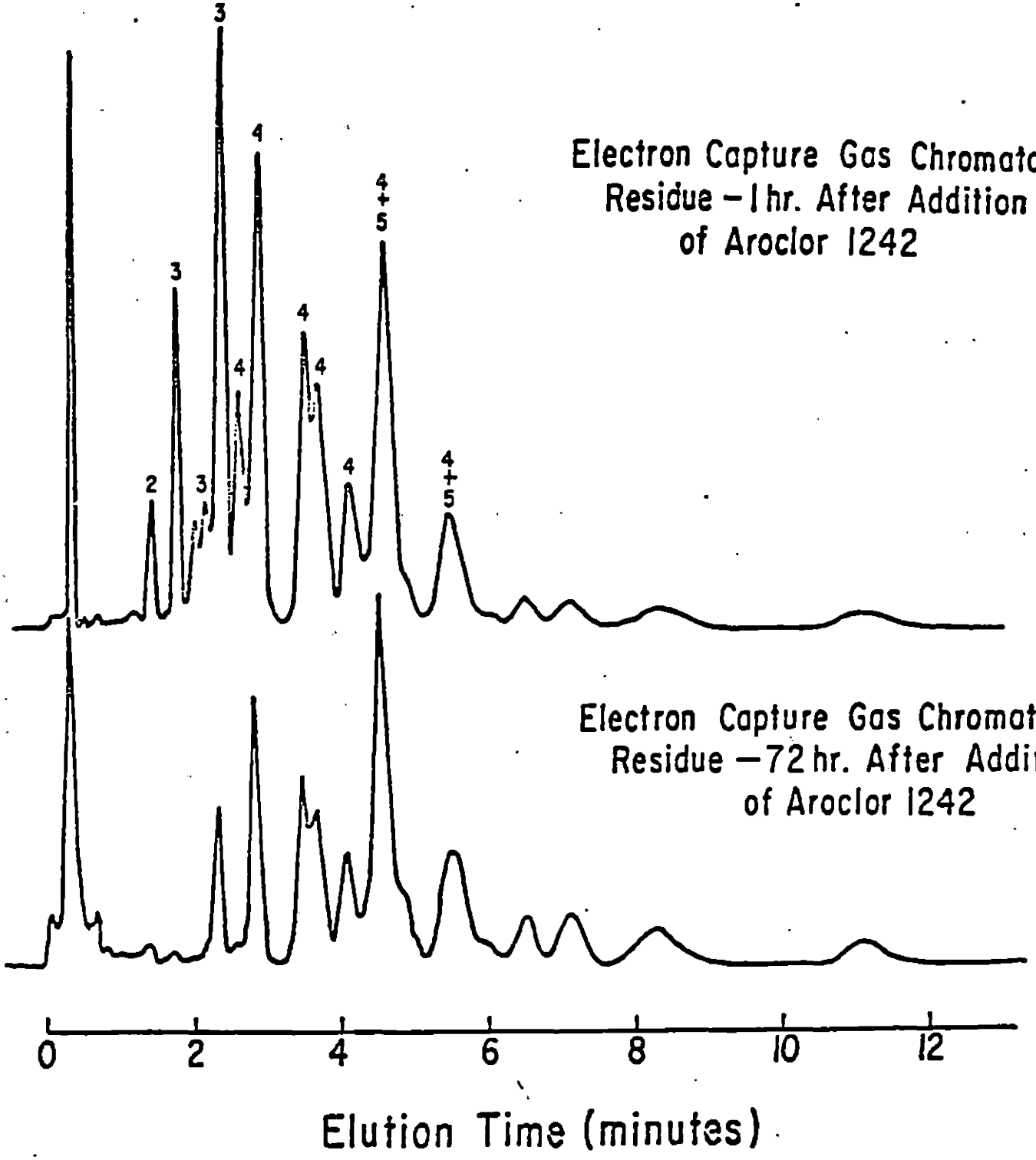
MECHANICAL CYCLE



Semi-Continuous Activated Sludge Degradation of Polychlorinated Biphenyls



Semi-Continuous Activated Sludge Degradation of Aroclor 1242



BACTERIAL DEGRADATION STUDIES

CONCLUSIONS

- RATE OF PRIMARY DEGRADATION INCREASES AS THE DEGREE OF CHLORINATION OF THE AROCLOR PRODUCT DECREASES

BIPHENYL>AROCLOR 1221>MCS 1043 >AROCLOR 1016>AROCLOR 1242>AROCLOR 1254

- BIPHENYL, MONO-, DI-, TRI-, AND TETRACHLORO BIPHENYL HOMOLOGS UNDERGO PRIMARY BACTERIAL DEGRADATION

AROCLOR RESIDUE STUDIES

WHITE LEGHORN CHICKEN STUDIES

PRODUCTS STUDIED		90 DAY ORAL	
		AROCLOR 1242 AROCLOR 1254 AROCLOR 1260	AROCLOR 1242
NUMBER OF CHICKENS	FEMALE	200	80
	MALE	40	16
NUMBER OF SAMPLES	MUSCLE	40	8
	LIVER	40	8
	FAT	40	8
	EGGS	~250	~60
	CHICKS	30	10
NUMBER OF SAMPLES ANALYZED	MUSCLE	14	5
	LIVER	12	4
	FAT	18	5
	EGGS	25	8
	CHICKS	11	10
TOTAL SAMPLES COLLECTED		400	121
TOTAL ANALYZED		80	32

ORAL EXPOSURE CARRIED OUT BY
INDUSTRIAL BIO-TEST LABORATORIES, INC.
NORTHBROOK, ILLINOIS

RESIDUE STUDY OF AROCLOR 1242 IN WHITE LEGHORN CHICKENS

90 DAY ORAL

	PPM PCBs			HOMOLOG DISTRIBUTION									
ORAL EXPOSURE LEVEL	1	10	100	1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	126	1260	12602	-	(2)	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 12 WEEK EXPOSURE	14	136	1312	-	-	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 30 DAY RECOVERY	9	77	749	-	-	(3)	(4)	(5)	(6)	-	-	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

RESIDUE STUDY OF AROCLOR 1254 IN WHITE LEGHORN CHICKENS

90 DAY ORAL

ORAL EXPOSURE LEVEL	PPM PCBs			HOMOLOG DISTRIBUTION									
	1	10	100	1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	126	1260	12602	-	-	3	(4)	(5)	(6)	7	-	-	-
*RESIDUE, 12 WEEK EXPOSURE	38	362	3506	-	-	-	4	(5)	(6)	7	-	-	-
*RESIDUE, 30 DAY RECOVERY	17	164	1580	-	-	-	-	5	(6)	7	-	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

RESIDUE STUDY OF AROCLOR 1260 IN WHITE LEGHORN CHICKENS

90 DAY ORAL

	PPM PCBs			HOMOLOG DISTRIBUTION									
				1	2	3	4	5	6	7	8	9	10
ORAL EXPOSURE LEVEL	1	10	100										
†THEORETICAL RESIDUE	126	1260	12602	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 12 WEEK EXPOSURE	65	607	5909	-	-	-	-	5	(6)	(7)	8	-	-
*RESIDUE, 30 DAY RECOVERY	26	232	2363	-	-	-	-	5	(6)	(7)	8	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

RESIDUE STUDY OF AROCLOR 1242 IN ALBINO RATS

TWO YEAR CHRONIC ORAL EXPOSURE

ORAL EXPOSURE LEVEL	PPM PCBs 1	10	100	HOMOLOG DISTRIBUTION 1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	803	8037	80373	-	(2)	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 3 MONTH EXPOSURE	6	23	90	-	-	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 12 MONTH EXPOSURE	9	37	155	-	-	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 24 MONTH EXPOSURE	12	53	240	-	-	(3)	(4)	(5)	6	-	-	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

RESIDUE STUDY OF AROCLOR 1254 IN ALBINO RATS

TWO YEAR CHRONIC ORAL EXPOSURE

ORAL EXPOSURE LEVEL	PPM PCBs 1	10	100	HOMOLOG DISTRIBUTION 1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	803	8037	80373	-	-	3	(4)	(5)	(6)	7	-	-	-
*RESIDUE, 3 MONTH EXPOSURE	13	94	679	-	-	-	4	(5)	(6)	7	-	-	-
*RESIDUE, 12 MONTH EXPOSURE	24	189	1471	-	-	-	4	(5)	(6)	7	-	-	-
*RESIDUE, 24 MONTH EXPOSURE	42	355	3038	-	-	-	4	(5)	(6)	7	-	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

RESIDUE STUDY OF AROCLOR 1260 IN ALBINO RATS

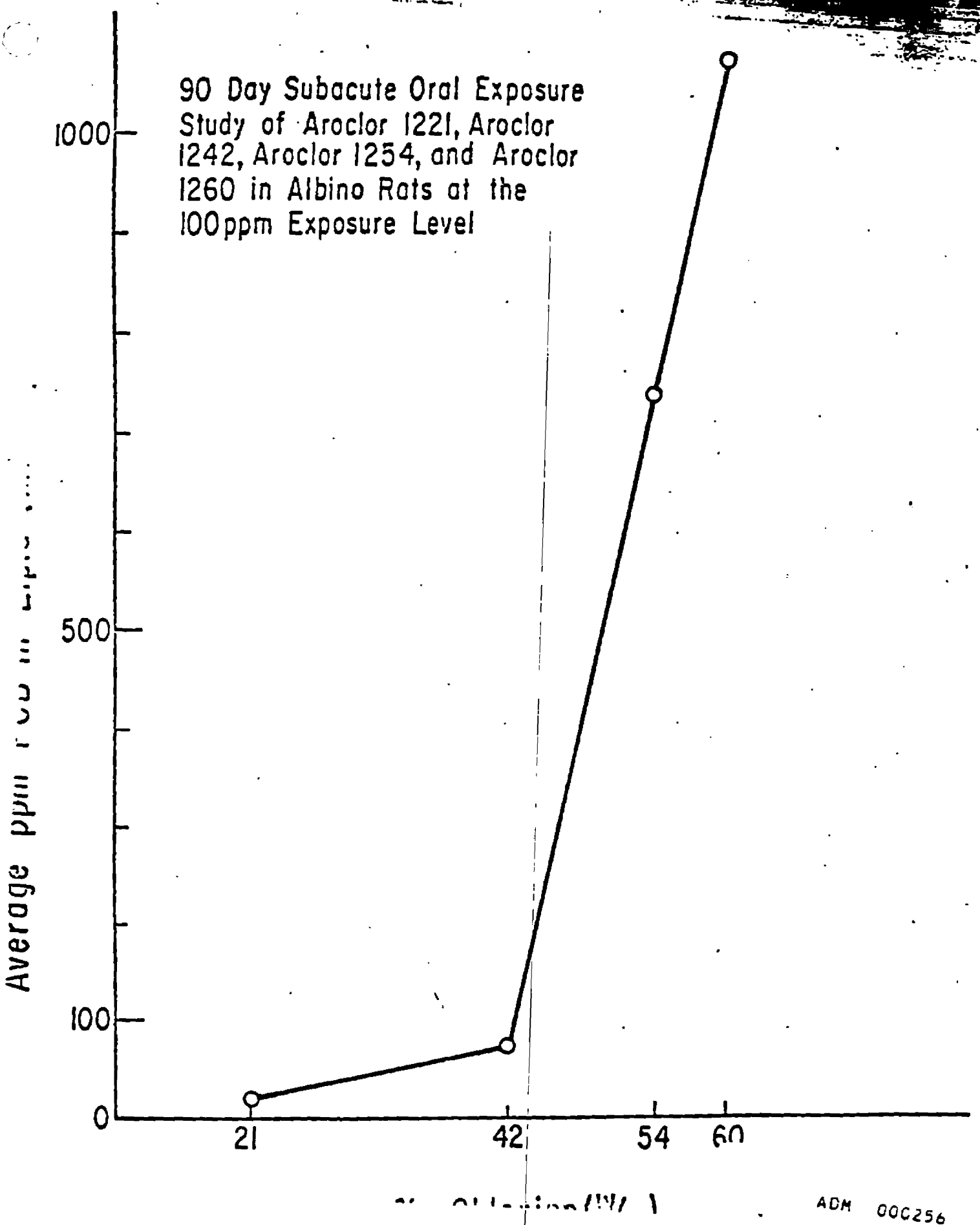
TWO YEAR CHRONIC ORAL EXPOSURE

ORAL EXPOSURE LEVEL	PPM PCBs 1	10	100	HOMOLOG DISTRIBUTION 1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	803	8037	80373	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 3 MONTH EXPOSURE	18	134	970	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 12 MONTH EXPOSURE	35	270	2099	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 24 MONTH EXPOSURE	59	507	4338	-	-	-	-	(5)	(6)	(7)	8	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE-PEAKS GREATER THAN 5% OF TOTAL


90 Day Subacute Oral Exposure Study of Aroclor 1221, Aroclor 1242, Aroclor 1254, and Aroclor 1260 in Albino Rats at the 100ppm Exposure Level
1000
500
100
0
21
42
54
60

BEAGLE DOG STUDIES

		2 YEAR CHRONIC ORAL	90 DAY SUBACUTE ORAL
PRODUCTS STUDIED		AROCLOR 1242 AROCLOR 1254 AROCLOR 1260	AROCLOR 1221
NUMBER OF DOGS	FEMALE	40	14
	MALE	40	14
NUMBER OF SAMPLES	MUSCLE	54	7
	LIVER	54	7
	FAT	54	7
TOTAL SAMPLES COLLECTED		242	21
NUMBER OF SAMPLES ANALYZED	MUSCLE	42	7
	LIVER	40	7
	FAT	43	7
TOTAL ANALYZED		125	21

ORAL EXPOSURE CARRIED OUT BY
INDUSTRIAL BIO-TEST LABORATORIES, INC.
NORTHBROOK, ILLINOIS

RESIDUE STUDY OF AROCLOR 1242 IN BEAGLE DOGS

TWO YEAR CHRONIC ORAL EXPOSURE

ORAL EXPOSURE LEVEL	PPM PCBs			HOMOLOG DISTRIBUTION									
	1	10	100	1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	519	5186	51865	-	(2)	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 2 YEAR EXPOSURE	2	6	12	-	-	(3)	(4)	5	6	(7)	(8)	-	-
*RESIDUE, 30 DAY RECOVERY	1	4	10	-	-	-	-	5	(6)	(7)	(8)	-	-
*RESIDUE, 60 DAY RECOVERY	0.8	3	6	-	-	-	-	5	6	(7)	(8)	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

RESIDUE STUDY OF AROCLOR 1254 IN BEAGLE DOGS

TWO YEAR CHRONIC ORAL EXPOSURE

ORAL EXPOSURE LEVEL	PPM PCBs 1	10	100	HOMOLOG DISTRIBUTION 1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	519	5186	51865	-	-	3	(4)	(5)	(6)	7	-	-	-
*RESIDUE, 2 YEAR EXPOSURE	7	30	132	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 30 DAY RECOVERY	5	24	109	-	-	-	-	5	(6)	(7)	8	-	-
*RESIDUE, 60 DAY RECOVERY	4	20	88	-	-	-	-	5	(6)	(7)	(8)	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

RESIDUE STUDY OF AROCLOR 1260 IN BEAGLE DOGS

TWO YEAR CHRONIC ORAL EXPOSURE

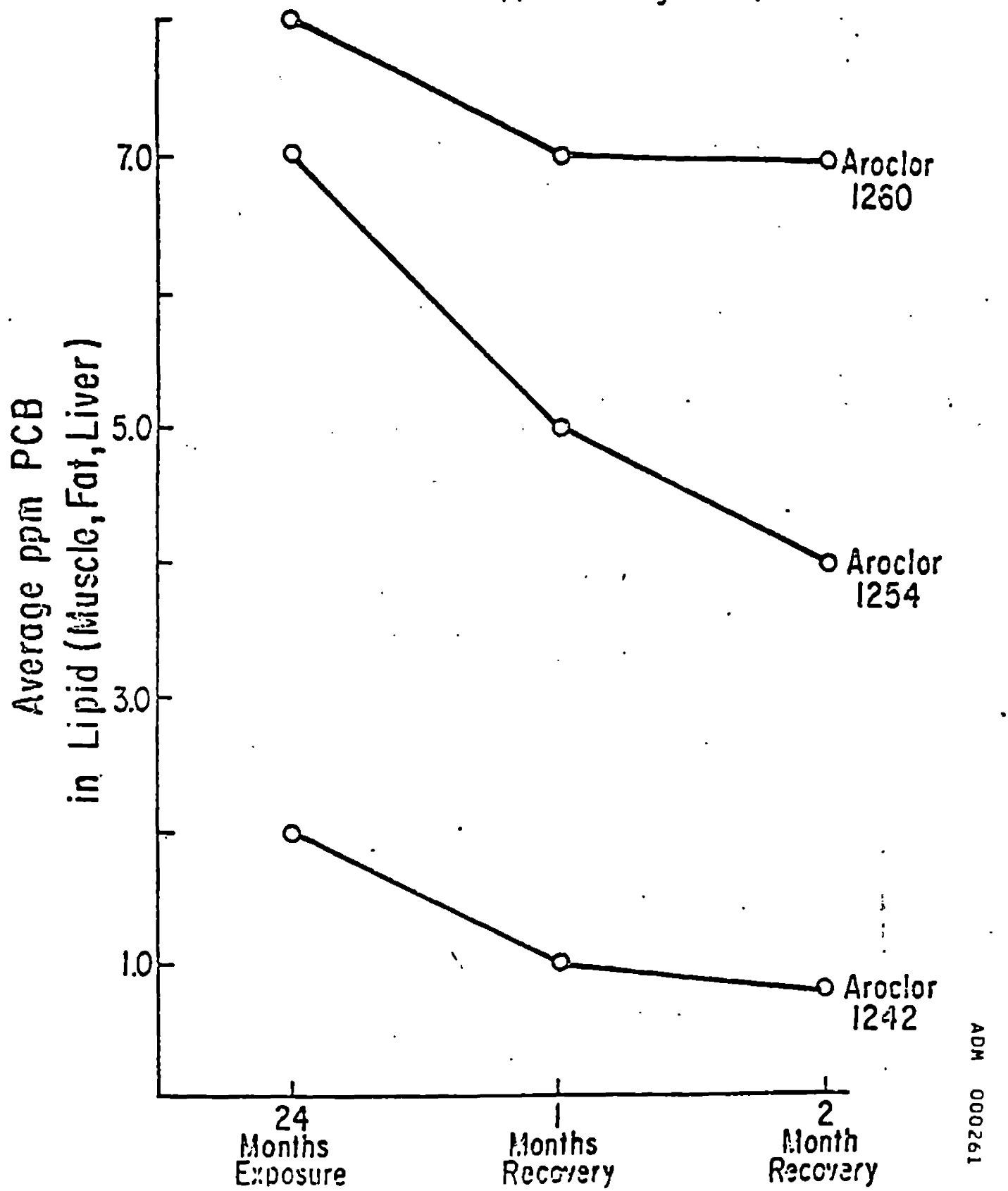
ORAL EXPOSURE LEVEL	PPM PCBs 1	10	100	HOMOLOG DISTRIBUTION 1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	519	5186	51865	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 2 YEAR EXPOSURE	8	63	388	-	-	-	-	-	(6)	7	(8)	-	-
*RESIDUE, 30 DAY RECOVERY	7	60	363	-	-	-	-	-	(6)	(7)	(8)	-	-
*RESIDUE, 60 DAY RECOVERY	7	55	337	-	-	-	-	-	6	(7)	(8)	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

ADM COC26C


Two Year Chronic Oral Exposure
in Beagle Dogs
(at The 1ppm Feeding Level)
Average ppm PCB
in Lipid (Muscle, Fat, Liver)
7.0
5.0
3.0
1.0
Aroclor
1260
Aroclor
1254
Aroclor
1242
24
Months
Exposure
1
Months
Recovery
2
Month
Recovery
ADM 000261

	EXPOSURE LEVEL (PPM)	EXPOSURE PERIOD	CONCENTRATION FACTOR*
WHITE LEGHORN CHICKENS	1.0 (FEED)	12 WEEKS	20
ALBINO RATS	1.0 (FEED)	2 YEARS	9
BEAGLE DOGS	1.0 (FEED)	2 YEARS	2

*CONCENTRATION FACTORS DO NOT TAKE INTO ACCOUNT EXPOSURE PERIODS

CONCLUSIONS

RESIDUE BUILDUP STUDIES

- FOR ALL PRODUCTS THE PCB RESIDUE LEVEL INCREASED AS THE EXPOSURE LEVEL AND PERIOD INCREASED

- RELATIVE TO AROCLOR 1260, THE HIGHEST CHLORINATED PRODUCT STUDIED, THE PCB RESIDUE LEVEL DECREASED EXPONENTIALLY AS AS THE WEIGHT % CHLORINE OF THE PRODUCT DECREASED

- RELATIVE LEVELS OF PCB RESIDUES FOUND WERE -

  FISH>>>>>CHICKENS>RATS>DOGS

- RELATIVE PCB RESIDUE LEVELS IN TISSUES WERE -

CHICKENS	FAT = MUSCLE>LIVER
RATS	LIVER>FAT = MUSCLE>KIDNEY
DOGS	LIVER>FAT = MUSCLE

- FOR ALL PRODUCTS THE DOGS AND RATS EXCRETED AND/OR METABOLIZED 93 TO 99% OF THE TOTAL AROCLOR ORALLY INGESTED

- CHICKENS EXCRETED AND/OR METABOLIZED PRODUCTS INJESTED ORALLY AS FOLLOWS -

  90% OF AROCLOR 1242
  70% OF AROCLOR 1254
  50% OF AROCLOR 1260

CONCLUSIONS

RESIDUE FALL-OFF

- DOGS AND CHICKENS CONTINUED TO EXCRETE AND/OR METABOLIZE PCB RESIDUES, INCLUDING PENTA AND HEXA HOMOLOGS, RETAINED WHEN PLACED ON PCB FREE RECOVERY DIETS

  DOGS > CHICKENS

- RELATIVE RESIDUE FALL-OFF RATES SHOWED -

  DOGS: AROCLOR 1242>AROCLOR 1254 >AROCLOR 1260

  CHICKENS: AROCLOR 1242>AROCLOR 1254>AROCLOR 1260

CONCLUSIONS

RESIDUE STUDIES

ALTERATIONS OF AROCLOR HOMOLOG DISTRIBUTION

- ALTERATION OF THE HOMOLOG DISTRIBUTION OF ALL PRODUCTS WAS OBSERVED IN ALL STUDIES EXCEPT FISH

- LOWER CHLORINATED HOMOLOGS PRESENT IN ALL PRODUCTS WERE PREFERENTIALLY EXCRETED AND/OR METABOLIZED

- ALTERATION OF THE HOMOLOG DISTRIBUTION INCREASED AS THE WEIGHT % CHLORINE OF THE PRODUCTS DECREASED (INCLUDING PENTA AND HEXA HOMOLOGS)

  AROCLOR 1221>>AROCLOR 1242>AROCLOR 1254 >AROCLOR 1260

  DOGS>RATS>CHICKENS>>>>>FISH

WHAT HAPPENS TO PCBs IN THE ENVIRONMENT?

By

Dr. R. H. Munch

Because they can be detected by the same analytical methods, and because some suspect that they may have similar biological effects to DDT, polychlorinated biphenyls in the environment (PCBs) have become a cause of concern. It is, therefore, important to present data to show that PCBs do disappear from the environment.

Probably the most effective way to do this is to compare what has been put into the environment with what is found there now. This can be done in the following way:

The commercial PCB products are mixture of chlorinated biphenyl homologs containing from one to ten atoms of chlorine per biphenyl molecule. If there were no degradation in the environment, or if all homologs degraded at the same rate, the ratio of homologs in "aged environmental samples" (samples taken at a distance from a known source) should be the same as that in the products introduced into the environment. On the other hand, if the homolog ratio in "aged environment samples" differs from that of material produced, some process must be operating in the environment to remove different homologs at different rates. Monsanto, the sole U. S. producer, recently released data on its sales of the various commercial grades of PCB for the years 1957-72. Rest-of-world sales by other producers and production before 1957 probably represent a similar product mix. Using the Monsanto data and known homolog analyses of each of the commercial grades, the percentage of each homolog in the total U. S. production can be calculated.

The other required datum is an estimate of the homolog distribution in "environmentally aged samples." Analysts experienced in this field generally agree that material recovered from such samples is similar to Aroclor 1254 or 1260, the Monsanto trade name for mixtures of PCBs with chlorine contents corresponding to an average of five and six chlorine atoms per biphenyl molecule respectively (1-8). In order to present a conservative comparison and because most analysts cite Aroclor 1254, we shall use the homolog content of that material in our comparison.

The homolog contents of the material produced in the U. S. from 1957 to 1971 and that of Aroclor 1254 are tabulated below:

	Homolog							
0	1	2	3	4	5	6	7	8
U. S. Sales 1957 - 1971								
0.1	1.3	14.8	29.9	21.9	16.1	10.5	4.2	1.1
Aroclor 1254								
<.1	<.1	<.5	1	21	48	23	6	ND

It is apparent that the homolog ratio of the material sold is quite different from that of Aroclor 1254. There must, therefore, be one or more processes in the environment which remove the lower homologs at much greater rates than the higher ones. The precision of the data is too low to permit accurate calculations of the relative rates of loss. However, it would appear that the homologs containing less than four chlorine atoms may be degraded at rates approximately thirty times those for the five and six chlorine homologs. Laboratory data which we hope to publish later show that the rate of bacterial degradation is an inverse function of the chlorine content for PCBs and might, therefore, be one of the degradative processes responsible for the relative decrease in the lower homologs.

1) L. M. Reynolds, Pesticide Residue Analysis in the Presence of Polychlorinated Biphenyls Residue Reviews 34, 27, 32, 41, 42, 44 (1971).

2) R. W. Risebrough, P. Reiche and H. S. Scott - Current Progress in the Determination of the Polychlorinated Biphenyls - Bulletin of Environmental Contamination & Toxicology 4, 192, 199 (197).

3) G. E. Bagley, W. L. Reichel and E. Cromartie - Identification of Polychlorinated Biphenyls in Two Bald Eagles by Combined Gas-Liquid Chromatography-Mass Spectrometry - Journal of the AOAC 53, 251, 252, 257 (1970).

4) Albert C. Tas and Rudolf H. deVos - Characterization of Four Major Components in a Technical Polychlorinated Biphenyl Mixture - Environmental Science & Technology 5, 1216 (1971).

5) Judith A. Armour and Jerry A. Burke - Method for Separating Polychlorinated Biphenyls from DDT and Its Analogs - Journal of the AOAC 53, 763, 765 (1970).

6) Ian Prestt, D. J. Jeffreries and N. W. Moore - Polychlorinated Biphenyls in Wild Birds in Britain and Their Arian Toxicity - Environmental Pollution 1, 3, 15 (1970).

7) V. Zitko - Polychlorinated Biphenyls and Organochlorine Pesticides in Some Freshwater and Marine Fishes - Bulletin of Environmental Contamination & Toxicology 6, 464, 467 (1971).

8) PCBs & The Environment - Interdepartmental Task Force on PCBs - Washington May, 1972 - COM-72-10419 - Table 6, P. 93.

WHAT HAPPENS TO PCBs IN THE ENVIRONMENT?

1. PCBs ARE MAN MADE.

2. WE CANNOT DETERMINE IF THEY DEGRADE IN THE ENVIRONMENT FROM THE TOTAL CONCENTRATIONS FOUND THERE.

3. THE PCBs ARE MIXTURES OF HOMOLOGS.

4. THEREFORE, COMPARISON OF HOMOLOG RATIOS IN "ENVIRONMENTALLY AGED SAMPLES" WITH HOMOLOG RATIOS IN MATERIAL PRODUCED CAN BE USED TO GAIN INSIGHT AS TO WHAT IS HAPPENING IN THE ENVIRONMENT.

HOW DO WE GET THE DATA NEEDED?

1. PRODUCTION FIGURES FOR ALL MONSANTO PCB PRODUCTS AND HOMOLOG CONTENT OF EACH PRODUCT ARE AVAILABLE FOR 1957-71. WE USE THESE DATA TO CALCULATE HOMOLOG RATIOS FOR 1957-71 PRODUCTION.

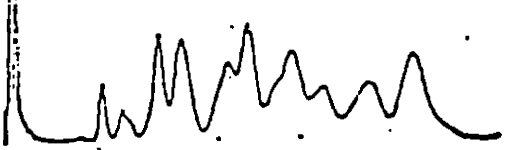
2. EUROPEAN PRODUCERS MAKE SIMILAR PRODUCTS IN ABOUT THE SAME RATIOS AS MONSANTO.

3. PRODUCTION BEFORE '57 WOULD NOT AFFECT THE FIGURES GREATLY SINCE PRODUCT RATIOS WERE SIMILAR AND PRODUCTION SMALLER.

4. ANALYSTS GENERALLY AGREE THAT MATERIAL FOUND IN "AGED ENVIRONMENTAL SAMPLES" IS SIMILAR TO AROCLOR 1254 OR IN RARE CASES EVEN TO AROCLOR 1260.

HARVEY [illegible]
WOODS HOLE OCEANOGRAPHIC [illegible]
AROCLOR 1254 VS ENVIRONMENTAL MATERIAL [illegible]

AROCLOR 1254



PLANKTON
K-19-4-STA. 10

A COMPARISON OF THE HOMOLOG RATIOS FOR PCBs SOLD WITH THOSE FOUND IN AGED ENVIRONMENTAL SAMPLES

	HOMOLOG								
	0	1	2	3	4	5	6	7	8
U.S. SALES '57 - '71	0.1	1.3	14.8	29.9	21.9	16.1	10.5	4.2	1.1%
AROCLOR 1254	<.1	<.1	<.5	1	21	48	23	6	ND

CONCLUSIONS

1. THERE ARE MARKED DIFFERENCES BETWEEN THE RATIOS OF HOMOLOGS IN PCBs FOUND IN "AGED ENVIRONMENTAL SAMPLES" AND THE RATIO OF HOMOLOGS FOR MATERIAL PRODUCED.

2. THESE DIFFERENCES CAN BEST BE EXPLAINED BY ASSUMING THAT THE PCBs WITH 3 OR LESS CHLORINE ATOMS PER MOLECULE DEGRADE MUCH MORE RAPIDLY THAN THE HIGHER HOMOLOGS.

3. THE HOMOLOG RATIO DATA DO NOT GIVE INFORMATION ON THE RATE OF DEGRADATION OF HIGHER HOMOLOGS. HOWEVER, SEMI-CONTINUOUS ACTIVATED SLUDGE TEST DATA SHOW THAT THESE TOO DEGRADE BUT AT A SLOWER RATE.

MONSANTO PCB ACTIONS

By

Dr. C. Paton

In this section I would like to present the voluntary changes that Monsanto has made in PCB sales with particular emphasis on the PCB product changes made in dielectrics. I also wish to show the significance of the data presented by Drs. Tucker and Munch.

Monsanto's sales actions can be divided into two categories (Slide 1: Monsanto's PCB Actions).

The first category is further described in:

Slide 2: Monsanto's PCB sales in U. S. A. and

Slide 3: Effect of phase-out policy

I respectfully submit we have achieved a significant reduction in PCB output by our actions. Turning to the second phase of our actions, viz, the product changes in PCBs for dielectric use. I will first take a moment to explain the variation in biodegradability of PCBs.

Slide 4: Degree of Biodegradation of PCBs.

The product changes made dielectrics are shown on Slide 5: PCB Product Changes in Dielectrics.

Dealing first with capacitors:

Slide 6: PCBs used in Capacitors

Note: (a) Penta-chlorobiphenyl percentages include hexa- and higher homologs. Do not add both percentages together.

(b) This slide shows a substantial decrease in production of homologs of penta-chloro and higher over the years.

Slide 7: Why Convert to Aroclor 1016?

Reasons were:

(a) 9-fold reduction in penta-chloro and higher homologs.

(b) 10-fold reduction in hexa-chloro and higher homologs.

(c) Aroclor 1016 was the PCB product that could be introduced into the capacitor industry while still meeting Underwriter's Laboratory requirement on flammability.

(d) Aroclor 1016 was selected because its electrical properties and in-plant processing performance most closely met the capacitor industry's requirements.

Note: Our choice of Aroclor 1016 has since been borne-out by industry experience which to date has shown no problems.

Slide 8: Capacitor Fluids: What is Effect of Aroclor 1016?

We have tried to show amounts of penta-chloro and higher and hexa-chloro and higher homologs which would have been produced (Not entering the environment) for each of three possible capacitor fluids in 1972. Aroclor 1016 (used at 97% level in U.S.A. in 1972) is obviously the PCB involving least penta and higher chloro biphenyl production.

Of obvious interest is the possible amount of PCBs entering the environment from capacitor failures.

Slide 9:

Using the worst case (0.2% per year failure) we see that no more than 40 pounds of hexa-chloro and higher homologs of PCB are likely to enter the environment if Aroclor 1016 is used at a rate of 20M lb./year.

Turning now to Transformers.

Slide 11:

Note: Higher chlorinated PCBs are needed in transformers than in capacitors because the correct Hydrogen/Chlorine ratio is vital in preventing formation of flammable, explosive arc-form gases.

Slide 12:

Slide 13:

In summary, Slide 14:

We will continue our voluntary policy of no more sales world-wide except to dielectric users. This means a 45% reduction in total PCB sales in the U.S.A. We will restrict over 97% capacitor fluid sales to Aroclor 1016 only. This means penta-chloro and higher production will be no more than 1.1% or 220 M lbs. in 1972. Hexa-chloro biphenyl and higher will be even lower 0.1% or 20,000 lbs. in 1972. We will eliminate Aroclor 1260 from transformer fluids and continue incineration facilities for scrap PCBs. We will encourage the dielectric industry through ANSI C-107, which represents both capacitor and transformer manufacturers and users, to enforce strict environmental control over PCBs. This is a committee on which several of the agencies represented here today are members.

MONSANTO PCB ACTIONS

- PHASE-OUT OF PCB SALES WORLDWIDE IN ALL APPLICATIONS EXCEPT DIELECTRICS
- CONVERSION OF DIELECTRIC FLUIDS TO MORE BIODEGRADABLE PCB'S

MONSANTO PCB SALES IN U.S.A.

(MILLION POUNDS)

	DIELECTRICS	ALL OTHERS	TOTAL
1969	37.0	30.0	67.0
1970	40.5	33.5	74.0
1972 (EST.)	32.0	--	32.0

EFFECT OF PHASE-OUT POLICY

PCB SALES REDUCED IN U.S.A. BY

30 TO 33 MILLION POUNDS.

OR 45%

PCB PRODUCT CHANGES IN DIELECTRICS

CAPACITORS

97% CONVERSION TO AROCLOR 1016

TRANSFORMERS

ELIMINATION OF AROCLOR 1260

DEGREE OF BIODEGRADATION OF PCB'S

BASED ON DATA PRESENTED

- TRANSITION IN BIODEGRADATION OCCURS AROUND PENTA-/HEXA-CHLOROBIPHENYL
- DISAPPEARANCE OF ALL HOMOLOGS BELOW HEXA-CHLOROBIPHENYL OBSERVED
- PENTA- AND HIGHER PCB DETERMINED BY SPECIFIC GLC/MS TEST METHOD

PCB'S USED IN

PCB	MAJOR USE PERIOD
AROCLOR 1254	1930-1952
AROCLOR 1242	1952-SEPT. 1971
AROCLOR 1016	OCT. 1971

CAPACITORS

% PCB (PENTA-CHLORO- AND HIGHER	% PCB (HEXA-CHLORO- AND HIGHER
77.0	29.0
9.0	1.0
1.1	0.1

CAPACITOR FLUIDS
WHY CONVERT TO AROCLOR 1016?

- 9-FOLD REDUCTION IN PCB'S OF PENTACHLORO- AND HIGHER
- 10-FOLD REDUCTION IN PCB'S OF HEXACHLORO- AND HIGHER
- MINIMUM INDUSTRY TESTING REQUIRED

CAPACITOR FLUIDS
WHAT IS THE EFFECT OF AROCLOR 1016?

U.S. CAPACITOR FLUID SALES (1972):~20 M LBS.

IF AROCLOR WAS	% PENTACHLORO- AND HIGHER PCBs WOULD BE*	% HEXA CHLORO- AND HIGHER PCBs WOULD BE*
1254	15,400,000 POUNDS	5,800,000 POUNDS
1242	1,800,000	200,000
1016	220,000	20,000

*THIS DOES NOT MEAN AMOUNTS OF PCB ENTERING THE ENVIRONMENT

AGM COC284

WHAT IS CAPACITOR FAILURE RATE ?

INDUSTRY SOURCES CITE : 0.02-0.2% PER YEAR

IF CAPACITOR FAILURE RATE IS 0.2% PER YEAR (WORST CASE)

PCB ESCAPE TO THE ENVIRONMENT* IS --

	AROCLOR 1242	AROCLOR 1016
ALL PCB HOMOLOGS	40,000 POUNDS	40,000 POUNDS
PENTA CHLORO- AND HIGHER	3,600	440
HEXA CHLORO- AND HIGHER	400	40

*ASSUMES U.S. FLUID SALES OF 20 M LB./YEAR

PCB CHANGES IN

TRANSFORMER FLUID APPLICATIONS

- AROCLOR 1260 BEING PHASED-OUT NOW
- INCINERATION OF SCRAP PCB'S - 1971

NOTE: ASKAREL (PCB) TRANSFORMERS ARE HERMETICALLY SEALED UNITS

WHAT IS FAILURE RATE IN LIQUID TRANSFORMERS?

INDUSTRY SOURCES CITE: UNDER 0.2% PER YEAR*

*ALL LIQUID TYPES - MINERAL OIL AND PCB.

IF ASKAREL (PCB) TRANSFORMERS FAIL AT 0.2%/YEAR HOW MUCH PCB IS AFFECTED*?

ALL PCB HOMOLOGS	24,000 LBS.

(ESTIMATED PCB TRANSFORMER FLUID SALES IN U.S. 12 M LBS./YEAR)

*WITH INCINERATION FACILITIES AVAILABLE, NOT ALL THESE AMOUNTS WILL ENTER ENVIRONMENT.

MONSANTO'S PRESENT PROGRAM TO PREVENT ENVIRONMENTAL POLLUTION BY PCB'S

- NO MORE SALES WORLD-WIDE EXCEPT DIELECTRIC USERS
- RESTRICT OVER 97% CAPACITOR FLUID SALES TO AROCLOR 1016 ONLY
- ELIMINATE AROCLOR 1266 FROM TRANSFORMER FLUIDS
- CONTINUE INCINERATION FACILITIES FOR SCRAP PCB'S
- ENCOURAGE DIELECTRIC INDUSTRY THROUGH ANSI C-107 TO ENFORCE STRICT ENVIRONMENTAL CONTROL OVER PCB'S

SUMMARY

By

W. B. Papageorge

In summary, our observations, admittedly limited, both from our laboratory data and from reports of other investigators lead us to believe with considerable confidence that PCBs do degrade in the environment. The complexity of the commercial mixtures has, however, hampered the determination of the varying rates of degradation of all the possible isomers.

Monsanto's sales actions have definitely reduced the amount of PCBs that could be introduced into the environment.

In those applications in which the use of PCBs is considered essential, namely transformers and capacitors, further actions will assure strict environmental control on PCBs.

In transformers the use of the lower chlorinated biphenyls along with proper handling during manufacture, use and repair and proper disposal of waste fluid by high temperature incineration should result in acceptable control.

For the capacitor application the development of Aroclor 1016, which satisfied all of the industry's requirements relating to dielectric characteristics and handling properties as well as having Underwriter Laboratory fire-resistance approval, permits the continued use of PCBs in this important hermetically sealed application but with a fluid that has a significantly lower content of the slower degrading isomers. The use of this material accompanied by proper handling and disposal of the scrap fluid by high temperature incineration represents in our considered opinion a significant step forward in our efforts to control the impact of PCBs on the environment.