REQUEST FOR VERIFICATION ☐ DEVELOPMENT ☐ PRODUCTION

WESTINGHOUSE FORM 7368 V

DEPARTMENT	BUDGET NO.	DATE
Materials & Processes Development		

APPARATUS (STATE SPECIFICALLY RATINGS, SIZES, ETC., TO BE VERIFIED) — SAMPLE ☐ HEREWITH ☐ NONE IN SEC. .....

Nonflammable Liquid Transformer Coolant

SUPPLEMENTARY INFORMATION ATTACHED	PAGES	DWG. NOS.	PHOTO NOS.

ANSWER ALL QUESTIONS (briefly in last column, supplemented by attached information where necessary.)

A	Do ratings and performance of apparatus conform with the standards of AIEE, NEMA, ASA and other associations as far as they apply?	Yes
B	Do construction and performance of apparatus conform with Underwriters' Laboratories Standards, National Electrical Code and other Codes as far as they apply?	
C-1	Do ratings and performance of apparatus meet specifications?	
C-2	Can the following agreed upon be met? (Attach present estimates or actuals) — W. O. C. / AMC & CC / TOTAL COST / SELLING PRICE / PROFIT	
D	Have endurance and field tests been made establishing suitability of apparatus for severe conditions? (Outline in attached)	See attached.
E	Have non-stock (Westinghouse) materials or sizes been used?	Yes
F-1 F-2	Has Patent Department been consulted and design approved? Give reference to Patents, Patent Cases or disclosures involved. (List on attached).	Not required.
G-1 G-2	Is any other Engineering or Works Dept. interested? (Signatures of those consulted)	No
H-1 H-2 H-3	Does new apparatus supersede existing apparatus? (List on attached) Will activity on any stocked items including raw material be decreased or discontinued by this? Have superseded materials (including raw material) been salvaged?	Yes Yes No
I	Is new trade mark, instruction book, dimension leaflet, or tag necessary?	
J-1 J-2	Is marketing of this device dependent upon other developments? If so, give reference and state advisability for combination test and verification.	
K	Are there any limitations with regard to application, manufacture, guarantees, radio interference, etc., other than those well understood with this type of apparatus?	
L	Have electronic circuits, tubes and components been thoroughly investigated and tested?	Not required
M-1	Before which Technical Society should the new technical information resulting from this development be presented as a formal paper? — AIEE / ASME / IRE / ASM / ACS / OTHER	
M-2	Probable date and place of presentation for maximum company advantage.	
N	Is the Sales literature available? Yes ☐ No ☐ If not, show schedule for completion—technical ..... promotional	

Where these items are discussed in sheets attached, refer to them by paragraphs lettered as above.

Authorization is requested for building ..... units for stock with complete / with existing tools prior to production verific

SIGNATURES REQUIRED PRIOR TO ACTION BY OPERATING DIVISION VERIFICATION COMMITTEE

ENGINEERING	MANUFACTURING	SALES
.....	.....	.....

VERIFICATION COMMITTEE APPROVALS

DIVISION MGR.	DATE	ENGINEERING MGR.	DATE	SALES MGR.	DAT
MANUFACTURING MGR.	DATE	MFG. ENGINEERING MGR.	DATE		DAT

NOTE: SEND ALL COPIES TO CHAIRMAN, VERIFICATION COMMITTEE OF OPERATING DIVISION FOR ROUTING.

COPIES FOR
- ☐ ACCOUNTING DEPARTMENT MGR.
- ☐ ENGINEERING DEPARTMENT MGR.
- ☐ ENGINEERING SECTION MANAGER
- ☐ MANUFACTURING DEPT. MANAGER
- ☐ PATENT DEPARTMENT MANAGER
- ☐ SALES DEPARTMENT MGR.
- ☐ FILE
- ☐ _____
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- ☐ _____

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Part I
General Information

Introduction

Inerteen 54201KA is presently being used as the nonflammable transformer coolant. This material is a mixture of 70% chlorinated diphenyl (Aroclor 1254) and 30% trichlorobenzene with 0.20% phenoxypropene oxide added as a HCl scavenger. A program has been conducted with the Monsanto Company to obtain a lower cost nonflammable coolant.

This program has led to a material which has the necessary requirements for general application as a substitute for Inerteen 54201KA. This material is Aroclor 1242, which would be used alone, except for the 0.2% scavenger. This material is about equivalent in cost per pound as Inerteen 54201KA, but weighs less and has properties nearly as good or better than Inerteen 54201KA. Due to the absence of the trichlorobenzene, it may also have less effect on the other component materials in the transformer.

This material has been tested in our laboratory in comparison with the presently used Inerteen. In addition to the laboratory work, a unit containing Aroclor 1242 has been operating for over three years at the local Sharon Steel plant.

Aroclor 1242 has been used for some time as a capacitor material and it has demonstrated aging stability over long periods of time.

Material Characteristics

Comparisons between Aroclor 1242 and Inerteen 54201KA have been made in the following areas:

(1) Physical properties
(2) Power factor vs. temperature
(3) Viscosity vs. temperature
(4) Aging in contact with paper, pressboard and cotton tape.
(5) Dielectric strength vs. temperature
(6) Impulse strength and impulse ratio
(7) Ability to function as a coolant

(1) Physical Properties

Table I shows a comparison between our specification 54201KA, Monsanto's data on Aroclor 1242, our laboratory tests on Aroclor 1242, and tests in a typical batch of Inerteen 54201KA.

The specific gravity range of 1.381-1.392 as compared with 1.518-1.528 for Inerteen 54201KA gives a weight reduction of one pound per gallon. This gives us less weight per unit volume, freight savings on shipments of coolant and on shipments of units, and lower transformer weight.

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(2) Power Factor vs. Temperature

The power factor and the dielectric constant of Aroclor 1242 are slightly better. Curves of the power factor vs. temperature for the two materials are shown in Figure 1.

(3) Viscosity vs. Temperature

The viscosity of the Aroclor 1242 is greater at low temperatures, but is about the same as Inerteen 54201KA above 60°C, which includes the operating temperatures of the apparatus in which it will be used. A comparison of the viscosities at various temperatures is shown in Figure 2.

(4) Aging in Contact with Paper, Pressboard and Cotton Tape

Comparisons of tests after aging samples of paper, pressboard and cotton tape in the two liquids are shown in Table II. The Aroclor 1242 showed lower power factor, higher dielectric constant and slightly higher resistivity throughout.

(5) Dielectric Strength vs. Temperature

The dielectric strength of the two liquids at the various temperatures are quite comparable. The comparison is shown in Figure 3.

(6) Impulse Strength and Impulse Ratio

Dielectric strength tests, both 60 cycle and impulse were run using .056" thick pressboard 1581-18 in the three liquids--WEMCO C oil 2772, Inerteen 54201KA and Aroclor 1242. Tests were made on 10" x 10" samples using 2" brass electrodes. The test values are shown in Table IV.

The dielectric strength was slightly less in the Aroclor than in the Inerteen and the impulse ratio was slightly higher in the Aroclor.

(7) Ability to Function as a Coolant

The ability of the two liquids to function as coolants can be evaluated by comparing the heat transfer coefficients of the two materials. This was done by using the following equation:

$$h_c = C\frac{k}{L}\left[\frac{g\ \beta\ e^2\ c_p\ L^3\ \Delta\ t}{\mu\ k}\right]^d$$

for fluids (liquids and gases) in free convection

C = constant
k = thermal conductivity
L = length dimension
g = constant of gravity
β = coefficient of expansion, 1/°C
e = density, lb./in.^{3}
c_p = thermal capacity (specific heat), cal./gram °C

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Δt = temperature difference
μ = viscosity
d = exponent 1/4 to 1/3. Use 1/3 for liquid.

$$\frac{h_c \text{ Aroclor}}{h_c \text{ Inerteen}} = \frac{k^{.7}_{\text{Aroclor}} \beta^{.33}_{\text{Aroclor}} e^{.67}_{\text{Aroclor}} c_p{}^{.33}_{\text{Aroclor}} \mu^{.33}_{\text{Inerteen}}}{k^{.7}_{\text{Inerteen}} \beta^{.33}_{\text{Inerteen}} e^{.67}_{\text{Inerteen}} c_p{}^{.33}_{\text{Inerteen}} \mu^{.33}_{\text{Aroclor}}}$$

= 1.0 if fluids have same heat transfer.
> 1.0 if Aroclor is better than Inerteen.
< 1.0 if Inerteen is better than Aroclor.

At 100°C	Inerteen 54201KA	Aroclor 1242
Thermal Conductivity cal./°C - cm. sec.	22.7×10^{-5}	24.7×10^{-5}
Specific Heat cal./gram, °C	.261	.302
Avg. Coefficient of Expansion	.00066	.00068
Density, lb./in.^{3}	.0545	.0498
Viscosity	32.5	34.0
At 60°C		
Viscosity	39.5	45.5

Other properties calculated as being the same at 60°C as at 100°C.

$\frac{h_c \text{ Aroclor}}{h_c \text{ Inerteen}}$ = 1.028 at 100°C = ratio of heat transfer coefficients

= 1.02 at 60°C

This indicates that the Aroclor 1242 is 2-3% better in the area of 50 to 100°C. This should not be significant from the stand-point of design of the apparatus and the cooler surface. The two liquids should be interchangeable from the stand-point of efficiency as coolants.

Cost Information

Material	Weight	Price/lb.	Price/gal.
Inerteen 54201KA	12.6 lb./gal.	$.133	$1.676/gal.
Aroclor 1242	11.5	$.1345	$1.547
		Savings =	$0.129/gal.

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Freight

In tank car, minimum rate = .68/hundred pounds. Presently shipped 8,000 gallons/tank car.

Inerteen 54201KA	8000 gal. = 100,800 lbs. =	$685
Aroclor 1242	8000 gal. = 92,000 lbs. =	$625

Savings = $ 60/tank car

Total

Therefore, the total savings is approximately $0.13/gallon. The present yearly activity is 480,000 gallons.

480,000 x .13 = $62,400 cost reduction

It is also anticipated that a more favorable price might be negotiated with Monsanto due to the fact that using Aroclor 1242 with no solvent will increase their total business.

Underwriter's Approval

Application has been made to Underwriter's Laboratories for approval of Aroclor 1242 for use in transformers. This should only be a formality as the material has previously been approved for capacitors.

Part II
Performance

Samples of Aroclor 1242 and Inerteen 54201KA have been aged in contact with pressboard, kraft paper and cotton tape, and the resultant properties of the two materials were compared. In all cases the Aroclor 1242 was somewhat better. These test results are shown in Table II.

Unit 7021007 on Order C-26537, YG 80249, ZBR2428 has been in operation at Sharon Steel since November 1, 1963, with Aroclor 1242 as the coolant. Samples were tested originally, after 9 months operation and after three years operation. The properties are continuing quite good as shown in Table III.

Summary

The use of Aroclor 1242 instead of Inerteen 54201KA would have the following advantages:

(1) Less weight.
(2) Lower power factor.
(3) In shop processing, it will be possible to pull full vacuum as no solvent is present.
(4) Less effect on other components of transformer.

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The only disadvantage is the high viscosity at low temperatures, however, since the dielectric strength appears to be comparable to Inerteen at all temperatures, this should present no serious problem.

The two liquids are compatible, therefore, the changeover should be no problem in the shop. Some increased difficulty in pumping may occur in cold weather, but this should not be serious.

H. A. Pearce, Jr., Matls. Engr.
Reliability Section
M. & P. Dev. Dept.

/scw

TABLE I

Properties

	Inerteen 54201KA Specification
Color, APHA, max.	150
Free Chlorides, ppm, max.	0.10
Dielectric Strength, .1" gap, KV, min.	30
Fire Point to Boiling Point	None
Neutralization No., mg KOH/gram, max.	.014
Pour Point, max.	-30°C
Refractive Index, 25°C	1.6153-1.6173
Phenoxypropene Content, % by weight	.18-.22
Specific Gravity	1.518-1.528
Viscosity, SSU, 37.8°C	56 ± 2
Viscosity, SSU, 100°C	
Condition	Clear
Water Content, ppm	35
Distillation Range	
Initial Boiling Point (1st Drop)	200°C
Percent Distillation at 270°C, max.	40
90% Distilled	285-300°C
Electrical Resistivity, ohms/cm^2 at 100°C, min.	10.0×10^{10}
Density, pounds per gallon, 25°C	12.6
Dielectric Constant	
Power Factor, %	
Interfacial Tension, dynes/cm^2	

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M & P Test on Inerteen 54201KA	Monsanto Data on Aroclor 1242	M & P Test on Aroclor 1242
	100	
0.10		
44	35	44.5
None	None	
.002	.010	.004
-39°C	-19°C	+5°C
1.6157	1.627-1.629	
	.18-.22	
1.52	1.381-1.392	1.38
56.6	82-92	89.4
About 35	34-35	About 35
Clear	Clear	Clear
	50	
223°C		
35.1		
410		
558		
	11.5	
4.5	5.8	5.84
1.39		0.89
41.7		44.7

TABLE II

Aging in Contact with Paper, Pressboard and Cotton Tape

Oven Dried Paper, Pressboard and Tape

		Inerteen	Aroclor 1242
Samples Aged 1 Week at Room Temperature	Power Factor	1.67	1.0
	Resistivity	3,600	4,700
	Dielectric Constant	4.64	5.82
Samples Aged 1 Week at 90°C	Power Factor	5.49	4.17
	Resistivity	950	1180
	Dielectric Constant	4.69	5.88
Samples Aged 1 Month at 90°C	Power Factor	5.73	2.69
	Resistivity	700	900
	Dielectric Constant	4.67	5.97

Solvent Dried Paper, Pressboard and Tape

Samples Aged 1 Week at Room Temperature	Power Factor	1.42	0.89
	Resistivity	4,200	5,400
	Dielectric Constant	4.64	5.82
Samples Aged 1 Week at 90°C	Power Factor	3.69	2.70
	Resistivity	1,800	1,750
	Dielectric Constant	4.66	5.86
Samples Aged 1 Month at 90°C	Power Factor	4.54	2.43
	Resistivity	1,020	1,400
	Dielectric Constant	4.65	5.93

TABLE III

WESTINGHOUSE ELECTRIC CORPORATION

TRANSFORMER DIVISION SHARON, PENNSYLVANIA

TESTS OF TRANSFORMER INSULATING LIQUIDS

CUSTOMER Sharon Steel

LOCATION Sharon, Penna.

DISTRICT Ser. #7021007 G.O. 275 gals.

Customer Order C-26537, YG 80249, ZBR2428

OIL ☐ INERTEEN ☒ .1242 DATE

TEST					
	TRANSFORMER SER. NO.	7021007	7021007	7021007	
	SOURCE OF SAMPLE	Bottom	Bottom	Bottom	
GENERAL CONDITION		Clear	Clear	Clear	
DIELECTRIC STRENGTH - KV		40.5	40.5	33.5	
POWER FACTOR - PERCENT 60 CYCLE 25°C		2.05	2.05	2.55	
INTERFACIAL TENSION - DYNES PER CM.		43.9	43.9	43.0	
NEUTRALIZATION NO. - MG KOH PER GRAM		0.003	0.003	0.005	
COLOR - ASTM D-1500		0.0	0.0	0.0	
SAYBOLT VISCOSITY - SECONDS - 100°F		83.0	83.0	85.2	
SPECIFIC GRAVITY - 60°F		1.390	1.390	1.395	
POUR POINT - °F		+2	+2	-15	
MOISTURE, PPM		18	18	6	
Samples taken -		Original 11/1/63	8/4/64	11/10/66	

REMARKS:

I HEREBY CERTIFY THE ABOVE REPORT IS A TRUE RECORD TAKEN FROM LABORATORY TESTS IN ACCORDANCE WITH CURRENT A.S.T.M. TESTING METHODS.

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ENGINEER [redacted] APPROVED DATE

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TABLE IV

Dielectric Tests on .056" Thick Pressboard Impregnated with Liquid Coolants

	60 Cycle Breakdown Average Volts/Mil	Full Wave Crest Volts/Mil at Failure	Impulse Ratio
Wemco C Oil 2772	724	2588	3.57
Inerteen 54201KA	1241	1912	1.53
Aroclor 1242	1147	1828	1.59

	INERTEEN 54201CM	Trichlorobenzene
HCl	55.0	95.3
Other Gases	45.0	4.7
N_2	8.0	2.5
O_2 + Argon	.5	.5
AO_2	.1	.5
H_2	29.4	.6
CO	1.2	.4
CH_4	.5	.1
C_2H_6	—	—
C_2H_4	.3	Trace
C_2H_2	5.1	.2
C'3s	—	—

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Tri Tetra Blend	Tri Tetra Blend +5% Oil	Tri Tetra Blend +10% Oil
87.4	76.2	46.2
12.6	23.8	53.8
8.4	11.3	11.4
2.5	2.4	2.7
—	—	Trace
.2	5.4	22.3
1.4	—	—
Trace	1.7	4.0
—	.2	.3
—	.7	1.8
.1	1.8	3.8
—	.1	.1

DRAFT

PCB's

Objective

Identify and communicate to our customers, users and appropriate Federal and State agencies, that a minute mixing of PCB materials into mineral oil used in insulating and cooling electrical devices such as transformers has occurred. This mixing effect has possibly occurred since the beginning of the use of PCB's such as INERTEEN and PYRANOL as insulating fluids and substitutes for oil where fire hazards dictated an inflammable fluid.

To date, no problem of this mixing effect has been evidenced in the operating characteristics of the equipment.

Recent investigations indicate that this mixing effect is very broad and possibly effects, to some extent, most manufacturers and users of these electrical devices.

The probable reason for the mixture stems from the proximity of the mineral oil and PCB oil systems used in the manufacturing of the electrical apparatus in separate but parallel manufacturing and testing operations since the inception of the use of PCB's in transformers in 1938. Similar mixing may have resulted from the installation, inspection, and maintenance of transformers by the users.

There is no functional problem with respect to the transformer resulting from this mixture.

Since the early 1970's, appropriate labeling and special handling of INERTEEN filled transformers has been carried out in all plants utilizing this fluid. All locations comply with the full intent of current Federal and State laws.

Recommendations

1. Immediate notification of the above facts to all customers and users.

2. Convince industry to request EPA to develop acceptable levels of PCB dilutions in oil similar to previously established PCB levels in other commodities such as food, milk, fish, etc.

3. Develop detailed responses to inquiries which may come from our customers and users or State regulatory agencies with respect to the proper handling and disposal of this oil should it be accidentally released to the environment.

4. Suitable technical press and general press releases developed for use when and if queried or if desirable to insure total customer notification.

5. Establish a Communications Center in Pittsburgh to handle inquires which are not covered in the communications to customers and the press.

6. Assign project coord. full time until problem is behind us.

General

It is recommended that a mature, confident and business-like approach be taken with respect to all of our communications.

It is recognized currently, that the subject of PCB's and their release to navigable waterways and regulation at both the Federal and State level is at a high and emotional point. Therefore, this mixing problem could be misunderstood and exaggerated, causing significant problems to our customers and the industry in general.

To the best of our knowledge, there is no current violation of any Federal or State law.

RAB,JR.
10/8/76

BACKGROUND

As a result of recent investiagations it has come to our (Industries) attention that many oil filled (mineral oil) transformers, and possibly other Electrical devices which utilize mineral oil as an insulator and coolant, may contain minute quantities of PCB's.

The probable reason for the mixture stems from the proximity of the mineral oil and PCB oil systems used in the manufacturing of the electrical apparatus in separate but various parallel manufacturing and testing operations since the inception of the use of PCB's in transformers in 1938.

There is no operating or warranty problem with respect to the transformer resulting from this mixture. From an operating standpoint, the electrical characteristics remain basically unchanged when filled with either mineral oil or INERTEEN.

Appropriate labeling and special handling of INERTEEN filled transformers has been carried out in all plants utilizing this fluid and all locations comply with the full intent of current Federal and State laws.

Recent Federal and State regulations may require precaution and special handling methods with mineral oil filled transformers due to the small quantities of PCB's which have become mixed with the main oil supplys.

There does not appear to be any feasible or economic way to separate minute quantities of PCB's from oil.

Since policies have already been formulated within Westinghouse to cease manufacture of transformers containing PCB's by December 1976, future mixing of PCB's in mineral oil will be eliminated. However, it could be many years before all the mixing effect could or would be eliminated in units already manufactured.

It is recommended that suitable communications be made with our customers and State and Federal and Regulatory Agencies so that appropriate caution can be taken to minimize or prevent the inadvertent releases of PCB's to the environment.

RAB,JR.
10/6/76

PQ 425 12/15 1520 CG12/16 215P

D L LITTEN

RE YOUR WIRE ON PCB/OIL MIXING, THE FOLLOWING DISTRIBUTORS HAVE BEEN NOTIFIED-
ALL WESCO LOCATIONS
BUFFALO ELECTRIC
FIFE
DICKMAN
MCGOWAN
TAFEL
RENSENHOUSE
IOWA ELEC. SUPPLY
S M
D & S
INDIANHEAD
JUDD
ECKHART
ARKANSAS VALLEY ELEC

A R BEAL CHGO OFC CODE CG
DR

Westinghouse Teletype - Rush Reply

FORM 21072

NPC00007759

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From : Philadelphia Office
WIN : 324-5281
Date : December 14, 1976
Subject: PCB'S PRESENCE IN OIL-FILLED TRANSFORMERS

To : PITTSBURGH (W) BUILDING
ROOM 2221
Mr. D. L. Litten

In response to your wire of December 9th on the PCB letter issued by Messrs. Oliver, Sherman and Litten, letters of notification have been sent to the following Distributors in the Eastern Zone:

Mass. Gas & Electric
Yale Electric
Gettens Electric Supply
Gilman Electrical Supply
Equitable Electric Supply
All Wesco District Managers in Northeastern District

Andrea Electric Supply - New York and Nanuet, N.Y.
Douglaston Electric
Liberty Electric Supply
Monarch-Irving
Ohm Electric Supply
Onesco, Inc.
A. B. Electric Supply
Wesco-Bridgeport
Wesco-Newark
Wesco-New Brunswick
Wesco-Maspeth
Wesco-Hicksville
Wesco-Poughkeepsie

Prince George's Electric
Wesco-Washington
Wesco-Springfield, Va.
Wesco-Richmond
Wesco-Norfolk
Wesco-Hampton

Standard Electric Supply
Anthracite Electric Supply
Bell Electric of Pennsylvania
Crowder Jr. Company

Dover Electric Supply
Penn Electric Supply
National Electric Supply
Fairlite Electric Supply
Kay Electric Supply
Doylestown Electric
Northeast Electric
Coatesville Electric Supply
Wesco-Philadelphia
Wesco-Norristown
Wesco-Trenton
Wesco-Wilmington
Wesco-Camden
Wesco-Salisbury
Wesco-Hagerstown
Wesco-Baltimore
Wesco-Allentown
Wesco-Reading
Wesco-Wilkes Barre
Wesco-Williamsport
Wesco-Harrisburg
Wesco-York
Wesco-Lancaster

Should anything else be required, please let me know.

J. S. Bentley

JSB:ml

PQ 133 12/14 1851 QV 12-14-76 1745

D J LITTEN -> PGH
CC/ ATLANTA OFFICE - T FULLER

D P KEISER 11/22/76 LETTER ON OIL PCB MIXING. ALL DISTRIBUTORS IN MY DISTRICT WHO SELL THESE PRODUCTS HAVE COPY OF KEISER LETTER INCLUDES ALL WESCO LOCATIONS, NUNN LOCATION, PERRY SHANKLE, SERVICE ELECTRIC AND ELECTRIC FIXTURE SUPPLY.

A M KAPPLER - HOUSTON
GH

- Rush Reply
Westinghouse

GENERAL STATEMENT OF WESTINGHOUSE POSITION

The problems of PCB's being mixed in oil of electrical apparatus is not confined just to Westinghouse. Evidence indicates it encompasses the entire industry, involving oil supplied by the oil industry, various manufacturer's oil-filled transformers, and customer's oil-storage facilities. Evidence indicates the problem is not confined to any particular geographic region. No one knows how long it has existed. A logical guess would be for several years.

It is a customer decision as to what is done with his equipment when and if the presence of PCB is detected in his equipment. This decision is dependent on the status of legislation in his particular area. Our customers have the responsibility to determine for themselves what laws and regulations apply. There is no practical reason for us to engage in any conjecture as to how, where, or when the condition originated.

1. Q. - What manufacturer's equipment is involved?

   A. - Potentially, any oil insulated equipment. Since PCB traces have been found in all parts of the oil cycle, in supplier shipments, in completed units of oil-filled electrical apparatus, and in user oil-storage systems.

2. Q. - What is being done to specify or define the extent of this problem?

   A. - NEMA (National Electrical Manufacturers Association) has commissioned a special task force to study the extent of the presence of PCB's in oil-filled environments.

3. Q. - Why am I being notified by Westinghouse of this problem?

   A. - Some states have recently enacted specific legislation for the control of PCB's and are interpreting general legislation for their control. Because of this legislative environment, Westinghouse began and is in the process of doing extensive testing to define the existence of this substance. Initial tests confirm the existence of PCB's in some pieces of oil-filled equipment of several manufacturers, including Westinghouse, in oil shipments received from oil suppliers, and in user oil-storage facilities. Having made these determinations, we felt it our obligation to notify you of our findings.

4. Q. - What actions should I take?

   A. - Since there are no nationally established standards for allowable levels of PCB's in oil for closed electrical systems and since various states have enacted legislation, we suggest you determine the status of legislation for your area and institute any special procedures which may be required for conformance.

5. Q. - What procedure for testing oil should I follow?

   A. - Although we cannot specifically recommend a complete procedure because of varying legislative constraints, we can make the general recommendations that you check for PCB content in oil when performing repair, during routine maintenance, or disposal of oil-filled equipment. We also recommend that oil storage and oil handling systems be checked for PCB content.

6. Q. - What actions should I take if I find traces of PCB's in oil-filled equipment or systems?

   A. - We can make no specific recommendations because of the various and often undefined legislation now in effect.

7. Q. - Assuming I find PCB's in the oil, how did the PCB's become mixed with the oil?

   A. - It may be impossible to determine since PCB's have been detected in the mineral oil of various makes of transformers, in oil storage facilities, and in oil supplied directly from oil suppliers. The manner of mixing is unknown.

8. Q. - How can tests for PCB's in oil be made?

   A. - Any industrial laboratory familiar with analyzing PCB's and familiar with chromatographic or similar techniques should be able to make the tests.

9. Q. - Can Westinghouse make these tests?

   A. - Westinghouse has a limited capacity at the Sharon facility. Limited outside testing can be performed on a scheduled/fee basis. Since scheduling is a problem, contact H. A. Pearce, Westinghouse Electric Corporation, 469 Sharpsville Avenue, Sharon, Pennsylvania 16146. All requests should be made through your local Westinghouse sales representative.

10. Q. - What is required for sampling?

    A. - A 4-oz. sample should be taken in a new glass or plastic container. The container should be identified with your company name, location and address, and your name. The sample should also identify the source for your information. All samples should be properly packed for shipment.

11. Q. - Can we remove the PCB's from the oil?

    A. - At this time, we do not know of an economical way of removing the PCB's from the oil.

12. Q. - Is there an operating problem in having PCB's in transformer oil?

    A. - No. The mixture of PCB's with mineral oil does not affect electrical performance.

13. Q. - I have a transformer being repaired in one of your shops now. How can I be assured that it will not have PCB's in the oil when it is returned?

A. - We have a sample of the oil analyzed when it is received, and you will be advised of the findings. When it is repaired and ready for shipment, another sample will be taken and you will be advised. If a transformer did not contain PCB's when it was received, it will not have PCB's in the oil when it leaves the plant.

Westinghouse, as well as others in the industry, has since the late 1930's manufactured transformers using Inerteen (a substance containing polychlorinated biphenyls--PCB's) as a coolant as well as transformers using mineral oils for this purpose. Inerteen filled transformers have long been favored for applications to minimize the risk of fire. In the latter part of 1970, when it was first suspected that PCB's may be injurious to the environment, Westinghouse commenced to affix a special warning label to each Inerteen filled transformer sol

As a result of recent investigations it has come to our attention that many oil filled (mineral oil) transformers, and possibly other electrical devices which utilize mineral oil as an insulator and coolant, may contain minute concentrations of PCB's. Westinghouse has conducted tests of oil storage tanks at its manufacturing locations and concentrations of PCB's ranging from ____ppm to____ppm have been detected only at the Sharon and South Boston facilities. Also, tests are being conducted at certain of our repair locations. These tanks are filled with oil from oil suppliers as well as with oil removed from returned customer-owned units for repair.

Effective immediately, oil-filled transformers are being filled from other sources or from tanks which have been cleaned. There is no operating problem with respect to the transformer resulting from this mixture. From an operating standpoint, the electrical characteristics remain basically unchanged when filled with either mineral oil or Inerteen.

A number of states have recently enacted legislation which provides for special reporting, labesling and/or disposition of PCBs. Some of this legislation is applicable only with respect to products containing PCB concentrations of 100 parts per million or more.

Westinghouse urges each user of an oil filled transformer manufactured or repaired by Westinghouse to test the oil for presence of PCBs and examine applicable requirements affecting PCBs. Customers should immediately institute any special procedures or safeguards which may be required. In any event, oil filled transformers should not be disposed of prior to ascertaining that applicable regulations have been followed. Finally, your own storage tanks, as well as oil used for topping-up purposes, should be carefully examined.

Westinghouse is continuing its thorough investigation of this matter and will keep you informed of developments.

From : 1178 Building
WN : 235-3366
Date November 9, 1976
Subject

RECEIVED
NOV 10 1976
LAW DEPARTMENT

To : GREENTREE
J.E.D. Morris

cc: SAN FRANCISCO - C. R. Roehrig
GREENTREE - F. F. Colecchia
GREENTREE - R. N. Cartmell
GREENTREE - V. J. Kropf
GREENTREE - G. J. Maiuri
BUILDING - J. P. Daley
BUILDING - R. E. Wills
BUILDING - H. J. Rosenzweig

In the absence today of Bob Cartmell and in line with my conversation with you, I am returning Chuck Roehrig's article on transformer oil reclamation which is intended for publication in PLANT ENGINEERING. Bob had rewritten some of the article and the attached copy is the one on which he had made changes and which has division approval.

The problem is principally one of timing coupled with the fact that we and the Power Systems people are presently wrestling with the question of when and how we should announce to the trade and possibly to the public that we have a PCB contamination problem in some oil filled transformers. The appearance of Chuck Roehrig's article prior to the time such an announcement is made and without any reference to the PCB aspect of the problem would make it at lease incomplete and, in view of what we now believe, partly inaccurate.

Roger Wills of the law department feels, and I concur, that we need to include some appropriate references to the PCB problem and what might be done about it if we want a "complete" article. How this might be best done and when I must leave to your judgement. I will be glad to help in any way I can but I do not feel qualified to say what additions need to be made.

52

Robert A. Deasy
Manager
Industry Products Public Relations

RAD/rs

Enclosure

74-1-00-0308

FORM 3504X

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ATTACHMENT 4

This news release was mailed November 24 to the following four publications:

Electrical Construction & Maintenance
Electrical Contractor
Industrial Maintenance & Plant Operation
Plant Engineering

Contact: J. P. Daley
Telephone: (412) 255-33

FOR USE: At Will

PITTSBURGH, Nov. 24 -- Since the late 1930's, the electrical industry has supplied transformers using askarels which contain PCB's (polychlorinated biphenyls) for use in installations where a high degree of fire resistance is required, such as schools, hospitals and high-rise buildings. In addition, major applications of PCB's were carbonless paper, fire resistant hydraulic fluids, heat transfer fluids and plasticizers. Moreover, capacitors containing PCB's are used in fluorescent lighting ballasts, air conditioning compressors, and television receivers.

In late 1970 studies began to indicate that PCB's had a tendency to persist and accumulate in the environment. Since that time, Westinghouse has attached an additional identifying label to each PCB-filled transformer shipped.

Westinghouse said recent tests it has conducted indicate that some oil-filled transformers may contain varying concentrations of PCB's.

The company said the presence of PCB's in mineral oil does not affect the performance of the transformers.

- more -

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Currently there are no nationally established standards for allowable levels of PCB's in oil for closed electrical systems. A number of states have recently enacted legislation providing for special reporting, labeling and/or disposition of PCB's. Because legislation varies in different states, it is suggested that customers institute any special procedures which may be required for conformance.

In addition, when performing repair, routine maintenance or disposal, oil-filled transformers should be checked for the presence of PCB.

On November 8, the National Electrical Manufacturers Association (NEMA) commissioned a special task force to study the possibility that PCB's may be present in detectable quantities in oil-filled electrical apparatus and oil-storage systems for electrical insulating oil.

##2610-7L##

-1176-

Only somewhat helpful.

Toxicology of PCBs for Mammals and for Birds

by J. G. Vos*

Introduction

In the early days of its use, little work was done on the toxicology of the PCBs, and this was only in relation to the risks of occupational exposure. As will be shown many more studies were made as soon as it appeared that the extremely stable PCB's became a threat to the environment and its wildlife, and accidents occurred of acute poisoning in man and animals. These studies have been made with material with different contents of chlorine, from different manufacture, and—as we can now say in retrospect—with different and unknown contents of toxic impurities. For this reason the toxicological information of PCB's is difficult to summarize, but since the character of some important impurities has recently been elucidated, it is well to discuss these first in order to be able to consider their contribution to the overall toxicity of the different preparations studied.

These studies were started because of the analogy between the effects of the PCBs (1–6) and some toxic effects associated with toxic factors in crude chlorophenols and in "toxic fat". Effects of the latter are liver damage (7), chloracne (7,8) and edema formation (9).

Chemical, Toxicological, and Pathological Identification and Evaluation of Toxic Impurities in Technical PCB Preparations

The first indication of the presence of toxic impurities was obtained in a comparison of the toxicity of three commercial PCB samples (containing 60% chlorine on the average): Phenoclor DP6 (sample I), Clophen A60 (sample II) and Aroclor 1260 (sample III). These three mixtures showed a marked resemblance in their gas chromatograms and mass spectra (10). In this comparative feeding test in one-day-old chicks (11), it was found that 100% mortality, subcutaneous and abdominal edema, and centrolobular liver necrosis occured in only two groups (fed the samples I and II). Hydropericardium (Fig. 1), a common effect of these two mixtures, was only occasionally seen in the chicks fed the sample III. The



FIGURE 1. Hydropericardium in a chick fed 400 ppm of sample I.

* Institute of Veterinary Pathology and Institute of Veterinary Pharmacology and Toxicology, State University of Utrecht, The Netherlands.

Environmental Health

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Table 1. Mortality, and Pathologic Observations of Chicks Fed 400 ppm PCB for 60 Days.

PCB sample	N	Number of deaths	Number of birds with edema			Number of birds with liver necrosis
			Hydro-pericardium	Abdominal	Subcutaneous	
I	24	24	18	8	5	9
II	22	22	20	9	7	9
III	20	3	3	0	0	0
Control	20	0	0	0	0	0

mortality in this group was only 15% (Table 1). The excretion of coproporphyrin and protoporphyrin in the feces was increased. Examination of tissues under Wood's light showed the presence of red fluorescence indicating porphyrins in the liver and other tissues of especially the birds that died. This hepatic porphyria was found in all three experimental groups.

In the subsequent study (12) by means of column and gas-chromatography the presence of relatively more polar compounds was demonstrated in the 25% diethylether fraction of samples I and II. In a chick embryo assay (Table 2), the difference in toxicity between the three samples was confirmed: the high toxicity of the 25% diethylether fraction of sample II is demonstrated by the similarity between the mortality levels in the group injected with 3.5 sample II/egg and the group injected with the 25% diethylether fraction from 3.5 mg sample II/egg.

Mass spectrometric analysis revealed that identical chlorinated compounds were present in the 25% diethylether fraction from samples I and II but not in that from sample III. They included compounds with mass number 304 and 338. The proposed identity of these compounds, tetrachlorodibenzofuran and pentachlorodibenzofuran, is indicated by the following chemical-analytical, pathological, and toxicological data.

Table 2. Chick-Embryo Assay of Three PCB samples and the 25% Diethylether Fraction from Sample II

PCB sample	Dose (mg/egg)	Number of eggs treated	Percentage hatch of fertile eggs
I	3.5	15	0
II	3.5	20	5
III	3.5	15	80
Fraction from sample II	35	15	0
	3.5	15	7
	0.35	15	92
	0.035	15	100
Ethanol control	0	20	94
Untreated control	-	20	90

From exact mass measurements it was found that the formulae of these peaks were $C_{12}H_4O^{35}Cl_4$ and $C_{12}H_3O^{35}Cl_5$. The formulae of the fragment ions 241 and 275 were $C_{11}H_1{}^{35}Cl_3$ and $C_{11}H_2{}^{35}Cl_4$. From this data it can be concluded that the parent ion has a preferential fragmentation for the loss of a single ClCO unit. Mass spectra were compared with the spectrum of a chick edema factor 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin. The mass spectrum of this compound has a similar fragmentation pattern, i.e. the loss of two successive mass units of 63 suggests a loss of two ClCO units. With microcoulometric analysis a certain maximum level could be indicated. This maximum level was found to be five ppm of the compound with mass number 338 in sample II and 20 ppm in sample I.

Polychlorinated dibenzofurans are strong hepatotoxic and acnegenic compounds. Tri- and tetrachlorodibenzofurans in a single oral dose of 0.5 – 1.0 mg/kg caused severe and often lethal liver necrosis in rabbits (7,13), and application to the ear resulted in chloracne. Tetrachlorodibenzodioxin was about 10 times more toxic (7). Injection of the 25% diethylether fraction obtained from 35 mg sample II into the aircell resulted in 100% mortality (Table 2). It can be calculated that the maximum dose/egg is 0.2 μg pentachlorodibenzofuran (taking five ppm as the maxi-

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mum value). This confirms the order of toxicity found by Higginbotham et al. (9) in the case of chloro-dibenzodioxins. Tetra and pentachloridibenzofurans were considered responsible for the higher toxicity of samples I and II.

Confirmation is also obtained from the subsequent comparative toxicity study in rabbits (14). Again samples I and II were more toxic; the liver and skin lesions were more severe. Porphyria, especially of the liver, was present in all three groups (Fig. 2). A remarkable finding was the intense red fluorescence of small foci inside hepatic cells. They probably represent nuclei. This was confirmed in an additional cell culture experiment with the Aroclor sample and with 2,4,5,-2',4',5'-hexachlorobiphenyl. (This experiment was carried out by my colleague Dr. J. G. Wit of the Biochemical Section).

Application of the 25% diethylether fraction on the skin of rabbits resulted also in differences in toxicity (Fig. 3). So the presence of the hepatotoxic and acnegenic polychlorinated dibenzofurans as impurities in samples I and II was found to be established.

In another experiment (15), the toxicity of the Aroclor (60% Cl) sample was compared with the toxicity of 2,4,5,2',4',5'-hexachlorobiphenyl. From the increased fecal excretion of coproporphyrin in both experimental groups (Table 3), it is very likely that PCBs themselves are responsible for the porphyrogenic action of crude preparations. From the presence of slight skin lesions induced by 2,4,5,2',4',5'-hexachlorobiphenyl when compared with the Aroclor sample, it can be concluded that the major acnegenic action of crude mixtures comes from a possible contamination with chlorinated dibenzofurans. It can also be concluded that PCBs themselves have a slight acnegenic action. Liver damage was essentially the same after treatment with both 2,4,5,2',4',5'-hexachlorobiphenyl and the Aroclor mixture. The conclusion that the liver injury, caused by crude preparations, is predominantly due to the contaminants, is based on the differences in liver toxicity between the three PCB preparations (11, 14).

The probable contribution of polychlorinated dibenzofuran (PCF) and pure polychlorinated biphenyl (PCBs) in the toxicity of crude preparations is summarized in Table 4. A proper evaluation of toxicity data and residue data can be hindered by the possibility that PCB samples may



FIGURE 2. Fluorescence of porphyrins under ultraviolet light in livers from rabbits treated with 60% chlorinated PCB's, 1, Aroclor; 2, Clophen; 3, Phenoclor; and 4, Control liver (14).

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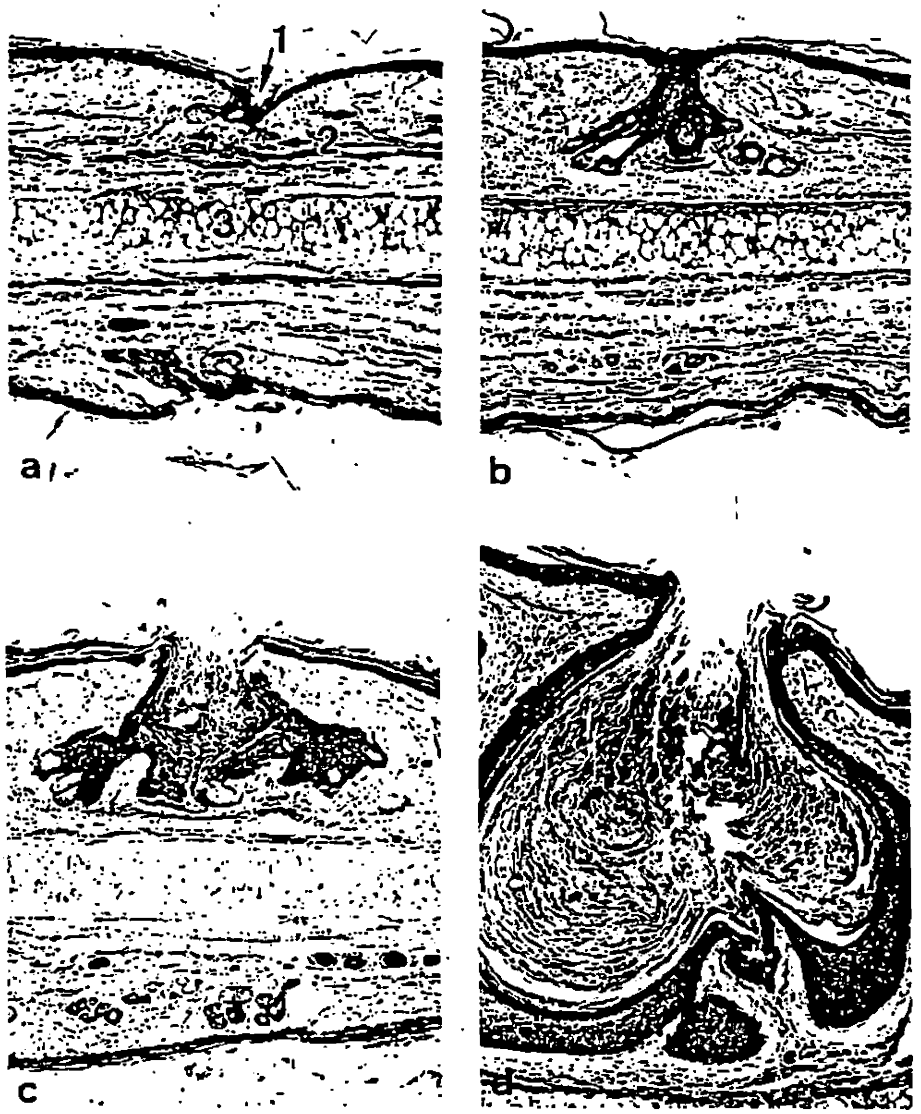


FIGURE 3. Response of the inside of the rabbit's ear after topical application of the 25% diethylether fractions from technical PCB's. Haematoxylin and eosin. ×60. (a) Skin of control animal treated with ethanol. Note the hair follicle at 1, sebaceous gland tissue at 2, and cartilage at 3. (b). Ear skin of the animal treated with the fraction from sample III. Some hyperplasia and hyperkeratosis of the follicular epithelium can be seen. (c). Ear skin of the rabbit treated with the fraction from sample II. Considerable hyperplasia and hyperkeratosis of the follicular epithelium. (d). Ear skin of the rabbit treated with the fraction from sample I. Part of a section that shows the most severe lesion. The gravity of the response was in general the same as seen in (c). Note the cystic dilated hair follicle with prominent hyperplasia and hyperkeratosis of the follicular and epidermal epithelium (14).

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differ in an important respect: the presence of toxic impurities. The possibility of distinguishing between the effects of PCBs and their impurities can be further improved by using pure isomers with known positions of the chlorine atoms.

Mortality, Liver Effects, Edema Formation and Other Effects

These data, as presented by different authors, are summarized in Tables 5, 6, and 7. As can be seen in Table 5, the acute and subacute toxicity data of PCB's are poor. The established values are high. Semichronic oral toxicity studies are summarized in Table 6. Dermal and inhalation studies are given in Table 7.

Table 3. Coproporphyrin Contents (μg/g Dry Weight) of Feces of Rabbits Treated with PCB for 4 weeks, and of Controls.[a]

2,4,5,2',4',5'-Hexachlorobiphenyl	Aroclor (60% Cl)	Control
45.0	24.1	4.5
6.2	5.0	3.7
20.8	29.4	3.6
39.6	16.0	3.5
Mean 27.9[b]	18.6[b]	3.8

[a] Figures are the contents of feces, collected from the cecum of the individual animals.
[b] Significantly different from controls, $P \leq 0.025$.

It is very probable that the results of these studies may have been influenced by the presence of polychlorodibenzofurans or other toxic impurities. For example, in the study of Rehfeld et al. (23) general edema was already found in chicks fed 30 ppm Aroclor 48% Cl, while Kohanawa and co-workers (22) noted edema formation at the 100 ppm level of another 48% chlorinated mixture. Mortality in the latter study was also lower (Table 6).

Liver Effects

The most important liver effects, summarized in Tables 5, 6, and 7, are weight increase, fatty degeneration, hyalin degeneration and necrosis. Increased liver weights, as noted in several studies,

Table 4. Probable Contribution of Polychlorinated Dibenzofuran (PCF) or 3 Pure Polychlorinated Biphenyl (PCB) in the Toxicity of Crude PCB Mixtures.

	Chloracne	Edema formation	Liver damage	Hepatic porphyria
Polychlorinated Dibenzofuran	++	+÷	++	−
Polychlorinated Biphenyl	÷	−	÷	++

Table 5. Acute and Subacute Oral Toxicity Studies of PCB Preparations.

Preparation	Animal	Treatment	Mortality	Liver effects	References
Unknown	Mouse	single dose of approx. 2000 mg/kg	LD50		(16)
Aroclor 54% Cl	Rat	single dose of 500 mg/kg	0%	Increase of weight and lipid; potentiation of CCl_4 toxicity	(17)
Aroclor 42, 54, 60, and 68% Cl	Mallard	single dose of 2000 mg/kg	0%		(18)
42% Cl	Rat	20 daily doses of 138 mg	0% in 3 months	Hyalin bodies in liver cells	(19)
42% Cl	Guinea pig	2 doses of 69 mg 1 week apart	100% between 11 and 29 days	Fatty metamorphosis; central atrophy	(19)
65% Cl	Rat	6 daily doses of 300 mg	70% in 14 days	Increase of weight; cell swelling; hyalin granules	(20)

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Table 6. Semichronic Oral Toxicity Studies of PCB Preparations.

Preparation	Animal	Treatment	Mortality	Liver effects	Other effects	References
65% Cl	Rat	Doses of 50 mg every second day	60% in 5 weeks	31% weight increase; cell swelling; hyalin globules		(20)
48% Cl	Cynomolgus monkey	From 641 mg in 49 days to 348 mg in 230 days	not given	Enlargement; SER proliferation	Main cause of death: pneumonia or diarrhea	(21)
48% Cl	Squirrel monkey	From 320 mg in 46 days to 67 mg in 48 days	not given	Enlargement; SER proliferation SER proliferation	Main cause of death: pneumonia or diarrhea; palpebral edema in 1 animal	(21)
48% Cl	Mouse	Daily doses of 0.001 ml for 13 to 26 weeks	0%	Enlargement; SER proliferation RER reduction; myelin figures; increase of microbodies, lysosomes and lipid	Skin: loss of hair, erosion and ulceration after 3 months	(21)
Aroclor 42% Cl	Chicken	100, 200, 400, and and 1000 ppm in diet for 4 weeks	0, 0, 50, 90, and 90% respectively	Enlargement; damage at the higher levels	Edema formation from 200 ppm; at high levels internal haemorrhage and tubular dilatation in kidneys	(5)
Aroclor 42% Cl	Chicken	200 and 400 ppm in diet for 3 weeks	0 and 12% respectively		Pronounced edema at 400 ppm; enlarged kidneys; small spleen; defeathering and dermatitis	(6)
48% Cl	Chicken	1, 5, 10, 25, 50, 100, 300, 600, 1200, 2400, and 4800 ppm in diet for 20 days	0% from 1 to 100 ppm; 100% from the 100 ppm level		Edema formation 100 ppm level	(22)
Aroclor 48% Cl	Chicken	10, 20, 30, 50, 100, and 150 ppm in diet for 4.5–5 weeks	After 3 weeks: 0, 0, 30, 30 and 20%; at the end 0, 0, 80, 60, and 80% respectively	Enlargement	General edema and depression of the secondary sexual characteristics from the 30 ppm level	(23)
Aroclor 54% Cl	Chicken	250 and 150 ppm in diet for 6 to 13 weeks	250 ppm 100% between 3 and 10 weeks; 500 ppm some mortality at the end		500 ppm at end; comb weights 20-fold and testes weights 2-fold lower than controls	(24)
Aroclor 54% Cl	Bengalese finch	Estimated dose rate at 56 days of 254 mg/kg/day	50%		Hydropericardium in some birds	(25)
Phenoclor 60% Cl	Japanese quail	2000 ppm in diet	100% between 6 and 55 days		Hydropericardium	(10)

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Table 7. Dermal Toxicity and Inhalation Studies of PCB Preparations.

Preparation	Animal	Treatment	Mortality	Liver effects	Skin effects	References
42% Cl	Guinea pig	11 daily skin applications of 34.5 mg	100% between 11 and 21 days	Fat; central atrophy; perinuclear basophilic granulation; focal necrosis in a few animals	Occasional thickening of the epidermis	(19)
42% Cl	Rabbit	Skin application at alternate days, total dose from 946 to 1980 mg	100% between 17 and 98 days	Fatty degeneration; central atrophy	Thinning of prickle cell layer and thickening of outer cornified layers	(19)
Aroclor	Rabbit	Daily skin applications of 0.3, 0.6, and 0.9 g	High dose died before liver necrosis developed	Moderate doses: mottled liver, subacute yellow atrophy, fatty degeneration, and marked necrosis	Reddening; formation of small papules and blisters; finally desquamation of external epidermal layers	(26)
Aroclor 65% Cl	Rat	Inhalation of 0.57 mg/cubic meter for 16 hours for 37 to 134 days	0%	Pale and yellow; cell swelling; hyalin degeneration; potentiation of CCl_4 and C_2H_5OH toxicity		(20)

are well explained by the proliferation of smooth surfaced membranes of the endoplasmic reticulum (SER) as was found by Nishizumi (21) in mice and monkeys and by Norback and Allen (27) in rats. The latter workers found a proliferation of the SER in rats fed PCB for 1 to 5 weeks. Concomitant with the structural changes, the activities of measured drug metabolizing enzymes (nitroreductase and aromatic hydroxylase) were increased. The induced level of drug metabolizing activity persisted as the proliferation of the SER decreased and concentric arrays pervaded the cytoplasmic reticulum (27). These concentric membrane arrays, probably representing the hyalin bodies described by Bennet et al. (20) and Miller (19), could have an enzymatic function similar to that associated with the SER (27).

Similar formations, the so-called myelin figures, were demonstrated in mouse liver by electron microscopy; in monkey liver they were not found (21). In both mouse and monkey liver a proliferation of the SER was found. In our comparative dermal toxicity study (15) in rabbits with 2,4,5,2',4',5'-hexachlorobiphenyl and Aroclor (60% Cl), the light microscopic findings included necrosis, hydropic degeneration (Figs. 4 and 5) as well as a peripheral and perinuclear shift of cell organelles (Fig. 5) and focal cytoplasmic hyalinization. In electron microscopy, the shift was found to be due to a proliferation of the SER resulting in a displacement of rough surfaced membranes (RER) and mitochondria. The focal cytoplasmic hyalin degeneration, often seen in hydropic cells, was recognized as tightly packed tubules of proliferated SER (Fig. 6). This very probably represents hypertrophic, hypoactive SER.

Sublethal effects caused by induction of hepatic enzymes have been noted by several authors. Increased steroid metabolism in pigeon liver homogenates has been demonstrated by Risebrough et al. (28). Lincer and Peakall (29) confirmed the effect of PCB on the hormone metabolism in birds at very low dose levels. They fed kestrels for 5 months with Aroclor 54% and 62% Cl at levels of 0.5 and 5.0 ppm. The higher

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FIGURE 4. Liver damage in a killed rabbit treated with 120 mg Aroclor (60% Cl), 5 times per week, for 28 days. Note the centrolobular necrosis (1) and the hydropic cells (2) at the margin of the necrotic and vital tissue. Haemotoxylin and eosin. ×150.

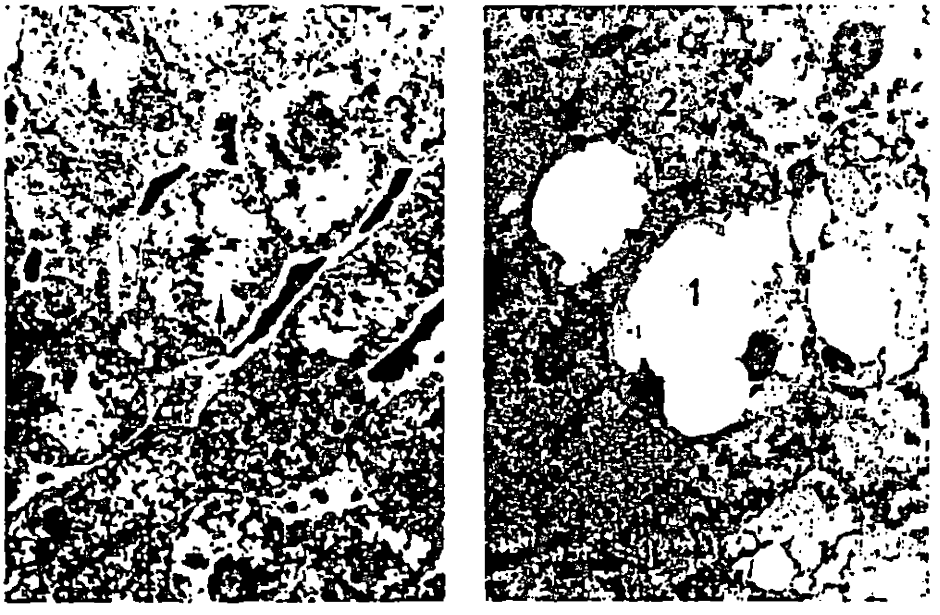


FIGURE 5(a). Liver cells of a control rabbit. Clear areas may represent negative images of glycogen (arrow). Toluidine blue. ×940. (b). Liver cells of an Aroclor treated killed rabbit. Note the hydropic cells (1) and the perinuclear and peripheral displacement of cell organelles with sometimes hyalin foci (2) inside hepatic cells. Toluidine blue. ×940.

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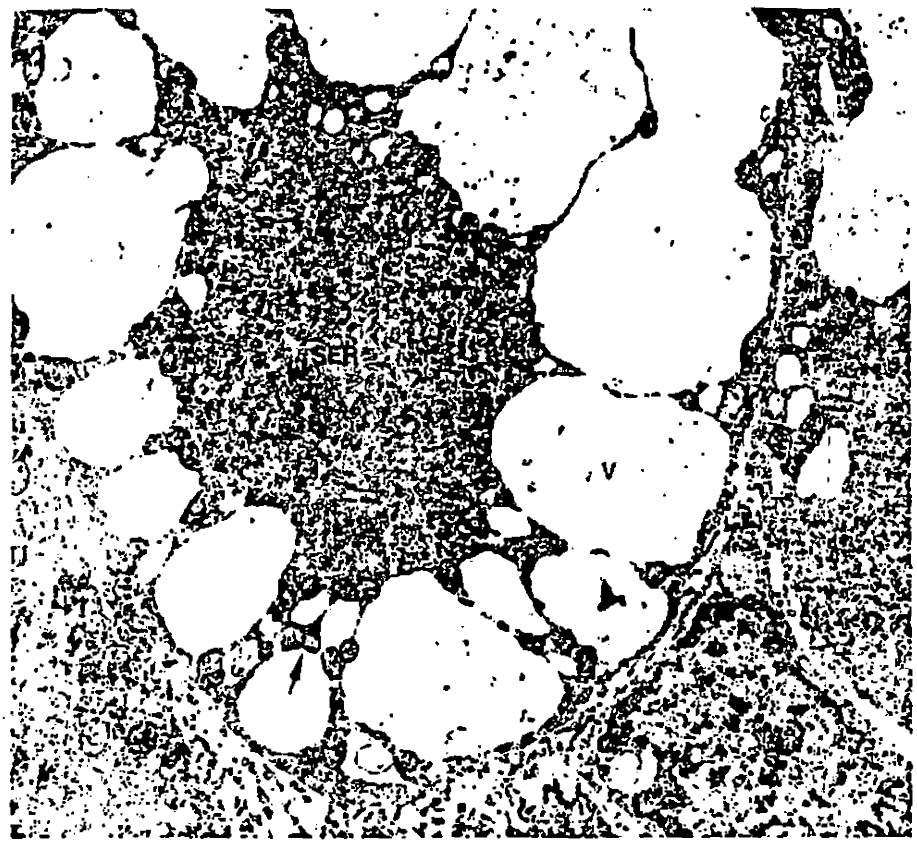


FIGURE 6. Hydropic liver cells from the same animal as seen in Figure 5b showing a large number of vacuoles (V) and a perivacuolar localization of mitochondria (arrow). Note the strong proliferation of the SER, consisting of tightly packed tubules. Uranyl acetate and lead citrate. ×5500.

dose being roughly equivalent to 2 mg/kg PCBs to each kestrel. A dose dependent in vitro breakdown of estradiol to a more polar metabolite occurred in the livers from kestrels fed either Aroclor 1254 or Aroclor 1262. No such conversion took place in the livers of the control birds. The increase in hepatic enzyme activity correlated with an increase in cytoplasmic RNA, as was measured cytophotometrically. A shortened sleeping time after treatment with hexobarbital, and enhanced in vitro rates of aniline hydroxylation and p-nitroanisole demethylations were demonstrated by Street and coworkers (30). These authors also found an increase of these effects with increasing chlorine content of the different PCB preparations (Aroclor 21 to 68% Cl).

Using enzyme induction as parameter, no-effect levels of some PCB preparations were established in the rabbit, rat, and Japanese quail. Oral administration of Aroclor 21% Cl and 54% Cl (1.0 and 10 mg/kg) for 28 days to pregnant rabbits resulted in liver enlargement and increased activities of the drug metabolizing enzymes aniline hydroxylase and aminopyrine n-demethylase at the 10 mg/kg level of the 54% chlorinated Aroclor. The no-effect level for enzyme induction in the pregnant rabbit appeared to lie between 1.0 and 10 mg/kg in the case of Aroclor 54% Cl, and higher than 10 mg/kg for Aroclor 21% Cl (31).

Another parameter for enzyme induction was used by Komatsu and Tanaka (32). They found that the hexobarbital induced sleeping times in rats were reduced by pretreatment with PCBs.

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The minimal effective dose was 5 mg/kg for 3 days with Kanechlor 400 (48% Cl) and 2 mg/kg for 3 days with the higher chlorinated Kanechlor 500. The porphyrogenic action of PCBs was further evaluated in a study with Japanese quail (33). The results (Table 8) indicate that the hepatic porphyria is closely associated with an increase of mitochondrial ALA synthase activity. A significantly increased activity of this enzyme was already noted after administration of daily doses of 1 mg/kg Aroclor 60% Cl for 1 week. Mean PCB content of the liver at that dose was 1.41 ppm. A less sensitive parameter is tissue fluorescence due to excess quantities of porphyrins. Liver fluorescence was only seen at the 100 mg/kg level. It develops, probably, only in animals showing clinical symptoms, such as loss of weight. A similar finding was done in the prior experiment with chickens (11).

Edema Formation

The most striking finding in birds is the accumulation of fluid. The pathogenesis of the edema formation is discussed by Flick and coworkers (6). The primary site of the edema causing factor could be the heart by increasing the permeability of the vascular bed, leading to cardiac congestion. Pulmonary edema could be the result of the cardiac congestion. The pulmonary edema might be followed by a flow of fluid into abdominal and subcutaneous air sacs. Decreased serum protein values (34) could also contribute to the edema formation. Liver damage can be responsible for reduced serum albumin levels.

As mentioned in Table 4, the edema formation is probably due to the presence of polychlorodibenzofurans. In our study the edema formation by the 60% chlorinated Aroclor sample was minimal at the 400 ppm level. As can be seen in Table 6, chick edema-like lesions were noted at low feeding levels and were caused by lower chlorinated Aroclors. Therefore the presence of toxic impurities in these Aroclor samples has to be considered.

Other Effects

An interaction of PCBs with duck hepatitis virus was found by Friend and Trainer (35). Ten-day-old ducklings were fed a 54% chlorinated Aroclor mixture at levels of 25, 50 and 100 ppm. The birds suffered no apparent clinical intoxications. Five days later they were challenged with duck hepatitis virus, and they suffered significantly higher mortality than birds which were not exposed to PCBs.

Effects of PCBs on the lymphoid system were noted in some studies. Feeding of PCBs to chickens resulted in small spleens (6,11). Lymphopenia, atrophy of the cortex of the thymus, and a reduction in the number of germinal centers in spleen and lymph nodes was found in rabbits (14). Therefore, an immunosuppressive action could be present. In an experiment with guinea pigs, this was established (36). Feeding of 10 ppm Aroclor 60% Cl, for 8 weeks resulted in a

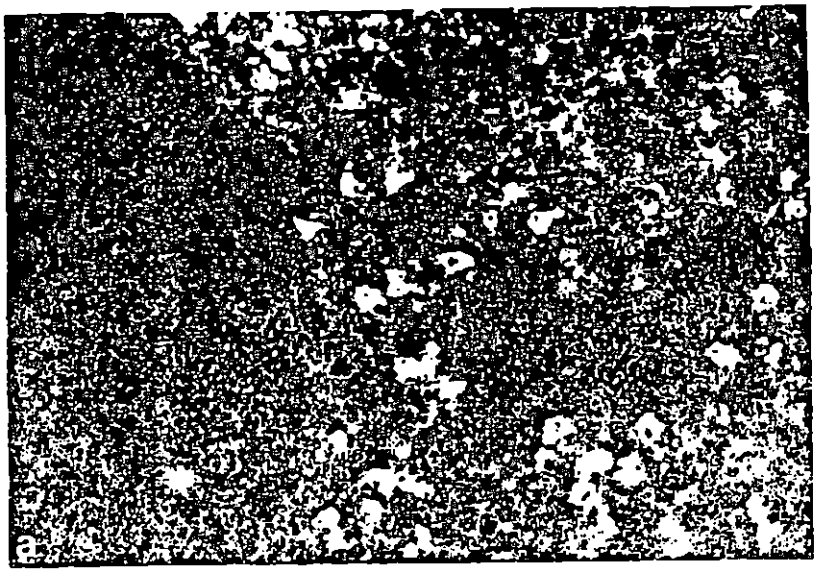
Table 8. Formation of δ-Aminolevulinic Acid by Liver Mitochondria, Liver Residues, and Tissue Fluorescence in Female Japanese Quail Orally Dosed with PCB for Seven Days.

Aroclor (60% Cl) (mg/kg body weight)	ALA formed (mμ moles ALA/g liver/hr)	PCB content liver (ppm)	Tissue fluorescence incidence	
			Macroscopic	Microscopic (liver)
0	6.46±1.64	0.15[c]	0/5	0/5
0.1	8.76±4.06	0.45±0.27	0/5	0/5
1	10.50±1.21[b]	1.41±0.67	0/5	0/5
10	17.3±6.4[b]	27.0±9.4	0/5	0/5
100	119.9[c]	478±294	3/5	2/5

[a] Mean values±SD, 5 birds per group.
[b] Significantly different from controls, $P \leq 0.01$.
[c] Pooled samples

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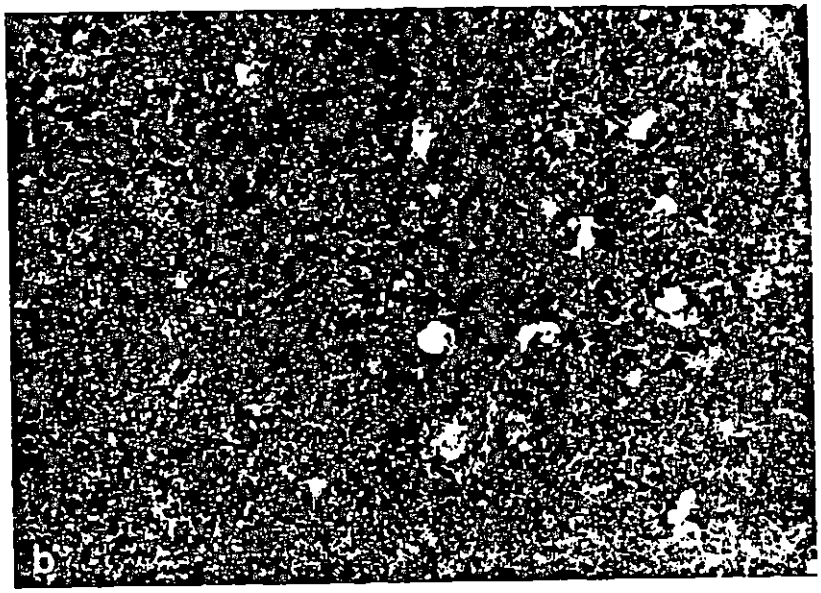


FIGURE 7. Representative areas of tetanus toxoid stimulated popliteal lymph nodes of guinea pigs. (a) Large number of antibody forming cells in a control animal. (b). Reduced number of antibody forming cells in an animal fed 10 — Aroclor (60% Cl) for 8 weeks. Direct fluorescent antibody technique. Cryostat sections. × 375. (30).

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decreased number of antibody-forming cells in the popliteal lymph node, after stimulation of the humoral lymphoid system with tetanus toxoid (Fig. 7). This suppression may explain the higher sensitivity of PCB-fed ducklings for duck hepatitis virus (35). In a comparative toxicity study in guinea pigs, an indication for an effect of PCB (Clophen and Aroclor 60% Cl) on the cell-mediated immunity was obtained. Feeding of these mixtures at 50 ppm levels for 6 weeks resulted in a decreased number of circulating lymphocytes (unpublished data).

An estrogenic activity of PCBs (Aroclor 21–48% Cl) was demonstrated by Bitman and Cecil (37). The estrogenic activity was evaluated using the 18-hr glycogen response of the immature rat uterus after a single subcutaneous injection. The minimum effective dose was 8 mg. The higher chlorinated PCB mixtures were inactive at the 8 mg level. In the above mentioned subacute feeding study of 60% chlorinated mixtures in guinea pigs, we found significantly increased uterus weights in the PCB treated animals. Both increased steroid metabolism, as mentioned by Rehfeld and coworkers (23), and the estrogenic activity could be responsible for the depression of secondary sexual characteristics (decreased development of comb and wattles) noted in cockerels (24).

Administration of Aroclor (54% Cl) at levels of 12.5, 25, and 50 mg/kg body weight during the first 28 days of gestation had embryotoxic effects in the rabbit (31). Edema and beak deformities in chicken embryos have been described after yolk-sac injection of 10 and 25 mg 42% chlorinated Aroclor, resulting in respectively 95 and 100% embryonic mortality (38).

An effect of PCB on the nervous system was noted by Ogawa (39). Oral administration of PCB (0.3–0.5 ml/kg/day) to rats for 14 or 21 days, resulted in marked or moderately impaired motor function, decreased motor conduction velocity and loss of large nerve fibres. He concluded that PCB caused neuropathy in rats.

Conclusion

Because of the possible presence of polychlorinated dibenzofurans (PCF) or other toxic impurities in crude PCB preparations, it is difficult to interpret many of the toxicity studies. Pure samples are required for comparative investigations. Also the fate of the toxic impurities in the environment has to be determined. As presented here, PCBs have several sublethal effects, such as microsomal enzyme induction, porphyrogenic action, estrogenic activity, and immunosuppression. Since porphyria seems to be an effect of PCBs themselves and not from PCF, the induction of ALA synthase could be used as criterion in the approximation of a no-effect level (at least for the 60% chlorine type of PCBs). The no-effect level could be about 0.1 mg/kg (mean PCB content of the liver in Japanese quail about 0.2 ppm). This is in the same order of magnitude as found in the other studies. Additional research is needed to determine fully the significance of these sublethal effects. Moreover, chronic and reproduction studies are necessary. The present results also make clear that manufacture of commercial PCB mixtures that are free from impurities is urgently requested.

Acknowledgment

The author gratefully acknowledges the helpful suggestions and critical reading of Prof. H. van Genderen, Head of the Institute of Veterinary Pharmacology and Toxicology. Many thanks are also due to colleagues of the working party of the Institute of Veterinary Pathology and the Institute of Veterinary Pharmacology and Toxicology: Dr. J. H. Koeman, Mr. H. L. van der Maas, and Dr. J. G. Wit. The author also thanks the students who studied for their degree in biological toxicology and Mr. M. C. ten Noever de Brauw, Mr. R. H. de Vos, and Dr. R. J. C. Kleipool of the Central Institute for Food and Nutrition Research, T. N. O., Zeist.

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Bulletin

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Bulletin of Environmental Contamination and Toxicology

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AIMS AND SCOPE

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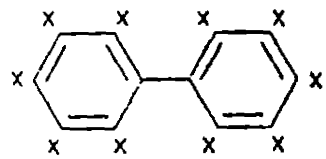
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Polychlorobiphenyls (PCB's) and their Interference with Pesticide Residue Analysis

by LINCOLN M. REYNOLDS
Ontario Research Foundation
Sheridan Park, Ontario, Canada

Introduction

The PCB's  (X indicating the possible chlorine positions) were studied as early as 1881 (1) and by 1930 (2) were in wide use. They are known to be quite toxic, especially to liver cells. As early as 1936, Jones and Alden (3) reported that men employed in the production of PCB's developed acne-type skin eruptions. Three years later, Greenburg and coworkers (4) reported that PCB's and polychlorinated naphthalenes were resposible for the deaths of three workers.

Residue chemists, especially in Europe, have recently become interested in these PCB's as well as the polychlorinated triphenyls, naphthalenes, terpenes, and other related compounds, since

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NOTE: This paper was presented at the Eastern Canada Seminar on Pesticide Residue Analysis, November 18-19, 1968, at Guelph, Ontario, Canada.

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Jensen (5) in Sweden reported their presence in wildlife tissues about two years ago.

The PCB's and related compounds (although in the rest of this paper reference will be made to the PCB's only, the other related compounds are also quite important) have very numerous and important industrial uses, but are not used as pesticides. Because of their similarities in structure and properties to the DDT pesticide group, the PCB's, if present, are carried through the usual pesticide extraction and screening procedures, and since they possess electron absorbing properties, will interfere with gas liquid chromatographic electron capture (GLC-EC) analysis of the organochlorine compounds.

Before any discussion of the type of interference encountered it would be appropriate to mention briefly some of the properties and uses of the PCB's.

They are produced and marketed under a number of commercial trade names e.g. 'Aroclor', 'Clophen A30', etc. The PCB's are available as liquids, resins, or solids; insoluble in water; thermoplastic; non-drying; stable on long heating at 150°C.; electrically non-conducting; not affected by boiling with NaOH solution; do not support combustion when alone above 360°C.; are easily soluble in most common organic solvents and drying oils.

They are used in protective coatings, as plasticizers and extenders, as sealers in water-proofing compounds and putty, in asphaltic materials, printing inks, waxes, and synthetic

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adhesives.

Liquid PCB's are used as dielectrics, as hydraulic fluids, in thermostats, in cutting oils, as extreme pressure lubricants, as grinding fluids, and as heat transfer media.

Solid PCB's are used to impregnate carbon resistors, as sealers or impregnating agents for electrical apparatus.

Obviously, the stability of these compounds makes them extremely useful and versatile for a great number of applications. Considering their stability - not affected by boiling with NaOH or nitric acid, not metabolized in living organisms, and nonflammable if containing more than four chlorine groups, it is as Jensen (6) pointed out, difficult to explain how these compounds find their way into living organisms.

However, with the numerous applications, it is not inconceivable that fish and other wildlife could be polluted as a result of the flushing of wastes into rivers, lakes, etc. It is also possible that contamination could proceed via the atmosphere when wastes containing these compounds are burnt.

However, a third and more likely source is the possibility that some companies might be using PCB's in pesticide formulation to increase the kill-life of insecticides. The Monsanto Company, which manufactures the Aroclors, stated back in 1965 (7) that the Aroclors can "trap" and hold more volatile ingredients making volatile insecticides and repellents last longer in residual activity. The most pronounced effect for increasing the

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kill-life of insecticides was obtained with lindane, chlordane, and benzene hexachloride (BHC). A ten-fold effectiveness for lindane was reported by the U.S.D.A. by including 5-25% PCB's in the formulation. Attempts to determine whether this idea had been put into practice by some companies have so far been unsuccessful. But there is no doubt that, if the PCB's are being used in pesticide formulation, then this would certainly explain their presence in wildlife tissues and other samples.

Jensen (6) has used a nitration procedure in order to differentiate the PCB's from the pesticide residues. He treated the cleaned-up extract with a mixture of concentrated HNO_3 and concentrated H_2SO_4 (1:1) for 5 min. at 0°C. After the addition of crushed ice, he extracted the reaction mixture with hexane and reinjected the extract. He states that the method should leave PCB's, lindane, and BHC unaffected. Our attempts to repeat this reaction have not been fully successful. There appears to be some loss of the more volatile (early emerging) PCB's, heptachlor epoxide is not affected, and peaks with longer retention times appear.

Although Jensen did not elaborate as to the fate of the pesticides, we have demonstrated that apparently, nitration does occur. This was shown for DDT when a large peak (probably due to the tetranitro derivative) appeared on the chromatogram about 2 hours after injection of the nitrated extract.

Of course, this reaction is a modification of the old

Schechter-Haller (8) DDT method in which more drastic conditions (fuming HNO_3 and concentrated H_2SO_4 with heating on steam bath) were used to ensure oxidation and removal of interfering biological materials. The nitrated pesticides were extracted with ether and a colorimetric method was used in the final determinative step.

Erro et al. used this technique to determine toxaphene in the presence of DDT, on the basis that the chromatographic pattern of toxaphene is not affected by nitration while the nitrated DDT does not chromatograph under the specified conditions.

Obviously, nitration does not appear to be the answer for complex mixtures of pesticides and PCB's since some pesticides (lindane, BHC, toxaphene, 'Strobane', etc.) apparently will not nitrate while some of the PCB's might nitrate. Although we have not used Jensen's column packing (the liquid phase SF-96 is a methyl silicone), it is impossible to avoid complication and interference from the nitro derivatives formed, especially when the pesticides are present in large amounts.

There are three main reasons why we prefer an approach different from Jensen's:

1. It is preferable to separate the two groups rather than destroying one, especially when it is the pesticides that are being destroyed.

2. The nitration approach tends to complicate the interpretation of the chromatograms, since the nitro derivatives

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possess greater electron absorbing power and with their longer retention times, should emerge and interfere with subsequent injections.

3. We have been unable to repeat Jensen's clear-cut differentiation, apparently partly because of the nitration of some of the PCB's.

Interference of PCB's

We have attempted a more ideal approach to differentiate the two groups by separation followed by the separate analysis of each group.

The GLC work was carried out under the following conditions:

Gas Chromatograph: Varian Model 1200, fitted with tritium-electron capture detector; column: glass, spiral, 6' x 1/8" O.D., packed with 6% QF-1 and 4% SE-30 on Chromosorb W (AW). No. of theoretical plates for DDT = 2227.

Operating Conditions: Column temperature 190°C.; injector temperature 245°C.; detector (base) temperature 240°C.; N_2 flow rate, approximately 40 ml./min.; volume injected, 5µl. Recorder: Varian Aerograph Model 20, 1 mV, full scale deflection. Chart speed: 2/3" per min.

Fig. 1 indicates the degree of separation of 8 pesticides in a standard mixture. The excellent separation obtained for DDE and dieldrin in this column which was first used by McCully and McKinley (10) should be noted.

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FIG. 1 CHROMATOGRAM OF STANDARD MIXTURE OF ORGANOCHLORINE PESTICIDES.

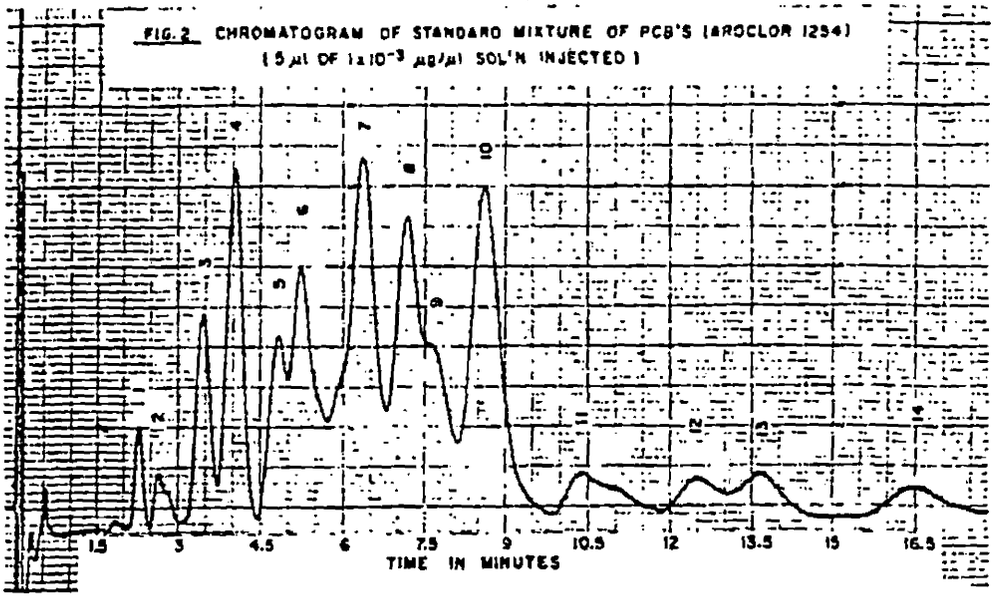


FIG. 2 CHROMATOGRAM OF STANDARD MIXTURE OF PCB'S (AROCLOR 1254)
(5 µl OF 1×10^{-3} µg/µl SOL'N INJECTED)

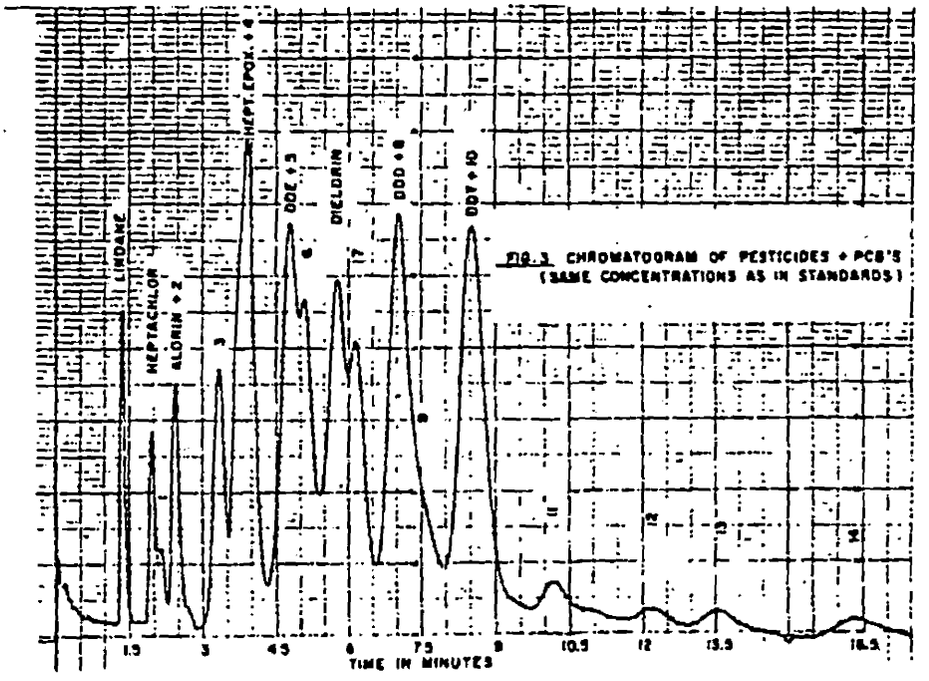


FIG. 3 CHROMATOGRAM OF PESTICIDES + PCB'S
(SAME CONCENTRATIONS AS IN STANDARDS)

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Figure 2 shows the number of peaks and the separation obtained for a sample of PCB's ('Aroclor' 1254) while Figure 3 demonstrates the degree of interference encountered when the pesticides are mixed with the PCB's.

It is interesting to note that the peaks of the commonly found pesticides all have a corresponding PCB peak that would interfere if present in the same extract. This is in agreement with Jensen's work.

Separation of PCB's from Pesticides by the Use of Florisil

With thin layer chromatography (TLC) it was observed that the PCB's ('Aroclor' 1254) tended to run towards the solvent front on the TL plates. Bearing this in mind and the fact that our cleanup procedures for pesticide residues in animal tissues usually involve a final Florisil step, we experimented to see if the PCB's could be eluted from the Florisil column with n-hexane knowing that most of the pesticides are not eluted under these specific conditions.

Four preliminary experiments were carried out to test the feasibility of this separation on Florisil. In Expt. I, 5 ml. of standard PCB preparation was added to the glass column (30 cm. x 2.5 cm. O.D.) packed with 40 ml. (ca. 19 gm. or 10 cm. in height) Florisil (60-100 mesh, Floridin Co., stored at 130°C. until ready for use) and topped with an 1/2" layer of anhydrous Na_2SO_4. Elution was carried out with 100 ml. n-hexane, and the percentage recoveries were determined. This experiment was

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repeated but the elution was effected with 200 ml. hexane (Expt. II). The same experiments were carried out with the standard pesticide mixture eluting with 100 (Expt. III) and 200 ml. (Expt. IV) hexane respectively.

TABLE I

Percent recovery of PCB's and Pesticides from Florisil columns by elution with hexane (a)

PCB peak no. (GLC)	Expt. I 100 ml hex	Expt. II 200 ml hex	Pesticide(b) peak	Expt. III 100 ml hex	Expt. IV 200 ml hex
1	80.1	92.2	Lindane	None	None
2	86.7	103.1	Heptachlor	None	92.7
3	65.6	100.0	Aldrin	62.8	94.1
4	98.2	101.0	Hept. epox.	None	None
5	42.1	100.0	DDE	20.5	97.3
6	44.9	98.7	Dieldrin	None	None
7	64.0	101.2	DDD	None	None
8	96.8	105.2	p,p'-DDT	None	None
9	60.4	105.8			
10	72.6	103.8			
11	76.9	99.9			
12	57.2	100.0			
13	100.0	100.0			
14	71.4	100.0			

a. Recoveries are based on peak height comparisons and each value represents the average of duplicate determinations.

b. Under the experimental conditions, 250 ml. of 20% ethyl ether in hexane is used normally to elute the pesticides although 200 ml. can quantitatively remove them.

The experimental results which are shown in Table I indicate that separation on a Florisil column is feasible. Almost quantitative removal of the PCB's is effected with 200 ml. hexane, while under the same conditions only three of the 8 pesticides tried showed evidence of elution (heptachlor 92.7%, aldrin 94.1%, and DDE 97.3%). It is interesting to note that these three pesti-

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-cides showing some elution from Florisil with hexane, are, like the PCB's, quite mobile under our TLC conditions.

Two further experiments were carried out to see if the separation was still effective when PCB's and pesticides were mixed (Expt. V) and when they were present in the extract from an animal tissue (Expt. VI). The first elution was made with 200 ml. hexane, the receiver was changed, and the second elution was carried out with 250 ml. of 20% ethyl ether in hexane to remove the pesticides.

The results of the two experiments are shown in Table II, and confirm our earlier finding that with the exception of DDE, aldrin, and heptachlor, a clear-cut separation of the PCB's and pesticides can be made by the use of a Florisil column.

The fact that DDE is eluted with the PCB's by pure hexane can be used to advantage in the confirmation and quantification of DDT by dehydrochlorination. The estimation of small amounts of DDT in the presence of interference (for example, a PCB) is enhanced if DDE is previously removed. The DDE produced by dehydrochlorination can then be used to estimate the amount of DDT originally present. In the presence of comparatively large amounts of DDE, this approach is not very dependable.

Discussion

The results of the above experiments coupled with the work of Jensen indicate that there are serious problems confronting residue analysts. However, as far as the writer is aware, there

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TABLE II

Percent Recoveries of PCB's and Pesticides from a Mixture after Separation on Florisil (Expts. V & VI)*

Eluted with 200 ml. hexane			With 250 ml. 20% ether in hexane		
PCB and/or pest. peak	% Recov.(a)	% Recov.(b)	Pesticide peak	Recov.(a)	Recov.(b)
			Lindane	93.6	98.5
Heptachlor	92.7	98.1	Heptachlor	None	None
PCB1	104.0	101.7			
PCB2 + Ald.[c]	102.1	96.6	Aldrin	1.3	4.0
PCB3	100.0	106.0			
PCB4	104.2	102.6	Hept. epox.	96.4	102.2
PCB5 + DDE[c]	97.8	102.4	DDE	None	None
PCB6	101.3	100.0			
			Dieldrin	100.0	100.0
PCB7	97.8	105.1			
PCB8	100.0	100.0	DDD	102.3	98.9
PCB9	91.6	97.0			
PCB10	104.7	104.3	DDT	99.8	92.5
PCB11	100.0	105.5			
PCB12	100.0	100.0			
PCB13	100.0	100.0			
PCB14	96.2	100.0			

* The peaks are arranged in order of their emergence (increasing retention time) from the GLC column, and where a PCB and a pesticide peak appear in the same line (horizontally) they have similar retention times.

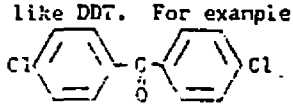
a. A standard mixture of PCB's and pesticides in pure hexane was placed on the Florisil column; first elution was made with 200 ml. hexane, receiver was changed, and the column eluted with 250 ml. 20% ethyl ether in hexane.

b. Same as in (a) except that the PCB's and pesticides were first mixed with an extract from an animal tissue which was known to be essentially free of pesticides.

c. Since a single peak was obtained, the recovery was calculated by a comparison of the peak height against that in the combined standard mixture of PCB and pesticide. In all other cases the peak height was compared to that in the standard injected separately.

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has been no positive confirmation of the presence of PCB's in wildlife tissues by techniques other than chromatography. This leaves doubts that the presence of the unidentified peaks (UIP's) is actually due to PCB's. There is the possibility that some or all of the peaks are due to condensation products of the metabolites of pesticides like DDT. For example, 4,4'-dichlorobenzophenone (DCB)  is known to be a metabolite of the DDT group.

The presence of the keto group makes it quite feasible for condensation to take place.

There are at least two points that lend support to this possibility.

1. The UIP's (being called PCB's) are usually observed only when large amounts of the DDT group are present.

2. Jensen checked eagle feathers collected since 1880 and first detected PCB (not confirmed) in an eagle from 1944. It might be a coincidence, but this is approximately the time that DDT use came into prominence. It should be noted also that the PCB's were in wide use as early as 1930 (2). Thus until positive confirmation (e.g. with mass spectra) is obtained, there will remain some doubt that these UIP's are due to PCB's - especially if PCB's are not used in pesticide formulations.

It is certainly true, however, that whether or not the UIP's are PCB's their presence leads to difficulties. The results obtained for some samples of fat recently analyzed in our labora-

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-tory are typical of the problem. The sample containing the highest levels of residues contained the following pesticides in p.p.m.: DDE - 1.42, dieldrin - 2.13, DDD - 5.61, and p,p'-DDT - 2.60.

Even prior to subjection to TLC confirmation, the DDD value appeared unusually high when it is considered that its presence in tissues is usually accounted for by three main routes:

a) It is used as a pesticide, but not extensively.

b) It is one of the metabolites of DDT - however, the DDT⟶DDE pathway is much more prevalent than DDT ⟶DDD, with the latter usually occurring in the liver, hence the fat tissue is an unlikely location for large amounts of DDD.

c) It is a frequent contaminant of technical DDT used in spray programs.

When confirmation of the pesticides was attempted, the TLC plates showed no DDD, although the apparent amount present should have given a distinct spot on the plate. However, a spot was observed running near the solvent front, a considerable distance from DDD. When this spot was scraped off the TLC plate, eluted, and reinjected into the gas chromatograph, a peak having retention time identical to DDD was observed. Although this interfering material has not been identified - it could be a PCB since its retention time coincides with one of the PCB's - it is obvious how easily one could report false results, especially if use is made of the GLC-EC results without further confirmation.

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TLC continues to be our main confirmatory method, but there are times, especially with smaller (but significant) amounts of pesticides, when it is impossible to make a positive confirmation with this technique alone.

The determination of GLC retention times on two or more stationary phases is quite useful in some cases, but as Robinson (11) has pointed out, it cannot be regarded as an independent parameter of identity since it may be shown that various organochlorine pesticides on different stationary phases are significantly correlated.

Bearing in mind these problems and the difficulty of applying infrared, mass spectra, and other spectroscopic methods for confirmation of small amounts of pesticide residues, more emphasis and reliance should be given to chemical modification of the pesticides and reinjection into the gas chromatograph, using the retention times of the products as means of confirmation.

With our SMI technique (S = Separation of PCB's on Florisil, M = Modification of the pesticide by chemical means, I = Injection of the extract containing the product into the GLC apparatus) we have observed some cases where a single GLC peak indicating one pesticide was in fact a mixture consisting of the pesticide plus some other PCB-type unknown having the same retention time. With TLC as the sole confirmatory method, one could quantify the whole as being due to the pesticide and be out by many factors depending on the ratios of the two compounds giving rise to the

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single GLC peak.

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THE NEED FOR CONTINUED USE OF POLYCHLORINATED BIPHENYLS AS ELECTRICAL INSULATING LIQUIDS

Introduction

In view of the questions which have been raised about the environmental impact of PCB's, it seems appropriate to examine the reasons why these materials are employed by the electrical industry, and the public benefits associated with such use.

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What are Polychlorinated Biphenyls (PCB's)?

Polychlorinated biphenyls are derivatives of the hydrocarbon, biphenyl, which has the chemical formula $C_{12}H_{10}$, consisting of mixtures of variously chlorinated isomers as seen in Table 1. They are usually identified by the weight percent of chlorine in the total mixtures, e.g. Aroclor* 1254 contains 54% chlorine. Aroclors are characterized by stability - high flash points and even higher combustion temperatures essential to safe operation.

How are PCB's used by electrical industry?

The principle use of PCB fluid in the electrical industry is in transformers and capacitors (both large and small) as an insulator and coolant.

Transformers are devices for converting electrical power from one voltage and current level to another, and the conducting parts of these devices must be separated from each other by a suitable insulating medium.

Capacitors are devices for storing electrical energy through the physical separation of charged metal surfaces by an insulating medium.

* Monsanto Registered Trademark

Table 1

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	.03			
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.

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Because of the nonflammability (Table 2) of aroclors, their vapors, and their arc-formed gaseous products, transformers filled with askarels are free of fire and explosion hazards and may be used in locations where failures of oil-insulated transformers would present a potential danger to life and property. In addition to improving the safety aspect of capacitors the use of arochors also gives them the advantages of reliability, long life, and small size.

Table 2

Underwriter Laboratory Flammability Rating

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 1016	2- 3

The need for PCB's in Transformers

~~Transformers of two broad types use PCB's wherever fire protection is important. power transformers, which are generally used to step up voltages; and distribution transformers, which are used to~~

step down voltages. Most of these transformers are located inside public, commercial, or industrial buildings; on the roof tops of such buildings; or in close proximity to such buildings, and require no special enclosures other than what are 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 gals. (516 to 6,450 lbs.) with an average of about 235 gals. (3,032 lbs.). During 1968, the last complete "normal" year for the electrical industry, the total amount of PCB's used in transformers 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).

A. Mineral oil-insulated transformers

1. If one disregards safety considerations, there are no technical reasons why mineral oil-insulated transformers could not be directly substituted for Askarel-insulated transformers. The size of the unit would be unchanged; the weight and cost would be less.

2. But one cannot disregard ~~this~~ safety considerations, which are often embodied in legal codes, ~~safety considerations;~~ and obviating the safety hazards involves serious economic and space constraints, that would occur by either

vaulting or use of insulated buses (with the transformer located outdoors). Either solution, if the space is available, could cost $5,000 - $50,000 per transformer.

B. Dry-type transformers

In most locations, dry-type transformers (either those open to the atmosphere or those that are gas-filled and sealed) could not be directly substituted for askarel-insulated transformers. There are several restrictions to such a direct substitution:

1. The reliability of dry-type transformers is less than that of comparably rated liquid-insulated transformers. An EEI survey of failures in network transformer banks showed a 7% per year failure rate for dry-type units compared to 0.2% for liquid-insulated units.
2. Furthermore, liquid-insulated transformers have a much greater overload capability. Many liquid-insulated units can sustain a 100% overload for 8 hours and a 200% overload for 2 hours. These transformers are able to maintain continuity of electrical service during periods of temporary outage of related equipment.
3. Some dry-type transformers are larger by 10 to 30% than comparably rated liquid-insulated units, and most are more expensive.

4. Dry-type transformers are noisier by 5-10 dB than are liquid-insulated transformers.

5. Open dry-type transformers, which are cheaper than sealed dry-type transformers, cannot be used in certain corrosive or hazardous atmospheres, e. g. on furnaces or on electrostatic precipitators near hot stacks.

The need for PCB's in capacitors

PCB's are used in more than 90% of the electric utility ~~and~~ (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 0.009 gals. (0.05 to 1.0 lbs.) of askarel per unit. The largest power capacitors contain about 6.7 gals (77 lbs.) of askarel. The most popular size contains about 3.1 gals (36 lbs.). 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 PCB's used in capacitors was approximately 14.4 thousand tons.

Possible alternatives to askarel-impregnated capacitors are capacitors impregnated with mineral oil, or ~~capacitors impregnated~~ with certain other liquids.

Mineral Oil

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 volume (size) by approximately 600%, the weight by 500%

Table 3

Alternate Insulating Fluids

Some Significant Properties of Certain Candidate Insulating Fluids to Replace Aroclor 1242

Fluid	Dielectric Constant, ϵ'_r, at 25° C	Cleveland Open Cup Flammability Flash Point - °C - Fire Point		Density	Cost ¢/lb
Aroclor 1242	5.85	154	343	1.38	18
Aroclor MCS 1016	5.85	191	319	1.36	24
Aroclor MCS 1243 (lower-chlorinated diphenyl)	5.7	160	294	1.28	18
Nanco G Oil (Mineral Oil	2.25	145	150	.9	3

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ENVIRONMENTAL RELATIONSHIPS OF PCB COMPOUNDS

by

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Environmental Control
Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

As you have already heard today, there are 209 possible homologs of PCBs. The mixtures of PCBs used by the electrical distribution equipment industry for the past forty-five years include Aroclor 1260, 1254, 1242 and 1016. Presently Westinghouse uses only Aroclor 1016 for capacitors and Aroclor 1242 for transformers. The basic differences in these materials is in the degree of chlorination. For example:

1. Aroclor 1254 contains 54 percent by weight chlorine and is primarily 77 percent five chlorine atoms and higher.

2. Aroclor 1242 has 42 percent chlorine and is only 9 percent five chlorine atoms and higher.

3. Aroclor 1016 contains 41 percent chlorine and is only one percent five chlorine atoms and higher.

For the polychlorinated-biphenyl materials, the level of chlorination appears to be the most significant factor in their relative biodegradability. The rate of biodegradability decreases as the number of chlorine atoms per biphenyl molecule increases. Chromatograms (which

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I'll explain in a minute) representing samples after exposure to activated sludge (as used for example in the City of Bloomington sewage treatment plant) show significant alterations in the Aroclor 1016 distribution but little for Aroclor 1254.

Passage of PCBs through activated sludge has shown that 33 percent of Aroclor 1016 degrades per forty-eight-hour cycle with a semi-continuous treatment method. This compares favorably, since 25 percent of Aroclor 1242 degrades in forty-eight hours, and 15 percent of Aroclor 1254 degrades in forty-eight hours. Results of additional tests with Aroclor 1016 showed that treatment for fourteen days reduces the various mixtures in 1016 from 17 to more than 98 percent. More on this later.

These tests have led to the conclusion that Aroclor 1016 is sufficiently biodegradable to remain in controlled usage.

Most analytical data for PCBs utilize chromotography. This is a device to analyze a micro-sample of the material which is injected into a column or coil of tubing under controlled conditions of temperature, injection rate and volume. The heated column selectively releases each isomer. The release is recorded on a chart. Slide 1, 2 and 3 show typical charts or chromotograms for Aroclor 1016, 1242 and 1254. The horizontal axis indicates time while the vertical axis represents the amount present. The total amount of PCBs present is determined by integrating or measuring the area under the curves. You will note that while Aroclor 1016 and 1242 exhibit similar retention times, Aroclor 1254 shows a much greater retention time due to its higher chlorination and higher molecular weight. Slide No. 4 shows the small differences between 1016 and 1242. Note additional peaks from time 70 on 1242 also showing some higher chlorination and higher molecular weight.

These data on degradation plus the complexity experienced developing analytical tools to correctly identify and quantify the mixtures of PCBs used within our own plants led us to conclude that many of the agencies supervising PCB analyses are arriving at erroneous results.

For example, analytical data provided to Westinghouse by agencies in Indiana show amounts of Aroclor 1016 in waters and in fish which could not possibly be there from degradation. In addition, the analyses for PCBs in fish used the whole fish. More commonly, however, only the edible portions are analyzed, allowing a correction factor of about four. In other words, the amount of PCBs in the whole fish should be divided by four to arrive at the concentration in the edible portion.

It seems incongruous that PCB standards are being imposed using as background information an analytical technique which was nonexistent five years ago and is presently, at best, questionable. An analytical technique which stretches technology to the limit and shows error ranges up to plus or minus 50 percent. How can reasonable replies to these important questions be answered, using inaccurate and/or non-existent data.

In November, 1975, the EPA held a conference on PCBs in Chicago. At this meeting, many papers were presented on research studies, under EPA supervision and support, to determine the effect of PCBs on fish and animals. It was unfortunate that practically all experiments, at that time, were conducted using Aroclor 1254. This material has not been used in Westinghouse transformers since 1968, because of its

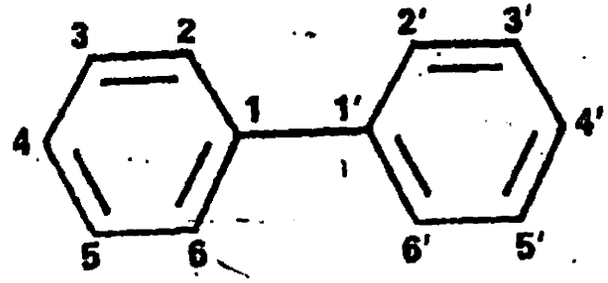
nonbiodegradability and its possible detrimental effects on the environment. Importantly, Aroclor 1254 has never been used in the Bloomington plant. While a few screening studies were carried out by EPA on Aroclor 1242, no studies on the use of Aroclor 1016 had been planned at that time.

In addition, most of the data reported at this meeting indicated that massive doses of PCBs (not even available for the last two or three years -- 1248, etc.) given to rats and monkeys had detrimental effects. However, little work was carried out using concentrations as found in the environment. Another critical factor, often overlooked, is that residual PCB levels in the fat tissues of animals do decrease rapidly, following the cessation of exposure to PCBs (See slide No. 6).

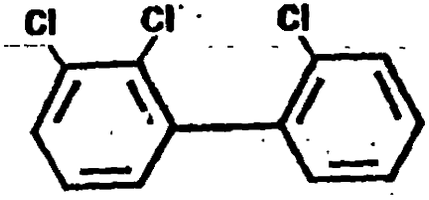
Fish found to contain the highest levels of PCBs were the bottom dwelling scavengers such as catfish, carp and eel. The game fish showed much lower levels. Factually, in surveys carried out between 1973 and 1975 in Lake Michigan, the number of fish found to contain PCBs decreased. Moreover, we are unaware of any study to measure PCB content in fish after cooking. Cooking should remove fat and fat containing PCBs from edible fish.

Presently EPA has agreed to carry out studies on the effects of Aroclors 1016 and 1242. These data should be available within 12 to 18 months. We feel that these studies will show a dramatically reduced environmental effect from these lower homologs -- effects that allow a timely and orderly conversion to other dielectric fluids that will not cause severe penalties in safety and energy use.

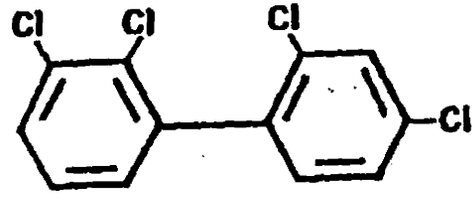
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BIPHENYL

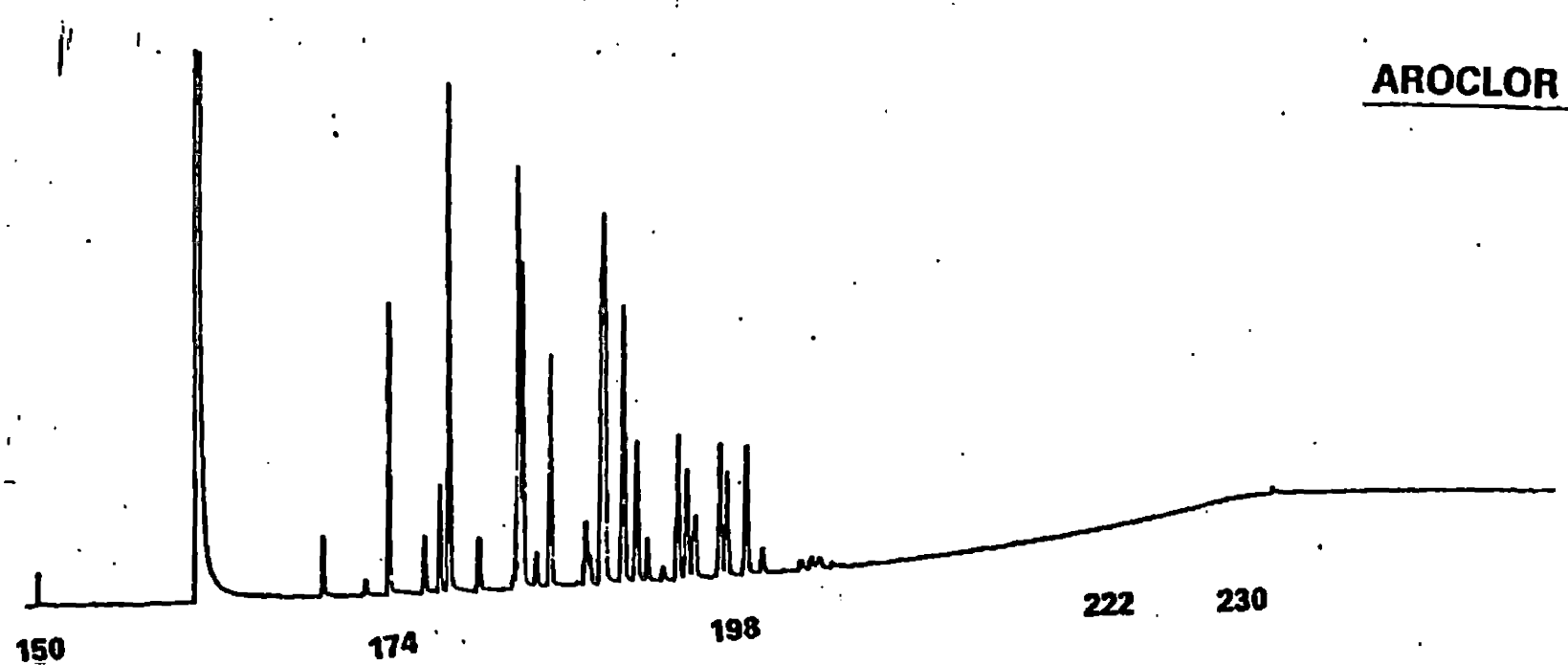


2,2',3-TRICHLOROBIPHENYL



2,2',3,4'-TETRACHLOROBIPHENYL

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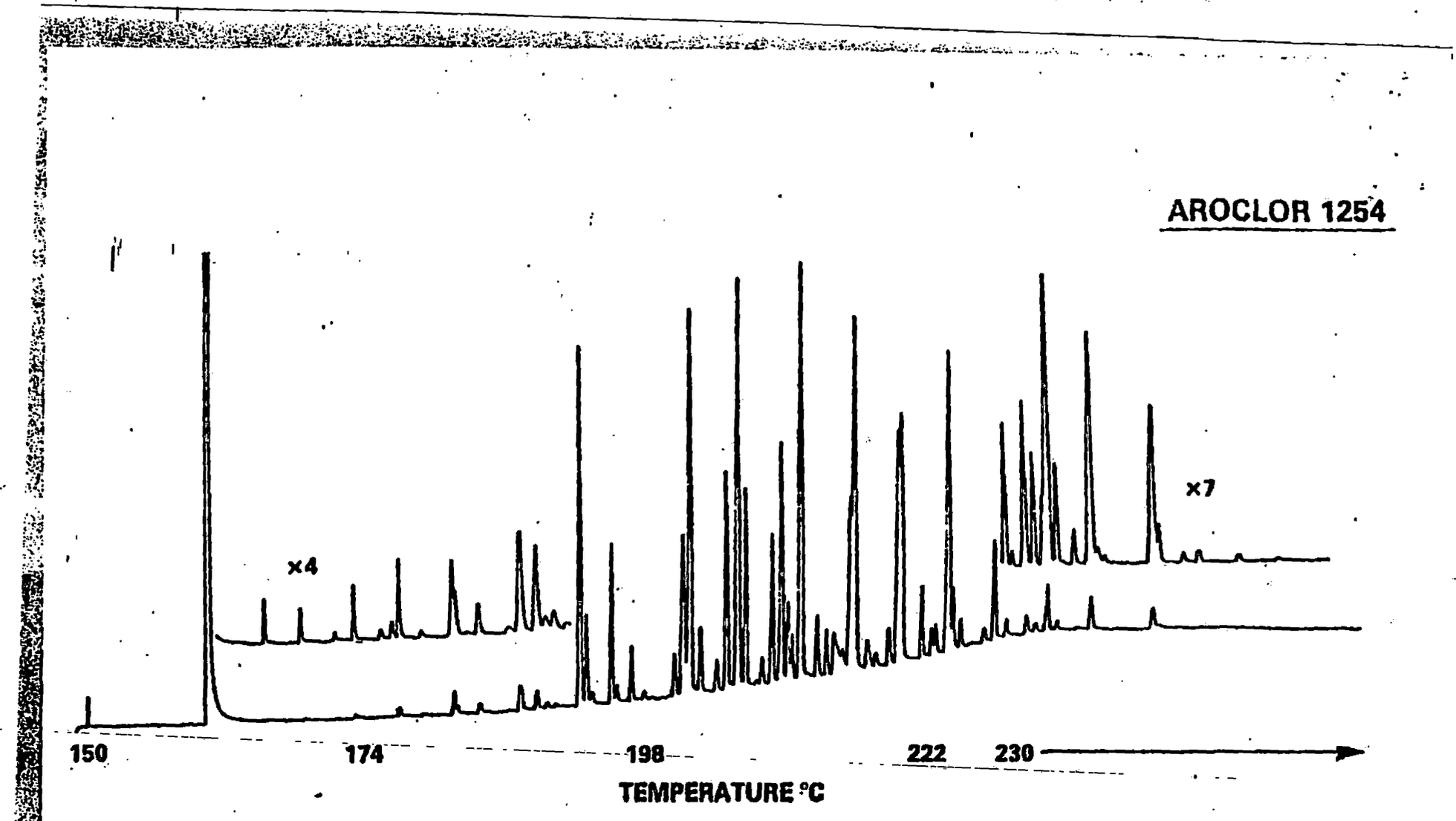


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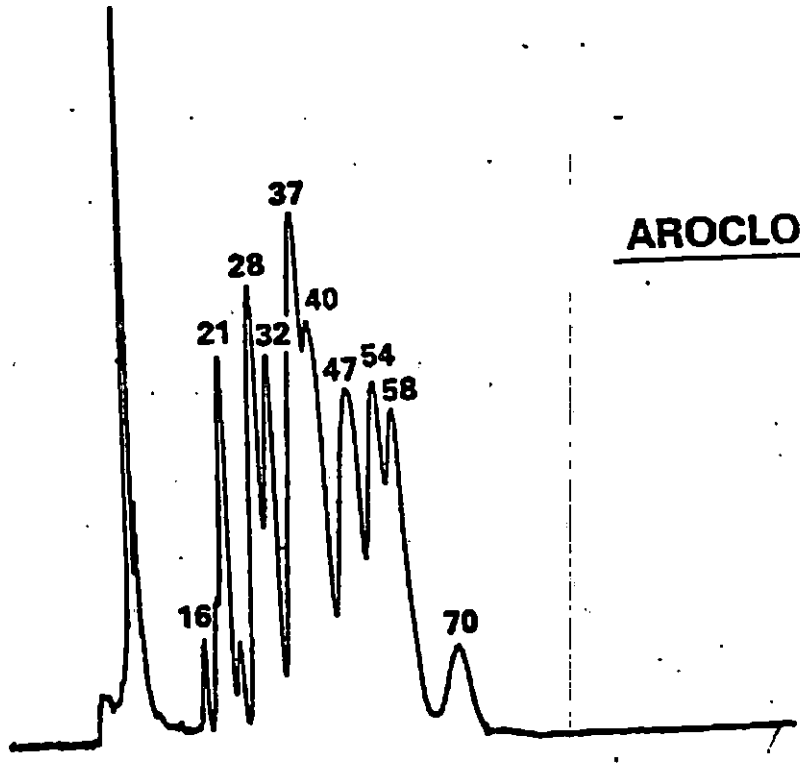
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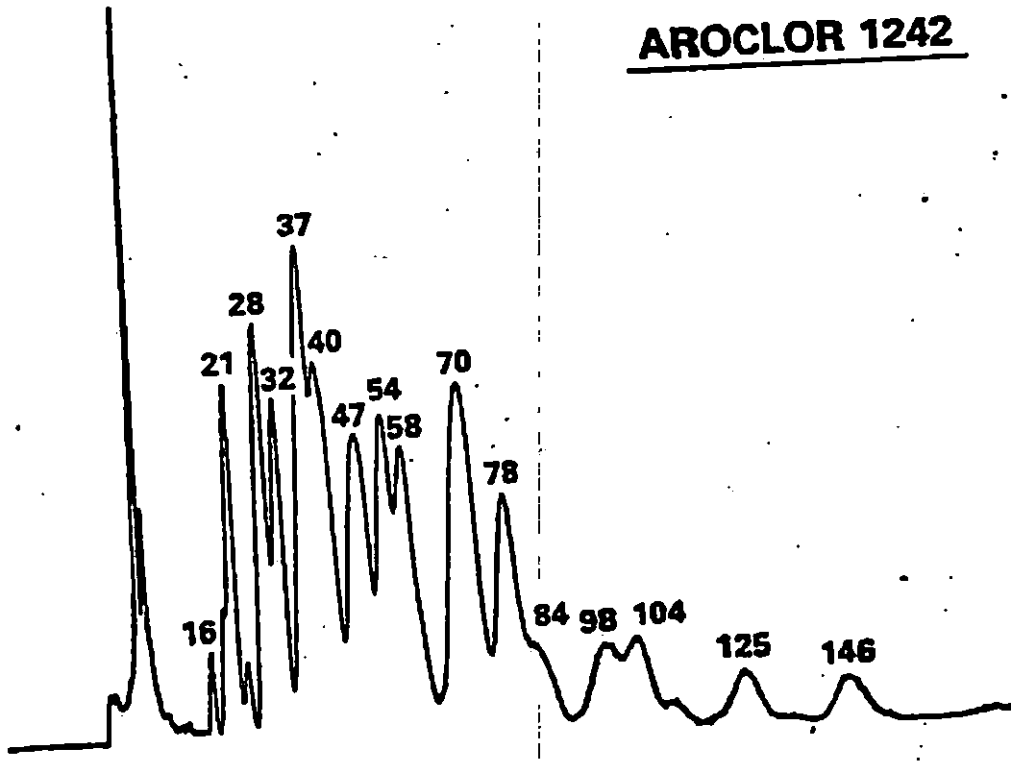
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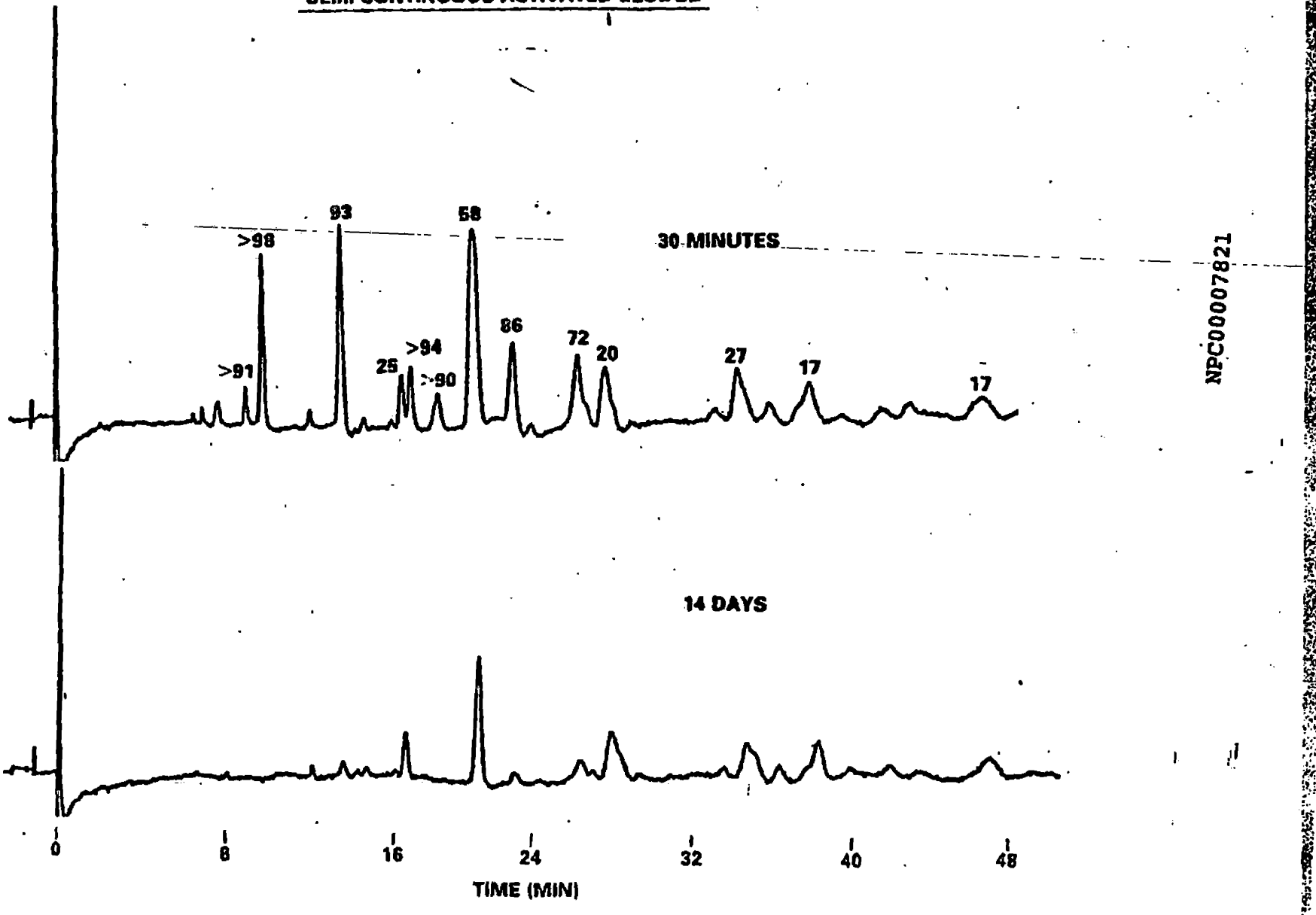
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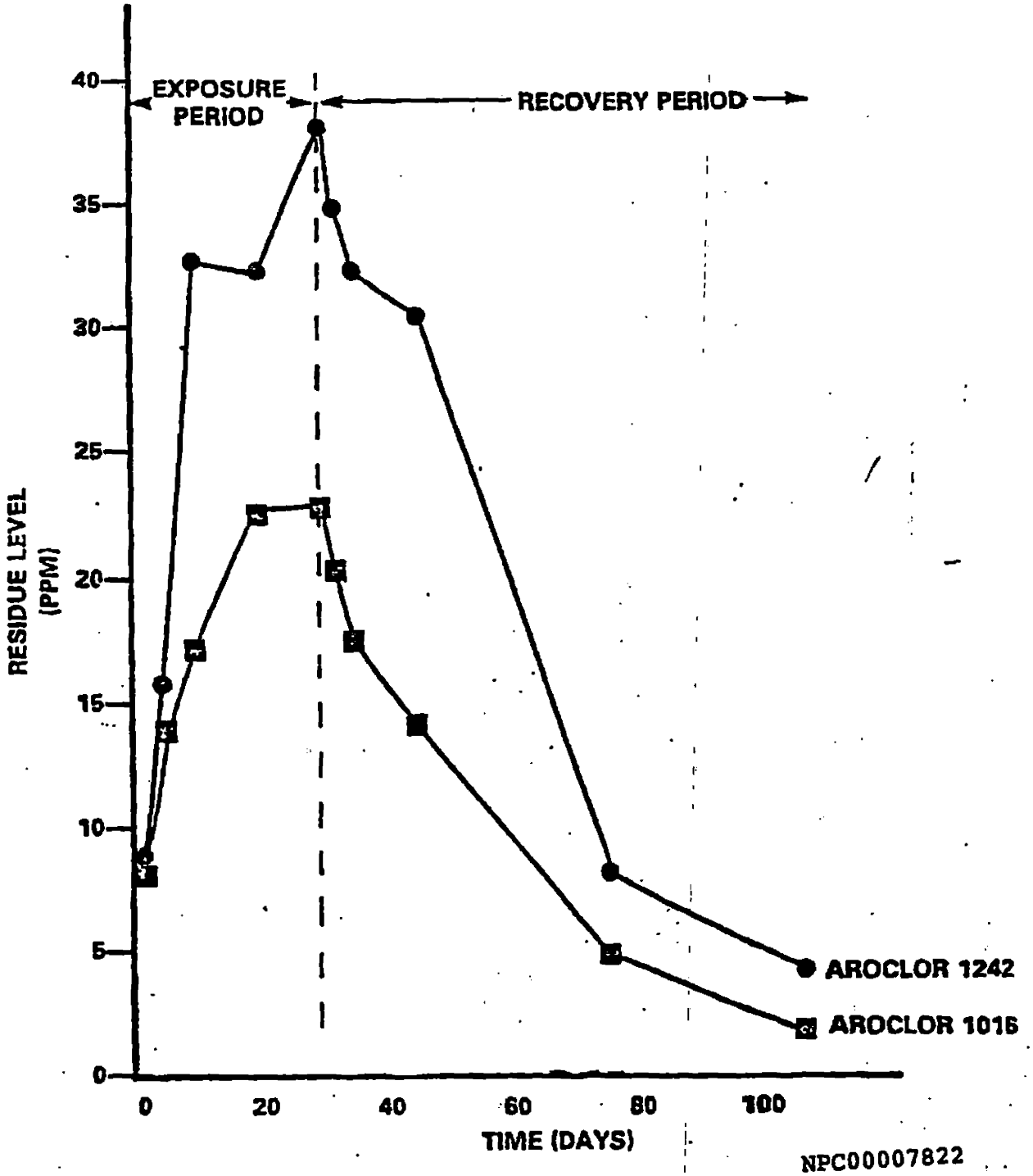
AROCLOR 1016 BIODEGRADATION

SEMI-CONTINUOUS ACTIVATED SLUDGE



FAT TISSUE RESIDUE LEVEL VS. TIME

25 PPM FEED LEVEL FOR RATS



770461

cc. Sauter
McClain.

Consideration of Bio
and Non-Biodegradeable PCB's

On 10-14-71 I wrote a memo of the same subject. This memo will supersede that memo. Monsanto refuses to state that Aroclor 1016 is biodegradeable and request that we state only that the tetra-, penta-, and hexachloro content has been reduced. Our best information (confirmed by Papageorge in October 1971) of the content in Aroclor 1016 and 1242, is as follows:

	1016	1242
Biphenyl	0. %	.05%
Mono-Chloro Biphenyl	1. %+	1. %+
Di-Chloro Biphenyl	19. %+	19. %+
Tri-Chloro Biphenyl	70.85%	53.95%
Tetra-Chloro Biphenyl	9. %	18. %
Higher Chloro Biphenyl	0.15%	8. %

Discussion with Tom Munson brought out the fact that on all sample analysis that he does he determines the % of the various di-, tri-, tetra-, etc. It is my impression that the tri-chloro and down tend to rapidly disappear from the tissue of fish.

It would, therefore, appear that 1016 is a real improvement over 1242, however, 1016 does still contain various amounts of suspected compound. Munson is of the opinion that the people in the government laboratory concerned with PCB's are well aware of the improvement of 1016 over the other PCB's. The time does not yet appear right to try to make a distinction between 1016 and other PCB's. If the subject of control of PCB's is put into the hands of a commission where it can be discussed on a scientific basis, there is a good possibility that 1016 could be separated out from other PCB's.

NPC00007823 JBB, 10-28-71

A CASE STUDY*

POLYCHLORINATED BIPHENYLS

by William Papageorge
Monsanto Industrial Chemicals Co.
St. Louis, Missouri
January 1975

*Written for the study on Decision Making for Regulating Chemicals in the Environment, Environmental Studies Board, National Research Council, National Academy of Sciences, undertaken at the request of the U.S. Environmental Protection Agency, Contract No. 68-01-2262.

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CASE STUDY
POLYCHLORINATED BIPHENYLS

Nature of Decision

Monsanto Company management decided to terminate the sale of commercial mixtures of polychlorinated biphenyls for all applications except for use in closed systems as a dielectric fluid in capacitors and transformers for which no acceptable fire resistant alternative materials exist. This decision was made voluntarily and is not based on any state or federal legislation.

Chronology

During the period 1968-1969 several laboratories throughout the world were developing analytical methodology for identifying and quantifying polychlorinated biphenyls. This activity followed a report in which Doctors S. Jensen and G. Widmark of the University of Stockholm had claimed that unknown peaks observed in chromatogrphs developed during pesticide analyses were due to the presence of polychlorinated biphenyls. Reports from these laboratories alleged that polychlorinated biphenyls were present in the environment. The material being discovered was reported to resemble commercial material containing highly chlorinated

isomers. Also, about this same time, some investigators attributed the inability of some species of wild birds to properly reproduce because of poor egg shell formation to the presence of polychlorinated biphenyls, a premise, incidentally, that has not been supported by subsequent studies.

During this same period of time, Monsanto initiated studies to be carried out by an independent laboratory to attempt to determine the effects of polychlorinated biphenyls on test animals. When it became apparent that polychlorinated biphenyls were, in fact, present in the environment and that there might be some substance to the allegations of harm to the environment, the first phase of the sales termination program was initiated, resulting in the discontinuance of sales of polychlorinated biphenyls to "open type" uses. "Open type" uses were defined as those which offered minimum opportunity for control and could result in relatively easy entry into the environment. These applications included coatings, sealants, waxes, plasticizers, pesticide extenders, adhesives and inks.

Alternative fluids were developed and were promptly offered to users to replace the polychlorinated biphenyls in fire resistant industrial hydraulic fluids and in carbonless copy paper coating systems.

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During 1970 incomplete reports from Japan indicated that illness in humans had occurred, possibly because of the presence of polychlorinated biphenyls in cooking oil extracted from rice bran. It now appears that the illness might have resulted from a contaminant in the polychlorinated biphenyls, which were manufactured by a Japanese company. The Japanese reports, when interpreted and verified, raised the possibility, albeit a remote one under U. S. food processing conditions, of direct contamination of human food by heat transfer fluid. Monsanto terminated sales of polychlorinated biphenyls as heat transfer fluids for systems used in processing food for human consumption.

As a result of Monsanto's sales termination program, polychlorinated biphenyls were sold only as fire resistant fluids for use in closed systems. These were (a) dielectric fluids in capacitors and transformers and (b) heat transfer fluids in systems not used in human food processing.

Monsanto's final act in its sales termination program was to cease all sales except for dielectric fluids in capacitors and transformers. In addition, as this program proceeded, steps were taken to replace the higher chlorinated mixtures with the less persistent lower chlorinated mixtures. Aroclor 1248 and Aroclor 1254 were no longer sold

to the heat transfer applications. Aroclor 1260 was replaced by Aroclor 1254 in transformer fluids. Aroclor 1016 was developed to replace Aroclor 1242 as the preferred capacitor fluid.

Objectives

The objectives of Monsanto Company's management in arriving at the polychlorinated biphenyl marketing policy were and continue to be as follows:

1. Minimize the potential for the entry of polychlorinated biphenyls into the environment.

2. Eliminate the potential for the entry of polychlorinated biphenyls into human food.

3. Retain those applications of polychlorinated biphenyls which involve closed systems offering opportunity for control and in which the fire resistant and dielectric properties of polychlorinated biphenyls are necessary.

4. Avoid major disruptions in commerce and industry resulting in unwarranted adverse consequences to society in general.

Information

Early reports available to Monsanto Company repeatedly referred to the detection in environmental samples of the presence of the higher chlorinated polychlorinated biphenyl mixtures. The absence of the lower chlorinated mixtures, which were used in greater quantities, led to some early misunderstandings relating to the polychlorinated biphenyl types and their applications which were the possible sources of entry into the environment.

Also, early reports of effects on wildlife were speculative in relating presence of polychlorinated biphenyls to noted harm; e.g., soft egg shells, dead sea birds and baby seals. Subsequent analyses of the data have not supported the early conclusions. The only observable effects to wildlife, fish and birds, have resulted from research studies conducted at exposure levels not found in the environment. The only exception reported was the sensitivity of juvenile shrimp to extremely low concentrations of polychlorinated biphenyls.

From all available information the following impressions were derived:

1. Polychlorinated biphenyls of higher chlorine content were present in the environment.

2. No known harm to wildlife has been conclusively documented, but the potential for harm at high concentrations of polychlorinated biphenyls did exist.

3. The food chain could possibly be adversely affected by the presence of polychlorinated biphenyls based on the allegations relating to the Japanese incident.

Information on what the unavailability of polychlorinated biphenyls has cost the ultimate user is not available. Conversion costs to alternate materials has in some cases been considerable; e.g., heat exchange applications have required extensive equipment modifications to permit use of flammable alternate fluids as well as the installation of fire detection and control equipment. Some applications, although small in volume, still lack a satisfactory alternative material; e.g., immersion fluid for optical microscopy, ingredient in investment casting wax formulations and component in military systems.

The decision to restrict the sales of polychlorinated biphenyls has resulted in a decrease in the amount of material manufactured by Monsanto Company by approximately

50 per cent. One Monsanto production unit has been dismantled and about 75 jobs (production, maintenance, administrative, engineering, shipping) have been eliminated. The cost of controlling effluent losses at the remaining production unit, installation of facilities to produce a less persistent mixture for capacitor application and the installation of an incinerator to destroy scrap polychlorinated biphenyls has exceeded $2,000,000.00. The cost of controlling effluent losses at the capacitor and transformer plants using polychlorinated biphenyls is not available.

One of the key considerations in arriving at the decision to continue to supply polychlorinated biphenyls as dielectric fluids in capacitors and transformers was the fact that in these applications the fluids are hermetically sealed in metal containers permitting a high degree of control of escape into the environment. Another major consideration was the important role these capacitors and transformers have in the efficient generation, transmission and distribution of power with reduced risk of fire and explosion and in compliance with specific laws, codes and insurance restrictions mandating fire resistant liquid content.

Implementation

Implementation of the restricted sales policy did create some localized hardships for the users of polychlorinated biphenyls. The costs involved in developing alternative materials or in sacrificing performance in their applications would be impossible to quantify.

There have been reports of fires in heat transfer systems which were converted to alternative flammable fluids. The number of fires and extent of damage is unknown. The risk of fires still exists and is exemplified dramatically by the potential hazards that are associated with installations such as off-shore gas and oil producing platforms.

During 1974 investigators with the EPA laboratory in Duluth, Minnesota, reported that the concentrations of polychlorinated biphenyls in the Milwaukee River are decreasing. Also in 1974 studies by Woods Hole Institute of Oceanography personnel indicate that the amount of polychlorinated biphenyls in the Atlantic Ocean is decreasing.

Observations, Comments, Recommendations

The lack of reliable data relating to the fate and effect of the many isomers of chlorinated biphenyl in the environment continually frustrated the decision making process.

Unproven claims of total nondegradability, carcinogenicity, teratogenicity, mutagenicity and extremely high toxicity created emotional unwarranted concerns.

The availability of more information could perhaps have helped define which commercial mixtures and which applications were undesirable. Lacking this data, the termination of sales was made on a broad rather nondiscriminatory basis. For example, it can be seriously challenged whether the use of polychlorinated biphenyls in immersion optical microscopy results in environmental problems. Also, the use of these materials in selected heat transfer systems, properly maintained and operated, could in all probability be justified based on the highly desirable fire resistant property of the fluids.

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...given first attention, and others an opportunity permits, including extractions, fillings, x-ray films, and treatment of Vincent's angina and gingivitis.

As yet no data have been gathered on the saving of lost time, but this is now being obtained. The important thing about the whole set-up is the ability to cooperate with community dentists and to provide facilities for workers on an emergency basis.

The Pomona plan was referred to, where dentists set aside one day a week for workers, and also use evening hours for day workers.

Industrial physicians can participate to good advantage in this program, along with the employer, the employee, and dentists.

Examples of clinical dental problems were described and commented upon and, finally, a pre-payment plan for ...as the American Medical Association, the American Public Health Association, the U. S. Public Health Service, and others.

It is believed that the Chamber of Commerce has a major job to do in educating the public, to help the public become more health-conscious, and to provide information for public release to the press, radio, printed bulletins, and other forms.

The second phase of this program is action as a result of information released. Health committees have been formed in city chambers of commerce and examples of the public health activities of these were summarized.

Booklets and bulletins have been prepared for distribution on various health problems.

It is proposed that an annual appraisal of community health programs be made by state health departments, with the advice of the U. S. Public Health Service.

Chlorinated Compounds

—Precautions in Handling—

DR. A. G. CRANCH, Director of Union Carbide & Carbon Company's Toxicological Laboratory, submits the following precautions for handling certain chloro-naphthalene, chloro-diphenyl, and related chlorinated compounds. These were developed, under his direction, by the Halowax Products Division, (30 East 42nd St., New York), and are presented here not only for their value in avoiding harmful effects from these chlorinated materials but also on account of the applicability of these precautions to operations where analogous materials are employed. The practice of the manufacturer in distributing this information to all of its customers, and to health agencies generally, is to be commended.

PRECAUTIONS for Handling Chloro-Naphthalene, Chloro-Diphenyl, and Related Chlorinated Compounds:

These compounds constitute a group of synthetic waxes made by the chlorination of a coal tar derivative. The compounds most commonly handled in industry are those containing chlorinated naphthalenes, chlorinated diphenyls, and chlorinated diphenyl oxide. These materials have certain characteristic toxic properties. Their toxic action is evidenced commonly in the development of a form of acne, which usually does not appear until after some weeks or months of continuous exposure to these materials. This exposure may be either to fumes from the hot material or from continued contact with the solid material. It can only follow repeated or continuous contact, and will not develop because of short and infrequent exposures. It closely resembles common acne, but differs in that it is usually encountered on the face—including forehead and temples—back, chest, anterior surfaces of the thighs, outer surfaces of the arms, and sometimes around the waistline, rather than simply on the face and back, which are the more usual locations for common acne. Usually the acne from this industrial exposure is accompanied by a larger proportion of comedones (blackheads) than in the case with common acne; also, itching may be a prominent symptom.

In exceptional cases liver damage may occur through inhalation of the fumes. This is a rare form of poisoning, in contrast to the appearance of acne, and seems to have no relation to the extent or duration of the acne, which may have occurred, but is dependent on other factors. It does not result from casual exposure, but is a cumulative effect.

Experience has shown that, despite their toxic properties, these chlorinated materials may be safely used if proper control measures are observed. Under good operating conditions the appearance of acne should be reduced to a minimum, and easily brought under control. With these precautions, cases showing liver damage probably would never occur.

Preventive Measures

MECHANICAL: Wherever these materials are handled, good housekeeping conditions must be maintained. There should be no careless scattering of material. All equipment and work places should be thoroughly cleaned, preferably every day. Those engaged in this work should take the same personal precautions as are outlined for operators. Equipment should be of an enclosed type, and fumes and vapors removed by exhaust ventilation. This is especially important where the materials are handled in a hot condition. Where the so-called cold process is used, in which the chlorinated waxes are dissolved in a solvent, full precautions should be taken to control the vapor given off by the solvent itself at room temperature, and by the compound as well when the solvents are driven off later by heating.

Our engineering department is ready at any time to advise regarding proper design for ventilating equipment for proposed or installed processes. The efficiency of ex-

such symptoms should appear as early as ... qualified physician who is aware of the possibilities present in their industrial exposure.

PERSONAL HYGIENE: (a) All unnecessary prolonged contact with these materials should be avoided. This as to vapors from the heated material, and exposure to the solid.

(b) There should be a complete change from street clothes to working clothes before going to work. Work clothes should be supplied including such items as starched and laundered cover-alls of light color and close weave; socks; caps; and underwear (preferably union suits with long sleeves and legs). Gloves and aprons should also be supplied where indicated. Sleeves should be buttoned at the wrist. Cover-alls should be buttoned at the neck. Fresh work clothing should be supplied for regular operators twice a week or oftener, daily in hot weather. It should not be taken home for laundering. Provision should be made by the employer for this. If exposure is occasional or intermittent, a different schedule might be warranted.

(c) Separate lockers should be provided for street clothes and work clothes, which should never be kept in close contact in the same locker.

(d) It is essential that face and hands be washed before eating, and that a shower be taken on quitting work. It is recommended that the daily shower should be supervised to make certain that washing is thoroughly carried out before resuming street clothes and leaving the work place.

(e) A suitable skin cleanser should be provided. Strong solvents or soaps containing mineral abrasives should be avoided. Powdered soap containing a corn meal abrasive is probably the most suitable soap, but there are a number of recently developed cleansers based on saponified vegetable oil, which may prove to be very satisfactory.

(f) Protective creams offer an additional protection when applied to the face and hands, or to other exposed skin surfaces. These should be applied before work and renewed at least once or oftener, if necessary, through the day. Contact of soiled hands with the face should be avoided. Soiled waste or rags should not be used on the face.

(g) Employees should be cautioned as to the effects of excessive use of alcohol, exposure to chlorinated hydrocarbon solvents, or continued exposure while under medication involving the use of the heavy metals, such as arsenic or bismuth. They should also report at once any evidence of dermatitis, or digestive or liver disturbance.

Light, Temperature, Humidity

—Effects in the Working Environment—

ANNA M. BAETJER, Sc.D.,
Associate in Physiological Hygiene,
School of Hygiene and Public Health,
Johns Hopkins University

THE EFFECTS of Temperature, Humidity, Air Movement and Radiant Heat.

A. Acute Effects of High and Low Temperatures;

These topics will be discussed from the viewpoint of the acute effects on health in general, on ability

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lair installations can be checked by special equipment, which we will make available when required.

HYGIENIC: Care must be used in the selection of workers. Young people are more prone to develop acne. It would not be desirable to employ such individuals on this work unless their skin is clear, dry, and free from excessive waxy secretion. Those showing an oily skin with a tendency to the formation of blackheads or acne should not be employed. Those having a history of skin disease, liver disorders, or alcoholism should not be employed. Those recently exposed to chlorinated volatile solvents, or those under treatment requiring the use of the heavy metals, as in syphilis, should not be employed. After employment, there should be close supervision of the workers to detect any evidence of acne in its earliest stages, or any evidence of digestive disorders, jaundice, or other symptoms suggesting liver involvement. *Employees showing such symptoms should apply at once for treatment by a qualified physician who is aware of the possibilities present in their industrial exposure.*

PERSONAL HYGIENE: (a) All unnecessary prolonged contact with these materials should be avoided. This as to vapors from the heated material, and exposure to the solid.

(b) There should be a complete change from street clothes to working clothes before going to work. Work clothes should be supplied including such items as starched and laundered cover-alls of light color and close weave; socks; caps; and underwear (preferably union suits with long sleeves and legs). Gloves and aprons should also be supplied where indicated. Sleeves should be buttoned at the wrist. Cover-alls should be buttoned at the neck. Fresh work clothing should be supplied for regular operators twice a week or oftener, daily in hot weather. It should not be taken home for laundering. Provision should be made by the employer for this. If exposure is occasional or intermittent, a different schedule might be warranted.

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THE EFFECTS of Temperature, Humidity, Air Movement and Radiant Heat.

A. Acute Effects of High and Low Temperatures:

These topics will be discussed from the viewpoint of the acute effects on health in general, on ability to work and their relation suggested methods of obt. and of preventing their har factors are of importance cause they control the an. lost by the body. If sufficipulse rate, blood volume, tion and, at high temper. crease. Because of the cu stolic blood pressure may fi. When excessive sweating be lost from the body in a fall in the concentration hydration of the blood. A. marked strain on the cir regulating mechanism an body, which, if extreme, stroke or exhaustion. Heat by spasmodic cramps of may be cured by sodium mouth or intravenously. T sodium chloride and water sweat, and may be prevente by mouth, at intervals dur exhaustion presents the greater or less degree. It is ure of the cardiovascular the adjustments necessary peratures. It is reported ti exhaustion in industrial w duced since salt or salt an provided. Heat stroke (or s by a very high body tem with delirium and convuls heat-regulating mechanism understood. It should be n cases show symptoms comm of heat disease. This is esp and exhaustion.

The chief effects of expo temperatures among indu changes in the skin and ex extremities leading to acut reactions, frost-bite, chilbl extensive, lead to necrosis an

B. Effects of Temperatu... sistance to Disease:

Exposure to high tempera predisposes industrial worl diseases such as pneumoni affect the incidence of tube tism appears to be higher i sudden changes in temperatu are present. Exposure to hig increase the rate of absorp substances. There is at pres that either high or low hu resistance to disease.

C. Relation of Temperatu...

The acute effects of high increased when a man is d since exercise itself causes a tion, pulse rate, respiration the same time, workmen physical work at high tem rise in air temperature t physical work, and at very ability to work is greatly cu tures sufficient to cause no ability to work. It is report

The text of Dr. Baetjer's Lecture... ene's Post-Graduate Course in Indus...

dling this type of material in the San Diego Division of the Consolidated Vultee Aircraft Corporation there has not occurred a single case of serious intoxication from exposure to any toxic material throughout this large plant.

Chlorinated Naphthalenes and Diphenyls

LEONARD GREENBURG, M.D.,
Executive Director, Division of Industrial Hygiene, New York State Department of Labor

THE chlorinated naphthalenes comprise a group of chemical substances made by the addition of various amounts of chlorine to a naphthalene base. The amount of chlorine may vary from three to six or possibly more atoms providing compounds from trichlornaphthalene to hexachlornaphthalene.

In the same manner, the varying amounts of chlorine are added to a diphenyl base providing a group of compounds of varying chlorine content.

As a rule, the final substances, as used in industry, are mixtures of differing chlorinated naphthalenes. Earlier, these were, as a rule, possessed of a lower degree of chlorination and later on the compounds were usually of a higher degree of chlorination with varying amounts of chlorinated diphenyls added thereto.

These substances are not new. Perchlornaphthalene was used in Germany during the last war.

It is to be clearly understood that these groups of compounds are not manufactured by any one company but rather by approximately five in the United States, and they are sold under varying trade names by the manufacturers.

The chlorinated naphthalenes and diphenyls are valuable industrial products. Because of certain properties which they possess, we may briefly state these valuable properties as follows:

1. Resistance to water and alkali.
2. High insulating value. They possess high dielectric constant.
3. Thermoplasticity.
4. Quite stable chemically.
5. Flame resistant.

For these reasons, these substances possess much value industrially in the making of electric condensers, and in the insulation of wire and cable, etc.

Method of Use in Industry

THE chlorinated naphthalenes and diphenyls are used in industry by two methods:

1. A cold method in which the material is dissolved in a solvent usually a mixture of petroleum naphtha and toluene, and
2. A hot method wherein the material is rendered plastic by heat.

Toxic Effects

IN THE United States, the first three cases of acne produced by chlorinated naphthalenes were reported by Sulzberger[1] and his co-workers in 1934. Fulton and Matthews,[2] of the Pennsylvania Department of Labor, reported 101 cases of dermatitis in a wire insulating plant in 1936.

In 1936, Dr. Louis Schwartz,[3] of the United States Public Health Service, described cases of acne produced by chlordiphenyls, and in the same year, Jones and Alden[4] reported similar findings.

In 1938, Mayers and Silverberg described acneform skin eruptions in workers making electrical condensers.[5]

Time does not permit a discussion of the histology of these dermatological changes produced by this substance.

In general, it can be said with a fair measure of certainty that these changes are brought about in the skin, primarily by the contact of the skin with the vapors of these compounds, or by actual contact with them in the form of solid or particulate matter. We have found, for example, that workers exposed to fumes have more acne than those exposed to dust alone, and we have also found that workers exposed to the solid material or its particulate form have developed dermatitis. In this connection, the report of Fulton and Matthews is very interesting. They picture and describe a case of an infant, 2½ years of age, who developed the dermatitis as a result of contact with the soiled working clothes of its father who was in the habit of playing with the child prior to changing his clothing.

More recently, Schwartz[6] has described cases of dermatitis among cable strippers employed at shipbuilding establishments and working with cables which had been impregnated with these compounds.

Systemic Effects

IN THE United States, systemic effects in the form of acute yellow atrophy of the liver were reported by Flinn and Jarvik[7] in 1936 among men working with tetra and pentachlornaphthalene. These findings were verified by animal experimentation. In 1937, Drinker, Warren and Bennett[8] reported such liver changes among animals exposed to the material by inhalation, and similar findings were obtained with the chlorinated diphenyl compounds. These latter authors also mention four non-fatal cases among humans and the three fatal cases previously cited by Flinn and Jarvik.

I should like to cite two or three cases which we have encountered in our own experience[9] and which may be of interest from the point of view of duration of exposure prior to this type of poisoning. A girl 17 years of age was engaged in soldering electrical condensers which were impregnated with tri- and tetrachlornaphthalene for a period of approximately three months. The autopsy for this case showed mild to severe degeneration of the liver and presented a clear picture of what is generally known as acute yellow atrophy. It was apparent in this case that the latter organ displayed areas of healing and new areas of pathology.

In the second case, a man 24 years of age developed jaundice after five months of exposure in the coating of wires with wax containing the higher chlorinated naphthalenes. He was away from work for a period of time and four months later the jaundice became quite intense, with general malaise and loss of appetite. After two months more of work he was sent to the hospital, where he rather rapidly passed away. The autopsy in this case showed extensive areas of necrosis and fibrosis of the liver with regeneration.

In a third case, published by Drs. Mayers and Smith,[10] of the staff of the New York State Department of Labor, an 18 year old girl became ill after five months of exposure in the soldering of electrical condensers. The waxes in this case were composed principally of trichlornaphthalene. She was hospitalized and recovered after a long and slow period of convalescence.

Recent Industrial Experience

DURING the past year the Division of Industrial Hygiene of the New York State Department of Labor has conducted an investigation in two cable plants using chlorinated naphthalenes and diphenyls. In this

Round Table Discussion, Recognition in the Use of Toxic Substances, National Conference of Governmental Industrial Hygienists, Rochester, New York, May 24, 1943.

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investigation, a large number of cases of dermatitis were found, and several deaths due to liver damage among workers in the industry.

The examination of workers in the two factories showed relatively few cases of enlarged liver—five in all, on palpation.

Comparison in these two plants showed a very much higher incidence of acneform dermatitis in one of the plants as compared with the other; namely 21% as compared with 60%, the former being in the cold process establishment and the latter being in the establishment employing the hot process only. The dermatitis appeared to take place on the average in about 1½ months in the hot process plant as compared with 10 months in the cold process plant.

Conclusions

As a result of our general re-study of this whole problem and our experience in two recent outbreaks, as well as several isolated experiences we desire to draw several basic conclusions:

1. Chlorinated naphthalenes and diphenyls are in general highly toxic compounds and must be used with extreme care. Industrial hygienists should make every effort to see that such exposures are controlled, in so far as humanly possible. In this effort, we do not believe it safe to rely on limiting atmospheric concentrations but rather to depend on a maximum of maintenance and engineering control.

2. Toxic exposures may be more readily controlled where the cold or solvent method of impregnating cable is employed than where the hot process is used.

3. Of the known cases of liver disease in our experience, the available history and experience generally points to exposure to vapors or fumes from the hot process. There is no clear evidence in our experience, although it is possible that skin absorption may produce systemic poisoning. Physiologically we see no reason why this is not possible. However, most dermatitis cases do not develop liver damage.

Finally, I should like to call attention to a group of recommendations which were agreed upon by all of the groups involved in the last outbreaks of poisoning as being of utmost importance in control of this hazard.

Recommendations

Unless there is a very good reason for using the hot method of impregnation all new installations should use the cold or solvent method of impregnation with chlorinated naphthalenes and diphenyls. Where the hot method is now being used it should be changed over to cold, if possible, or surrounded with every known protective measure.

4. General hygienic measures should be followed, but in no case should these be allowed to supersede engineering control of the primary source of the exposure, the operations in the plant.

The following hygienic measures may be considered good practice where these compounds are handled.

(a) Two lockers for each worker exposed to chlorinated waxes (one for working and one for street clothes).

(b) All work clothes above the underwear should be provided and laundered at least twice a week by the management.

(c) The workers should change to clean underwear at the end of each shift before getting into his street clothes.

(d) Supervised cleaning: (1) At noon the workers should remove outer clothing and scrub hands and face under supervision. (2) At the end of the shift they should be required to take a supervised shower before changing back to street clothes.

(e) Protective skin creams or protective clothing should be provided by the management at the discretion of the foreman, nurse, medical, or plant superintendent.

(f) All departments handling chlorinated synthetic waxes should be thoroughly cleaned according to a prearranged schedule. This should include the removal of all deposits of waxy material from the machines, floors and surrounding objects. Workers doing the cleaning should be provided with protective clothing and supplied air or organic vapor masks where exhaust ventilation is inadequate or not possible.

5. The foremen of all departments where this material is handled should be apprised of the toxic nature of the material and instructed in safe handling procedures. These men should make it their duty to check up on the workers in their departments and instruct them in safe practice.

6. Pre-employment and periodic physical examinations should be made of all exposed workers. These should include the taking of a full clinical history, with special emphasis on gastro-intestinal disturbances and dermatitis. In addition, the skin should be carefully examined periodically and the more reliable liver function tests performed. Gastro-intestinal complaints developing in a worker at any time should be a signal for an immediate medical check-up. A history of liver disease, jaundice, or antisyphilitic treatment should automatically exclude a worker from jobs involving a possible toxic exposure. Pregnant women should not be employed where there is a possible exposure to the synthetic chlorinated waxes.

7. Engineering control of plant operations cannot be overemphasized but specific recommendations are not applicable to all cases. It would be wise for a plant using this class of materials to check their control measures with the state industrial hygiene agency, the insurance carrier and some competent consultant before occupational disease occurs.

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Abstract of Discussion

Manfred Bowditch (Boston): A few issues ago an article appeared in the *Journal of the American Medical Association* dealing with that subject of cable wire treating. One of the two authors is here; he might say a word or two on that subject.

Dr. Irving R. Tabershaw (Boston): These were experiments to remove wax from the skin, and, as you know, it is practically impossible to get off. Dr. Greenburg mentioned scrubbing, but that doesn't do it. As a matter of fact, workers themselves have attempted everything, even washing their faces with ether and using the harshest abrasive soaps.

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We evolved a mixture which effectively removes the halowax from the skin, consisting of equal parts of butyl stearate and sulfonated castor oil. A little cornmeal is added as a mild abrasive and oleic acid is used to hold it in suspension. It is very effective in removing halowax.

We have not used it as a curative measure, although it can be used that way. However, if a case of halowax has once developed and is removed from exposure entirely, it takes three months or longer to clear up.

We have also found ultra-violet to be of some help. It is not completely efficacious in clearing the condition, but it does help, and, in my estimation, it helps as much as x-ray.

The crux of the situation is cleanliness, and, as DR. GREENBERG stressed, it is necessary to do it under supervision. Perhaps the use of this mixture might help in removing the halowax before the worker leaves.

DR. LLOYD M. FARMER (Seattle): I would like to ask DR. TABERSHAW to answer an observation we made in the state of Washington. We had 60-odd cases of cable dermatitis, and, interestingly enough, these cases were among men stripping cables in the shipyards. We saw not a single lesion of pore acne on the hands, and yet the hands were the most exposed part of the body.

We felt very definitely that the washing of the hands with plain soap and water was the reason we saw no lesions on the hand, because the men rubbed their ears and their faces, and the other parts of the body were exposed to the wax that adhered to and went through the clothing.

We saw lesions everywhere except on the hands. I would be interested in getting your reaction, Doctor, as to why that situation existed.

DR. TABERSHAW: Of course, it occurs chiefly where the sebaceous glands are present—ears, crevices along the eyes and face. As DR. GREENBERG pointed out, it develops along any abrasion or sebaceous gland. I can't explain it except they must have cleaned their hands very thoroughly.

DR. GREENBURG: I think you can wash this material off your hands. It is difficult to get any results once you develop pore acne. I believe these cable strippers did wash their hands thoroughly before they developed pore acne, and they prevented it from developing in the hair follicles in the hands, where it often occurs, in the sebaceous glands there. I think that is why you find pore acne on the body where it has penetrated through the clothing, around the neck and sometimes on the face. After it has developed, washing doesn't do very much good. Then you are up against a case where the skin is loaded down, and you have to get rid of it by some other more radical procedure.

Wartime Industrial Medical Services

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VICTORIA M. TRASKO, A.B., *Assistant Statistician*,
Bethesda, Maryland

THERE is little factual information regarding the status of industrial medical service since this country entered the war. Something is known concerning the medical organizations created to care for the needs of the very large new war plants, but little has been published concerning establishments with less than 5,000 employees which, after all, are carrying a large share of war production in this country. Comparisons of medical services found in plants of corresponding size but in different industries are still more rare.

The Division of Industrial Hygiene of the National Institute of Health is fortunate in having participated during 1942 in two surveys which threw some light upon the important problem of wartime industrial medical services. Nearly a thousand establishments located in 36 states and employing approximately 2.5 million workers were included in these surveys. More than four-fifths of the 962 establishments included in the present report were covered in a study which was primarily concerned with industrial nursing but necessarily included some data pertinent to this report; data from the remaining plants were secured from a study dealing more specifically with industrial medical services. Since definitions regarding medical personnel and facilities were the same for both studies it was possible for present purposes to combine the schedules for these items.

It should be kept clearly in mind that all establishments covered by the two surveys were chosen because they had some organized medical services already in existence in 1942. Obviously the majority of them had at least a full-time industrial nurse. At the time they were surveyed a large proportion of these establishments were engaged in or were in process of changing over to essential war activities. Approximately a third were located in the New England and the Middle Atlantic states, a half were in the Middle West, and the remainder were in the Pacific Coast states and in the South.

Within the limitations stated above these data should represent reasonably well conditions actually existing during the first year of the war. The topics chosen for discussion are of such nature that quantitative measures are readily available. No attempt has been made to evaluate the quality or the efficiency of the medical services being rendered in these plants. This paper aims merely to describe certain facts pertaining to the medical personnel, medical services, dispensary facilities, workmen's compensation and sick benefit plans, and the type of food service found in establishments according to certain size and industry groups. Comparisons by industry have greater significance when they are limited to establishments within the same broad size group.

Medical Personnel

THE medical service personnel of an establishment is considered to include all of those individuals employed or retained by the company officials to render medical care to the employees. Persons engaged in a specified activity for a regular work day, every day in the work week, are classed as full-time employees. Persons having regular hours of duty in the plant each week which are less than the entire period are classed as part-time employees. On-call physicians serve no regular hours at the plant but are called from a prepared list or panel whenever an emergency arises. All plants which had a full-time registered nurse, but no full-time or part-time physician, were considered to have a physician on call even if they did not so state on the schedule. No distinction has been made between part-time physicians who are at the plant for only one hour a week and those who spend several hours each day at the plant.

Of the 962 establishments included in Table 1, 39% had only an on-call physician, 43% had a part-time physician, and 18% had one or more full-time physicians. In Table 2 which considers each of these three groups separately, it is found that 12% of the plants with an on-call physician had no full-time registered nurse but depended on a practical nurse, first-aid worker, or part-time registered nurse for duty in the dispensary. Seventy per cent of these plants had a full-time registered nurse without other assistance, and 18% of the plants had a full-time registered nurse plus other assistance usually on the night shift when the regular nurse was not on duty.

Of the 414 establishments with a part-time physician, 6% had other attendants but no full-time regis-

From the Division of Industrial Hygiene, National Institute of Health, United States Public Health Service.

NPC00007838

770477

Scientific Claim

ED 24

Consideration of Bio and Non-Biodegradeable PCB's

On 10-14-71 I wrote a memo of the same subject. This memo will supersede that memo. Monsanto refuses to state that Aroclor 1016 is biodegradeable and request that we state only that the tetra-, penta-, and hexachloro content has been reduced. Our best information (confirmed by Papageorge in October 1971) of the content in Aroclor 1016 and 1242, is as follows:

	1016	1242
Biphenyl	0. %	.05%
Mono-Chloro Biphenyl	1. %+	1. %+
Di-Chloro Biphenyl	19. %+	19. %+
Tri-Chloro Biphenyl	70.85%	53.95%
Tetra-Chloro Biphenyl	9. %	18. %
Higher Chloro Biphenyl	0.15%	8. %

Discussion with Tom Munson brought out the fact that on all sample analysis that he does he determines the % of the various di-, tri-, tetra-, etc. It is my impression that the tri-chloro (and down) tend to rapidly disappear from the tissue of fish.

It would, therefore, appear that 1016 is a real improvement over 1242; however, 1016 does still contain various amounts of suspect compound. Munson is of the opinion that the people in the government laboratory concerned with PCB's are well aware of the improvement of 1016 over the other PCB's. The time does not yet appear right to try publicly to make a distinction between 1016 and other PCB's. If the subject of control of PCB's is put into the hands of a commission where it can be discussed on a scientific basis, there is a good possibility that 1016 could be separated out from other PCB's.

NPC00007839 JBB, 10-28-71

770478

Bloomington Works
522-4250
December 22, 1971
PCB

RECEIVED
DEC 22 1971
DEPT. MGRS. Works

R&D CENTER, BUILDING 601
Room 1856

Mr. Ed Boquist

cc: Mr. D. Sauter, General Manager, Bloomington Works
Mr. R. McClain, Capacitor Unit Engineering Manager, Bloomington Works

Attached is the information that you requested with regard to the use and importance of PCB's in power capacitors.

Mr. McClain and I will be in the plant on December 29. It is my understanding that you plan to be in your office on that day. If there are any questions with regard to this letter, please call us on December 29.

Attached also is some information you requested from Don McClain with regard to handling the PCB's in the plant and estimated usage.

John B. Brittain, Manager
Distribution Apparatus Engineering

JBB:kb

Attachs.

NPC00007840

770479

Bloomington Works
522-4250
December 22, 1971
PCB

RECEIVED

DEC 22 1971

DEPT. MGRS.

R&D CENTER, BUILDING 601
Room 7B56

Mr. Ed Boquist

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Mr. R. McClain, Capacitor Unit Engineering Manager, Bloomington Works

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John B. Brittain, Manager
Distribution Apparatus Engineering

JBB:kb

Attachs.

NPC00007841

770480

PCB - POWER CAPACITORS
DISTRIBUTION APPARATUS DIVISION

Basic DAD Position:

Continued use of PCB in capacitors with proper controls.

Purpose of Paper:

Establish the need for capacitors with PCB.

Functions of Capacitors:

Shunt - improve power system operating efficiency and reduce capital investment.

Series - allow transfer of larger amounts of electrical current over long transmission lines.

Benefits of Capacitors:

Shunt - reduced current flow through distribution and transmission lines and through transformers, breakers and generators.

1. Improved control (regulation) of voltage with varying load.
2. Economy of system installed cost: reduced conductor size/cost.
3. Economical use of generator capacity: reduced demand for leading current from generator.

Series - series capacitors are a special application making possible the operation of large, high voltage a.c. transmission system interconnections. Western electrical power systems: (Arizona - California - Oregon - Washington - Idaho - Wyoming) involve major metropolitan areas dependent upon operation of existing and planned series capacitor facilities.

Substitutes for Power Capacitors:

Other sources of leading current are several times more costly to purchase, install, operate and maintain than are present day capacitors.

1. Supply leading current requirements from the generators.
   This is probably the most expensive alternative (first cost and operation) and is not feasible except for systems embracing small geographical area and for systems that are very lightly loaded. (50 years ago, this practice was fairly common; today, it is rare.)
2. Supply leading current requirements from a synchronous condenser.
   (Such a device can be made to supply "leading" or "lagging" current in stepless quantities as desired.
   First cost and operation of a synchronous condenser compares with the cost of adding var capability to the generator. It reduces system losses (I^2R) somewhat by being located closer to the inductive load, but does not allow placing small increments near each individual load - a more nearly ideal condition better served by capacitors.
3. Synchronous motors can be made to deliver leading current.
   Expense is greater than for induction motors, and the constant drive speed is not always suitable for the load.
4. Cables produce leading current.
   Installed costs are high and leading current generated is constant for a system voltage, necessitating installation of switched inductive reactors. Cables are difficult to keep cool and thermal loading near the point of connection to an inductive load often necessitates installation of capacitors.
   (Changing to any of the above schemes at the removal of capacitors from service can only be accomplished over a very long time and at great expense.)

Substitute for PCB:

The most practical substitute for PCB presently known is mineral oil. Use of mineral oil impregnated kraft paper capacitors was pioneered by Westinghouse from 1924 - 1932.

Introduction of PCB's as impregnant resulted in drastic reduction in fire and explosion hazards and greatly increased safety to operating and maintenance personnel as well as the public. Size and cost were reduced commensurately. Further advancement resulted from the introduction of polypropylene film-paper-PCB capacitors in 1967.

Reverting to an oil-paper dielectric system would increase volume required by approximately 600% and cost by approximately 400%. At the present levels of demand for capacitor kvac, there would be a shortage of electrical grade papers and a shortage of capacitor factory facilities further tending to increase the cost to the utility, and ultimately to the consumer.

Use of oil impregnated paper for capacitors has been largely abandoned throughout the world, in favor of one or the other of the PCB systems. The only significant manufacturer in the world is Japan. Even during the recent most unfavorable balance of trade with Japan, this product was never considered for export to the U.S. because of its cost and because of the flammable rating of the impregnant.

PCB Control:

The most complete information embracing the entire situation of PCB control is available through Monsanto, 800 N. Lindbergh Blvd., St. Louis, Missouri, Mr. W. B. Papageorge. Monsanto, sole U.S. supplier, has already taken the following responsive actions:

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a. Stopped sales to "open" users (paint formulators, plasticizers, hydraulic fluid manufacturers, etc.).

b. Stopped sales for use in heat exchangers - particularly food processors.

c. Alerted all recipient manufacturers to excercise care in use of fluids.

d. Provided for waste fluids incineration.

e. Modified capacitor fluids, eliminating the more highly chlorinated and environmentally more objectionable fractions.

All of these actions have greatly reduced any environmental hazards that might emanate from the use of capacitors.

Greatest consideration for any potential environmental hazard that might arise from PCB's must be directed to the quantities of fluid already released to users. Total production figures are available from Monsanto.

— Relatively little may be accomplished in terms of quantities in "open" usage representing a substantial fraction of the total.

— PCB's considered to be in "closed" systems at the time of manufacture are <u>still</u> largely contained. These may be subdivided:

1. Non-electrical (heat exchangers)
2. Electrical:
   a. Transformers
   b. Capacitors
      1) small capacitors
      2) large capacitors

<u>Suggestions</u>:

Establishing a plan to control use and ultimate disposal of PCB appears most desirable. ANSI C-107 committee on the use and disposal of PCB's in electrical equipment has addressed itself to this problem.

With the development of such a program, the total PCB situation as it bears on the manufacture, use and disposal of power capacitors shall have reached a point where regulated usage can represent no more threat to the environment than that for numerous other necessary and beneficent materials likewise requiring precautions in use, distribution and disposal.

SUPPLEMENT:

WESTINGHOUSE DAD CAPACITOR ACTIVITY (PCB)

1. Exhibits A, B and C tabulate capacitor unit activity for several different years. At the present time the power capacitor codes account for [redacted] of DAD volume of business.

2. Control of PCB, in plant, in two parts:

   A. Employee safety. See SPDS #I-1, Exhibit D.

   B. Control over loss of fluid to environment:

      See Exhibit E, "PS #597076, Disposition of Scrap Inerteen and Inerteen Contaminated Materials".

      See Exhibit F, "PS #597077, Disposal of Solid Wastes Contaminated with Inerteen When Handled by an Authorized Scrap Dealer".

      Appropriation #68-1419 has been granted to further implement environmental control of Inerteen (PCB).

3. Notice of potential hazard to users:

   A. Letter, Exhibit G, "Inerteen and Environmental Contamination", was distributed by DAD Marketing to holders of Westinghouse capacitor catalogs in mid 1970.

   B. Each power capacitor unit had a caution label affixed after November 1970. (Exhibits H, I)

   C. Capacitor production involved Aroclor 1254 from 1934 to about 1951; Aroclor 1242 from 1951 to 1971; Aroclor 1016 is being phased into production and will be in total use in the first quarter 1972. (Exhibits J and K)

4. Aroclor (PCB) usage built from zero in 1933 to a maximum exceeding [redacted] lbs in 1968. Present usage rate approximately [redacted] lbs per year.

WESTINGHOUSE HIGH VOLTAGE SERIES CAPACITOR INSTALLATIONS

YEAR	PURCHASER	SYSTEM VOLTAGE (KV)	APPROXIMATE BANK SIZE (KVAR)
1957	Duquesne Light Co.	66	10,000
1958	Bonneville Power Administration	230	24,000
"	"	"	46,000
"	"	"	82,500
1961	Tennessee Valley Authority	46	18,000
"	Arizona Public Service Co.	69	9,600
1963	Pacific Power &	230	115,200
1964	Arizona Public Service Co.	345	147,000
"	"	"	147,000
1965	Southern California Edison Co.	287	6,000
1966	Idaho Power Co.	230	79,200
"	"	"	79,200
1966/67	Bonneville Power Administration	500	201,600
"	"	"	201,600
"	"	"	201,600
"	"	"	201,600
"	"	"	201,600
"	"	"	100,800
"	"	"	100,800
"	Pacific Gas & Electric Co.	"	259,200
"	"	"	259,200
"	"	"	191,400
"	"	"	191,400
"	"	"	129,600
"	"	"	129,600
1967	Portland General Electric Co.	"	201,600
"	"	"	201,600
"	"	"	201,600
"	Pacific Power & Light Co.	"	165,600
"	Bonneville Power Administration/Bureau of Rec.	"	158,200

add - APS
LIPOR
Southern California Edison

NPC00007848

Private (for future ability)
LADWP
MWD ASO
(understanding negotiations)
Southern Calif. Ed., Pacific Gas Elec., JIM BRIDGER

EXHIBIT "C"

INERTEEN

(Capacitor M-54201CF thru CH and Transformer PDS 54201CM)

GENERAL

Capacitor Inerteen, PDS 54201CF thru CH, is trichlorodiphenyl. Prior to January 1, 1965, transformer Inerteen PDS 7336-9 (54201CC) was a mixture of 60 percent hexachlorodiphenyl and 40 percent trichlorobenzene. From January 1, 1965 to January 1, 1968, transformer Inerteen PDS 54201KA consisted of a mixture of 70 percent pentachlorodiphenyl and 30 percent trichlorobenzene. On January 1, 1968, transformer Inerteen was changed to PDS 54201CM; it now consists of trichlorodiphenyl to which 0.2 percent glycidyl phenyl ether is added as a scavenger.

CONTAINERS AND STORAGE

Inerteen may be received in tank cars, drums, or cans. Containers, when received, should bear the Name, Westinghouse Material Number, and a brief statement of precautions to be followed during usage. In the Receiving Department, attach yellow Ⓦ Precautionary Label 35817 to all containers of Inerteen. This label is available from the Ⓦ Trafford Printing Division. Place this label on containers where it is always visible to the user. For drums, the label should be placed on the dispensing end and in such a position that it can be easily read by the person removing the Inerteen from the drum. Storage tanks and other containers of Inerteen for use in the shop should also bear the Name, Ⓦ Material Number, and Ⓦ Precautionary Label 35817.

Store Inerteen in an approved storage space, preferably indoors, which is cool, dry, and well ventilated. Precautions should be taken to prevent moisture from entering drums; therefore, as soon as drums of Inerteen are received, the bung should be examined and tightened if it is loose. To dispense Inerteen from drums, use molassas gate valve, Ⓦ M-72085GP. Bulk quantities of Inerteen are transfered from storage tanks by using equipment designed for that purpose.

PROPERTIES

FIRE -- Non-flammable.

EXPLOSION -- Non-explosive.

DECOMPOSITION -- When Inerteen or its vapors contacts flames, welding arcs, or extremely hot metal surfaces, it will decompose to form highly irritating hydrogen chloride gas, highly toxic carbon monoxide, and also some carbon dioxide.

BREATHING -- Inerteen vapor is moderately toxic, however, the possibility

EXHIBIT "D"

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INERTEEN (Continued)

of an existing health hazard at normal room temperature is not likely since the evaporation rate is very low. The health hazard increases if the material is heated, sprayed, or in any way atomized into the breathing zone of any person. The odor of Inerteen can be noticed at concentrations below the Maximum Acceptable Vapor Concentration. For the Maximum Acceptable Concentrations of vapor from capacitor or transformer Inerteen, refer to SPDS M-20. Concentrations of Inerteen vapor which exceed the Maximum Acceptable Concentrations may cause irritation of the eyes, nose, throat, and upper respiratory tract. Much higher concentrations could cause detrimental internal reactions after prolonged exposures.

SWALLOWING -- Inerteen is moderately toxic if taken internally. Swallowing of several ounces could cause irritation of the digestive tract and internal reactions.

SKIN IRRITATION -- Although the Inerteens are only moderate skin irritants when contact is for a short duration, there is a possibility that it can be slowly absorbed through the skin. Repeated contact over prolonged periods may result in a severe dermatitis which may persist for many months after removal from exposure. Inerteen and its vapors are also irritating to the eyes.

WASTE DISPOSAL

At the present time, scrap material as liquid Inerteen or oil contaminated Inerteen shall be placed in properly sealed drums and returned to the supplier for reclaimation.

Waste Inerteen fluids (Inerteen, oil contaminated with Inerteen, or solvent contaminated with Inerteen) can be destroyed by burning if a suitable 2000°F or higher temperature incinerator equipped with an acid gas scrubber to remove hydrogen chloride gas is available. The supplier is usually equipped with such an incinerator.

Pressboard, paper, sweeping compounds, and other Inerteen soaked material should also be destroyed by suitable incineration or collected and returned to the Inerteen supplier only with their approval.

Copper coils, core iron, and tanks should be sent to scrap dealers for remelting in appropriately equipped furnaces.

If incineration is not possible or the Inerteen supplier will not accept the scrap material, a State Approved Waste Disposal Area may be used.

Inerteen must be prevented from seeping into water supplies or streams even though its water solubility is low. Under no conditions should waste Inerteen be poured into sewer systems or streams.

PERSONAL PROTECTIVE EQUIPMENT

WHEN IT IS NECESSARY, UNDER EMERGENCY CONDITIONS, TO ENTER A SPACE CONTAINING A HIGH CONCENTRATION OF INERTEEN VAPOR, A HOSE MASK WITH BLOWER, ® M-76524AL, or BREATHING EQUIPMENT WITH A SELF-CONTAINED AIR SUPPLY, ® M-76524CJ, CL, SHOULD BE USED. GAS MASK, ® M-76524AP, AIR-LINE RESPIRATOR.

INERTEEN (Continued)

Ⓦ M-76524BF,BG, or HOSE MASK WITHOUT BLOWER, Ⓦ M-76524AM, MAY BE USED if there is no danger of oxygen deficiency, that is, where the breathing atmosphere contains at least 19% oxygen and not more than .1% Inerteen vapor. Air-line respirators should be provided with at least 4 cubic feet per minute of uncontaminated fresh air. To provide this minimum air requirement, follow the manufacturer's recommendation for air pressure, air flow controls, and length of hose to be used. When using a hose mask, place the hose opening in an area where air is not contaminated. When the odor of Inerteen is detected while wearing respiratory equipment, the wearer should immediately go into fresh air.

When there is a possibility of the atmosphere in the work area containing a concentration of Inerteen vapor not in great excess of the Maximum Acceptable Concentration (MAC), the Standard Chemical Cartridge Respirators, Ⓦ M-76524BL, equipped with cartridge, Ⓦ M-76524BM, or respirator, Ⓦ M-76524BQ, equipped with cartridge, Ⓦ M-76524BR, if properly fitted to the face, will provide satisfactory protection for concentrations up to about 10 times the Maximum Acceptable Concentration. For higher concentrations, emergency respiratory protection equipment shall be used. Respirator cartridges should be replaced according to a pre-determined schedule or at any time the odor of Inerteen becomes noticeable under the respirator.

All gas masks, respirators, and replacement parts should have the Bureau of Mines approval, which is indicated by a label on larger parts or BM#_____ (approval number) on smaller parts.

Refer to Safe Practice Procedure Sheet #12 for information concerning the use and care of respiratory protective equipment.

Neoprene coated aprons, Ⓦ M-76503AD; and neoprene coated gloves, Ⓦ M-76502CD, may be used where necessary to protect the skin. Hand cream, Ⓦ M-53535LM, may be of some value where the use of gloves is not practical. Waterless hand cream, Ⓦ M-53512KH, is very useful for removing Inerteen from the skin. To protect the eyes, wear safety spectacle, Ⓦ M-76522EA-EC, or goggles, Ⓦ M-76522CJ, depending on the type of protection needed.

PRECAUTIONS

Breathing vapor or fume from heated Inerteen should be avoided. A person should never enter an area containing a high concentration of Inerteen vapor, fume, or decomposition products without adequate protection. The Maximum Acceptable Concentration should not be exceeded under normal working conditions. This can be accomplished by completely enclosing the system or by providing exhaust ventilation sufficient to effectively control atmospheric contamination at its source with a minimum of exhaust air. Where this is not practical, adequate respiratory equipment should be used.

If skin contact occurs, remove the Inerteen by thoroughly cleaning the skin area with waterless hand cream, Ⓦ M-53512 KH, followed by a thorough washing with

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INERTEEN (Continued)

soap and warm water. Prolonged or repeated skin contact should be avoided. Contaminated clothing should be laundered before wearing again.

Personal cleanliness and the preventiln of skin contact are the most important precautions to be observed.

Any person who develops a skin irritation or respiratory tract irritation apparently due to Inerteen or its vapors should be placed under the supervision of the plant Medical Department.

Proper preplacement and periodic physical examinations should be made by the Medical Department on workers when the odor of Inerteen is repeatedly or continuously noticeable in the work area.

Spills of Inerteen should be removed immediately. Absorb liquid Inerteen with absorbent compound, ® M-5340lEA-EB, and dispose of per instructions under WASTE DISPOSAL, page 2. Employes performing this work should wear adequate protective equipment.

FIRST AID

Any person who has had an appreciable exposure to Inerteen, either by breathing an excessive concentration of vapor, fume, or decomposition products, or by swallowing, or where the material has been spilled over large areas of the body, should be placed under the supervision of the plant physician. In cases of swallowing, vomiting should be induced immediately by carefully inserting a finger in the person's throat.

If overcome from breathing high concentrations of Inerteen vapor, the person should be quickly removed from the vapor exposure to the nearest area of uncontaminated air and artificial respiration started at once if breathing stops. A physician should be called immediately. Do not give stimulants. If Inerteen should contact the eyes, they should be irrigated immediately only with large quantities of running water from an approved eye wash fountain for fifteen minutes and then the person should report to the Medical Department for observation and treatment, if necessary.

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INERTEEN (Continued)

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Spills of Inerteen should be removed immediately. Absorb liquid Inerteen with absorbent compound, ® M-53401EA-EB, and dispose of per instructions under WASTE DISPOSAL, page 2. Employes performing this work should wear adequate protective equipment.

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770492

From : Ⓦ Bldg. - 1535
WN : 235-3320
Date : April 1, 1976
Subject: REF: 2610-64

In : BLOOMINGTON
J. M. Shannon
cc: Ⓦ Bldg. - J. B. Wright
cc: Ⓦ Bldg. - J. P. Daley
cc: Ⓦ Bldg. - E. L. Schwartz
cc: Ⓦ Bldg. - D. K. Boyd
cc: Ⓦ Bldg. - S. M. Moore
cc: Ⓦ Bldg. - B. A. Kerns
cc: Ⓦ Bldg. - R. E. Wills

cc: Bloomington - D. M. Sauter
cc: Bloomington - R. B. Sawyer
cc: Bloomington - J. B. Brittain

This is to confirm some of the plans we discussed for the PCB seminar April 13, in Bloomington.

A rough draft copy of the basic invitation has been prepared and should be mailed no later than Monday, April 5. The letter to the press, radio and TV stations should emphasize the time (9 AM) of the event with attached directions leading to the plant. Of course, the invitation to the officials is much the same with the time changed to 2 PM. Furthermore, the invitation to the general managers of the Indianapolis TV channels should explain the briefing as an educational seminar that will be of news value for future investigative reporting on the subject. Therefore, we should suggest that the TV stations send a reporter only.

The news media invited to the 9 AM briefing is as follows:

- Herald-Telephone
- Daily Student
- Louisville Journal
- Indianapolis Star
- WTTS
- WTIU (Bloomington)
- Channel 4 (out of Bloomington)
- Channels 6, 8 and 13 (out of Indianapolis)

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FORM 3504 x

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For the 2 PM session:

- Representatives Pizzo and Schultz
- Senator Carroll
- Mayor McCloskey (?)
- Environmental Commissioner (Walter Bron)
- County Health Department (Ray Borland)
- State Health Department (?)
- Electric Utility (Rick Peoples)
- Representatives from Environmental Quality Control (President, Tom Moses)
- Don Neukranz of Westinghouse

The conference room, with display, at the Bloomington Plant is sufficient for the conference. The program for the day, subject to change, might run something like this:

9:00 A.M. - Arrival of press (coffee and sweet rolls)

9:30 A.M. - Sauter chair and introduce subject event (10 minutes)

9:40 A.M. - Brittain presentation defining PCB, its use in capacitors and results of tests on alternate material (10 minutes)

9:50 A.M. - Wills covers legal aspects (10 minutes)

10:00 A.M. - Sawyer explains what Westinghouse accomplished to abate PCB in the environment (10 minutes)

10:10 A.M. - Kearns details environmental consequences, other sources of PCB, etc. (10 minutes)

10:20 A.M. - Tour of plant (20 minutes?)

10:50 A.M. - Reassemble for Q & A

11:30 (depends on discussion) - Lunch (Table set up in room adjoining cafeteria)

For the officials, the event begins at 2 P.M. following the same suggested program outlined above and ends about 4:30 or 5 P.M.

Most important, I must have all the approved-for-publication presentations and illustrations by Tuesday, April 6, for massaging and for the press kit we will assemble here. Also, it might be wise to consider a rehearsal on April 12.

Jim, since you will be in a better position to know who will attend, I suggest you have easy-to-read name tags made up.

I'm sure I neglected to mention some things, but there will be additional planning.

Regards.

Vince Rinaldi

ccr

NPC00007856

770495

Westinghouse Electric Corporation

Box 341, Bloomington, Ind. 47401

January 14, 1972

Dr. A. Pozefsky, Chairman
C-107 Capacitor Working Group
General Electric Company
Engineering Department
Hudson Falls, New York 12839

Dear Dr. Pozefsky:

Attached is a copy of my first draft of the "Capacitor Plant Housekeeping and Employee Safety" portion of the proposed ANSI C-107 standard on the use and disposal of PCB's.

In order to expedite consideration of the various parts of the proposed standard at the next meeting of the working group at the Mariott Hotel in Chicago on February 8 and 9, I am also sending a copy to each of the attached list of addressees.

Very truly yours,

Robert D. McClain, Manager
Capacitor Unit Engineering

RDMcC:kb

Attachs.

NPC00007857

770496

N. R. Clark
Universal Manufacturing Company
902 Crescent Avenue
Bridgeport, Connecticut 06607

J. F. Kuzela
Engineering Manager
Power Capacitors
Sangamo Electric Company
P. O. Box 359
Springfield, Illinois 62705

Dr. E. M. Moore
2427 St. Vincent Avenue
LaSalle, Illinois 61301

W. P. Papageorge, Manager
Environmental Control
Monsanto Company
800 North Lindberg Blvd.
St. Louis, Missouri 63166

P. G. Benignus
Marketing Manager
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"ANSI C-107 1st Draft Proposal for February 8, 1972"

CAPACITOR PLANT HOUSEKEEPING AND EMPLOYEE SAFETY

The following procedures and limits are intended to be minimum requirements to be met by manufacturers of capacitors using polychlorinated biphenyl. Handling, control and disposal procedures are given, together with exposure limits and indicated antidotes and cleanup procedures.

1. Material. Chlorinated biphenyl for use in capacitors shall consist of chlorinated homologues and isomers of biphenyl not exceeding the tabulated values:

Pentachloro (and higher % chlorine)	.40%
Tetrachloro	15.00%
Trichloro (and lower % chlorine)	(Balance)

Solvents include benzene, kerosene, acetone, amyl alcohol, ether, and chloroform. Other typical properties are:

Flash point, Cleveland open cup: 177°C, minimum

Distillation Range: 10% below 323°C; 90% below 356°C

Specific Gravity: 1.362 to 1.372, at 25°C/15.5°C

Vapor Pressure

0°C	=	0.001 mm
25°C	=	0.006 mm (est.)
150°C	=	4.3 mm
200°C	=	29.0 mm

At 25°C and 760 mm Hg pressure, saturated air contains 0.____mg/liter.

(1 mg/liter = 98.8 ppm)
(1 ppm = 0.010 mg/liter)

2. Bulk fluid shipment, receiving, and transfer: Shipment of polychlorinated biphenyl from point of manufacture to point of receiving shall be done in closed containers: rail tank cars; truck tanks; marine or barge tanks; or sealed drums. Containers shall be labelled as to contents, and carry a precautionary label against loss of fluid to the open environment. Containers used for transport of poly-

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chlorinated biphenyl shall not be used for storage or transport of other material without being completely cleaned of all traces of PCB. (Cleaning procedures must take cognizance of precautions against excessive exposure and of the need for proper disposal of contaminated cleansing solvents and materials set forth below.) Transfer from shipping container to processing system shall be through closed piping or tubing with appropriate valves, pumps, etc. Provision shall be made for trapping and disposing of fluids lost by leakage or spills from the transfer system and from the storage containers.

Drums to be retired from use shall be cleaned before crushing, delivery to scrap dealers, or other diposal. Contaminated cleaning fluids and materials shall be disposed of as indicated below.

3. Handling during manufacturing operations: It is generally accepted that exposure to capacitor PCB is not hazardous, provided simple precautions are taken.

(a). Vapors. Maximum atmospheric concentration limit (8 hours) recommended: one milligram of capacitor PCB per cubic meter of air.

Breathing vapor or fume from heated PCB should be avoided. Provision of adequate ventilation and regulation of manufacturing operations to avoid open exposure of hot PCB (75°C, or higher) shall be made. The gases produced when askarel is decomposed by very high temperatures (such as that of an electric arc) in the presence of air or organic insulating materials contains a high percentage of hydrogen chloride, and small percentages of carbon dioxide, carbon monoxide, and oxygen. Minute concentrations of this combination of gases are very unpleasant and irritating, thus giving ample warning of their presence. When necessary, under emergency conditions, to enter a space containing a high concentration of PCB vapor or decomposition products, a hose mask with blower, or breathing equipment with a self-contained air supply should be used. [(Gas mask, air line

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respirator, or hose mask without blower may be used if there is no danger of oxygen deficiency (considered to be a breathing atmosphere of at least 19% oxygen and not more than 2% PCB)]. If the odor of PCB is detected by the person wearing protective equipment, he should immediately go into fresh air. All gas masks, respirators and replacement parts shall have Bureau of Mines approval, and be maintained on a regular schedule in accordance with the manufacturers recommendation.

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

Operating procedures should avoid contact with hot fluids (about 55°C). Use of eye protection is recommended. The use of gloves is not recommended. Contaminated clothing must be changed and laundered. Use of enclosed transfer and handling equipment, processing equipment and the use of mechanical washers reduces direct contact.

Medicinal washes or detergents followed by an application of cold cream will eliminate any irritation resulting from askarel coming into contact with an open cut or abrasion. Eye exposure to liquid PCB should be irrigated immediately with large quantities of running water from an approved eye wash source for fifteen minutes and then be examined by a physician. Persons developing a skin irritation or respiratory tract irritation apparently due to contact with PCB should be placed under the supervision of a physician. (A drop of castor oil has been found to neutralize any irritation caused by contact of PCB with the eyes.)

Ingestion or swallowing of PCB's is not generally regarded as a problem of the industry. PCB's are regarded as being moderately toxic if taken internally. Swallowing several ounces could cause irritation of the digestive tract and internal reactions, and should be referred to a physician.

4. Manufacturing control of losses: Manufacturing equipment and operating procedures must safeguard against excessive loss of PCB to the environment through close control and disposal procedures.

Enclosed systems of sealed piping, properly gasketed joints, valves, containers, and processing chambers are to be used for any portion of the operation where PCB temperatures may exceed 55°C. Enclosure shall preferably extend to all other portions of the system insofar as practicable.

Drains shall be plugged and curbs installed around all "open" portions of the PCB processing area, to assure against inadvertent loss to sewer systems by spillage, leakage, or other uncontrolled loss.

Ventilation of the area and exhaust of pump and systems gases shall be directed through filter entrapment capable of restraining vapor losses to the atmosphere of___ mg/liter, peak and___ kg per day.

Spills of PCB shall be removed promptly by use of absorptive material, preferably sawdust, or trapped and removed by pumping, or by other suitable means.

Waste fluids containing PCB and not suitable for reconditioning or reuse shall be collected (by means of traps, drip pans, trays, etc.) from the various parts of the manufacturing and processing area (including washers or other cleaning devices).

Wiper rags, clothing and other extraneous materials saturated with PCB's shall be collected within the curbed area.

5. Disposal of PCB wastes: Methods for disposal of liquids and saturated solids generated by the manufacturing operation shall be in accordance with those outlined in subsequent portions of this standard, and shall include (but not be limited to) the following:

A) Liquid PCB contaminated by aliphatic materials and other substances such as to make it unsuitable for reclaiming as a dielectric fluid.

B) Liquid PCB from solvent operations or water/detergent type washers.
C) Saturated earth or other absorbent media from filtering operations.
D) Saturated sawdust or other absorptive material from spills.
E) Saturated filters from vapor control devices and other filters.
F) Saturated wastes (paper, rags, etc.)
G) Saturated, spent gasket materials.
H) PCB contaminated vacuum pump oils.
I) PCB contaminated steam jet vacuum pump condensates.

6. Miscellaneous Procedures:

A) Spills by leakage from sealed, finished capacitors should be cleaned up promptly by use of absorbent sawdust, which should then be moved to containers for that purpose within the curbed or drained area, and later disposed of properly.

B) PCB wastes should never be disposed of, deliberately, down effluent drains or sewers. The utmost care must be excerised to prevent accidental loss by these means.

C) Capacitors failing test or otherwise designated for disposal must be controlled and handled in accordance with the intent of the procedures above, finally being disposed of by one of the means outlined below.

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tients. Thyroid function may be depressed in a higher percentage of cases if urethane therapy is maintained for a longer period. This possibility is currently being investigated.

SUMMARY

Twenty patients were treated with rectal suppositories of urethane. The therapeutic effectiveness of rectally administered urethane is equivalent to that of orally administered urethane. Urethane administered rectally is as effective as Fowler's solution in spacing irradiation therapy. Undesirable side-effects were minimal. It is concluded that rectal administration of urethane is preferable to oral or intravenous administration.

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CHLORACNE FROM AN UNUSUAL EXPOSURE TO AROCHLOR

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The first outbreak of acne-like lesions due to high boiling chlorinated compounds in industry in this country was noted by Schwartz [1] in 1936. Subsequently, during World War II, various reports of acne-like lesions in workers exposed to certain chlorinated naphthalenes and diphenyls followed. Collier [2] reported 12 cases of chloracne of the face in workers exposed to the fumes or dust of chlorinated naphthalene and one fatal case due to acute yellow atrophy of the liver. Fifty-five cases of acneform dermatitis were reported by Kelley [3] in 200 persons exposed to chlorinated naphthalene (Halowax). Good and Penaky [4] described 52 cases in electricians, who handled the cold-finished product for the most part. In none of their cases was systemic involvement found. Schwartz's report [5] concerned the involvement of electricians, who installed and stripped wires in ships during the war. The chlorinated naphthalene, which was impregnated into the asbestos and wrapped around the wire as insulation, flaked off in the stripping process. In the cases described, two months elapsed before the appearance of the chloracne of the face. There was no systemic involvement. Peck,[6] Cranch,[7] and Greenburg [8] discuss the chlorinated naphthalenes and chlorinated diphenyls, the appearance of the dermatological lesions, their value in industry, and precautions in handling these chemicals.

The value of the chlorinated naphthalenes and diphenyls in industry is due primarily to their resistance to water and alkali, high insulating value (high dielectric constant), thermoplasticity, chemical stability, and flame resistance, as described by various writers.[6]

The characteristic lesions of chloracne are pinhead to pea-sized pale straw-colored cysts formed by the plugging of the orifices of the sebaceous glands, resulting in retention of the secretion and in the keratinization of the lining membrane. Comedones are present but are not a striking feature. In nearly every worker exposed sufficiently to these chlorinated compounds for a few months these lesions will develop. The exposure may be either to fumes from the hot material or to the solid material on continued contact. Repeated or continuous contact is essential. Lesions have not been reported after short or infrequent exposures. Vesiculoerythematous eruptions, as seen in acute eczematous contact-type dermatitis and simple erythematous eruptions with pruritus, have also been described.[6a]

This paper reports the development of lesions of chloracne in seven workers employed in a chemical plant concerned with organic chemical production.

HISTORY OF EXPOSURE

A chemical company had for some months been using molten salt at 350 F as a medium for supplying accurately controlled quantities of heat to a large jacketed reaction chamber. Because of the dangers of solidification of the salt in the return line, as well as the corrosion problem, it was decided to use a chlorinated diphenyl (Arochlor) as the heat exchange material. The same apparatus was used. This included an oil-fired furnace containing the heating coils, a steel pipe supply line to the reaction chamber, a return line to a large sump pump, and an outflow line from the sump to the furnace (see figure). The reservoir for the sump pump had a capacity of about 400 gal. (about 1,680 liters).

The chemical product, designated as organic acid A, was manufactured with the use of molten salt for heat exchange from January to December, 1949. At that time, chlorinated diphenyl was substituted as a heat exchange material. It was soon apparent that under certain conditions there was slight leakage of vapors from a number of places, particularly around the cover of the sump, and also from all gasketed connections in the system. Because of the known toxicity of these substances, the assistance

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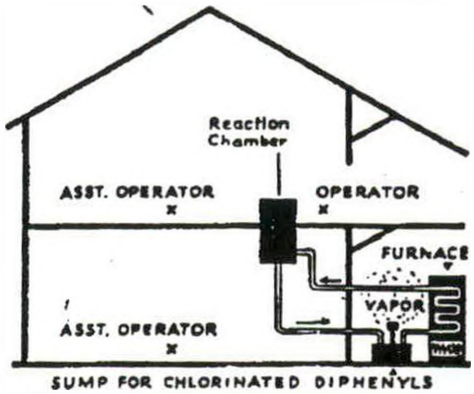
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of the Bureau of Industrial Hygiene, Connecticut State Department of Health, was sought and received. A field study under conditions of obvious vapor leakage was said to have shown negligible air concentrations of the chlorinated diphenyls in the actual breathing zones of the workers. In this study, which was four months prior to the dermatological findings reported here, the air concentration of chlorinated diphenyls was reported by the bureau to be 0.1 mg. per cubic meter of air. The recommended maximum allowable concentration is 1.0 mg. per cubic meter. The figure shows that most of the leakage was at points outside the building but under a roof. No one worked regularly at the points of leakage. Nevertheless, repeated attempts were made to control vapor leakage, without complete success. This operation continued for 19 months without incident or recognition of skin or other manifestations of exposure to chlorinated diphenyls. Each employee had a complete physical examination by an internist prior to working in this environment.



Schematic drawing of the heat exchange system in which the chlorinated diphenyl was used and the points at which workers were exposed to fumes.

An operator making organic acid A ("operator," figure) was sent to one of us because of acute contact dermatitis of the face. In addition to the contact-type of dermatitis, there were noted pinhead-sized straw-colored cysts and comedones on both cheeks and the forehead. A diagnosis of chloracne was made, and the source of exposure was determined. Examination of other workers in this working environment uncovered six additional cases. In all the face was involved especially the cheeks circumorbitally, the forehead, ears, and in one case the mastoid region. All employees were examined carefully by an internist. The seven employees in whom chloracne had developed had liver function tests performed. Tests included direct and total bilirubin determinations and 24 and 48 hour cephalin flocculation, thymol turbidity, and alkaline phosphatase determinations. Six of the subjects had completely normal test results. One employee had borderline cephalin flocculation and thymol turbidity. Thirteen months later repeated liver function tests showed an unchanged cephalin flocculation and improved thymol turbidity. Results of complete blood cell counts and urinalysis were normal in all instances. All had normal blood pressures with no other clinical evidence of any chlorinated diphenyl toxicity.

After the recognition of these cases of chloracne, all but one of the gasketed joints in the heat exchange system, including the cover of the sump, were welded together. A hand hole 6 in. (15 cm.) in diameter was left with a gasketed cover so that the system could be drained or filled when necessary. After that time no vapors were visible, and the odor of chlorinated diphenyls was barely detectable in the immediate vicinity of the sump pump. Continued careful observation of workers has revealed no new cases of chloracne.

COMMENT

The unusual feature of this outbreak of dermatitis was the long period of exposure before any cases were recognized. The sudden recognition of seven cases after exposure up to 19 months was due to the especially careful examination of the skin of all exposed employees after discovery of the first case. Of 14 men exposed or potentially exposed to the vapors of chlorinated diphenyls, 7 presented clinical evidence of chloracne. There was not a very good correlation between the apparent degree of exposure and the development of signs of disease. For example, a foreman, an assistant foreman, and a plant superintendent whose duties would appear to have exposed them only incidentally to the toxic agent had mild to moderate signs. The mean length of exposure of those in whom signs developed was 14.3 months and of those who did not show signs was 11.4 months, but there was considerable overlap, with chloracne developing in one worker after only 5 months in contrast to another who showed no signs even after 19 months' exposure to vapors. Since the manifestations were exclusively on exposed areas of the skin, it appears that the vapors were deposited directly on exposed skin and did not go through the clothing. The nature of each factor determining the appearance or nonappearance of lesions is not clear. Skin pigmentation may be a factor. Three of the workers were Negroes, and none of them had chloracne. No correlation with perspiration could be made, but all cases were discovered toward the end of the summer.

Prevention consisted of controlling the leakage of vapors. The fact that tests of the air, even in the presence of vapors, showed only negligible amounts of chlorinated hydrocarbons indicates that this type of intermittent but fairly long continued "mild" exposure is not innocuous. The low concentration of the chlorinated diphenyl in the air might account for the fact that lesions developed in only 50% of those involved.

SUMMARY

Seven cases of mild to moderate chloracne of the face and head occurred among 14 chemical operators exposed from 5 to 19 months intermittently to small concentrations of the vapors of a chlorinated diphenyl (Arochlor). Leakage of these vapors from a heat exchange system occurred chiefly outdoors, but chloracne was observed among men working inside the adjacent building. In all cases the condition cleared up after treatment. Control of vapors by welding all joints in the heat exchange system prevented recurrences.

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S. R. Hedges). Britain also has a large population of deer, which could become infected although they have no important epidemiological significance in the European rabies problem[11]. There is therefore a large potential reservoir in Britain for rabies infection and, as has recently been emphasized[12], the introduction of rabies might well create an actual reservoir. The few positive isolations of rabies virus from European bats, and their numbers and habit, suggest that they should be regarded as a cause for vigilance rather than concern[13].

Vaccines not Good Enough

The preparation of rabies virus[14] and the improvement of the potency of vaccines[15] have been reviewed recently[16]. The results suggest that rabies vaccines for man may soon be safer and more effective than current vaccines. At present, however, the bulk of the rabies vaccines produced in the world for therapy in man are made with virus grown in mammalian brain tissue[11] and their use carries a high risk of serious neural damage to the recipient. These risks may prove to have been completely eliminated, when the results of adequate tests of the new preparations are known. Improvement of the vaccine, however, provides no grounds whatever for the relaxation of existing regulations or for complacency concerning potential sources of infection. It is to be hoped that the long contemplated extension of the regulations, to cover the importation of exotic pets, in particular Mustelidae (skunks, badgers, weasels, stoats and so on) and Viverridae (mongooses, civets and so on) may soon be implemented. Some special provisions might also be made for neotropical bats and primates.

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DDT and PCB in Marine Animals from Swedish Waters

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Analyses of pesticide residues in a wide range of marine organisms from the coastal waters of Sweden show that there is a marked contamination in the Baltic. There are signs of an increase in polychlorinated biphenyls (PCB) from north to south in this area. Exceptionally large amounts of residues were found in white tailed eagles from the archipelago of Stockholm.

CHLORINATED pesticides can spread in living matter, and they are now present all over the world. In 1966 (ref. 1), it was discovered that some previously unknown substances isolated in analyses of pesticide residues were polychlorinated biphenyls (PCB). In Sweden, they occur in the natural environment in the same amounts as the chlorinated pesticides[1-3]. Recently, PCB has been found in organisms in the Netherlands, Great Britain[2-4] and the United States[5]. PCB is used almost exclusively in industry, and it seems to be more persistent than DDT. We have assessed PCB and DDT (including metabolites) contamination in Swedish marine ecosystems by analysing 176 samples. The hydrographical conditions along the Swedish coasts are not uniform so the residues are classified according to the four regional subdivisions shown in Fig. 1. Few samples were taken from the Sound and so this area has been included in the Baltic proper.

The species studied were: (1) mussel (*Mytilus edulis*); (2) herring (*Clupea harengus*); (3) plaice (*Pleuronectes platessa*); (4) picked dogfish (*Squalus acanthias*); (5) cod (*Gadus morhua*); (6) salmon (*Salmo salar*); (7) grey seal (*Halichoerus grypus*); common seal (*Phoca vitulina*) and ringed seal (*Pusa hispida*); (8) guillemot (*Uria aalge*); (9) white tailed eagle (*Haliaeetus albicilla*); (10) eggs of white tailed eagle; (11) heron (*Ardea cinerea*). Three samples of separated fish oil were also analysed. Two were taken from the Norway pout (*Boreogadus saida*) and one from herrings from the northern part of the west coast. One sample (largely herring oil) was also extracted from fish from the southern Baltic proper. This was unseparated.

Homogenates of one or more mussels were analysed. In the fish, axial muscle tissue extracted from the dorsal side above the lateral line, approximately a third of the length from the tail was analysed. In nine out of eleven salmon, the samples had to be taken immediately behind the head (only heads were available). Most of the samples from the seals were taken from the blubber in the tail. In two seal pups from the Gulf of Finland, the samples were from the fore leg, and in one grey seal from the Baltic proper, the sample was liver. It is reported[6], however, that in seals the chlorinated hydrocarbon content in the fat is approximately constant throughout the different parts of the body. As a rule, the specimens, or parts of the specimens, were sent to the Swedish Museum of Natural History immediately after capture and were stored at −20° C. Three seal tails from the archipelago of Stockholm and one from the Gulf of Bothnia were, however, kept by the hunter for six months in a non-heated room. In the homogenized eggs of the guillemot the fat varied from 3·6 to 11 per cent probably because homogenization before aliquotation was not quite perfect. Samples were taken from both the pectoral muscle and brain of the white tailed eagle. All the eagles were found dead and in some cases in a state of decay, and all the eggs were either addled, rotten or dry. In the heron, pectoral muscle only was analysed.

DDE was the principal metabolite of DDT found.

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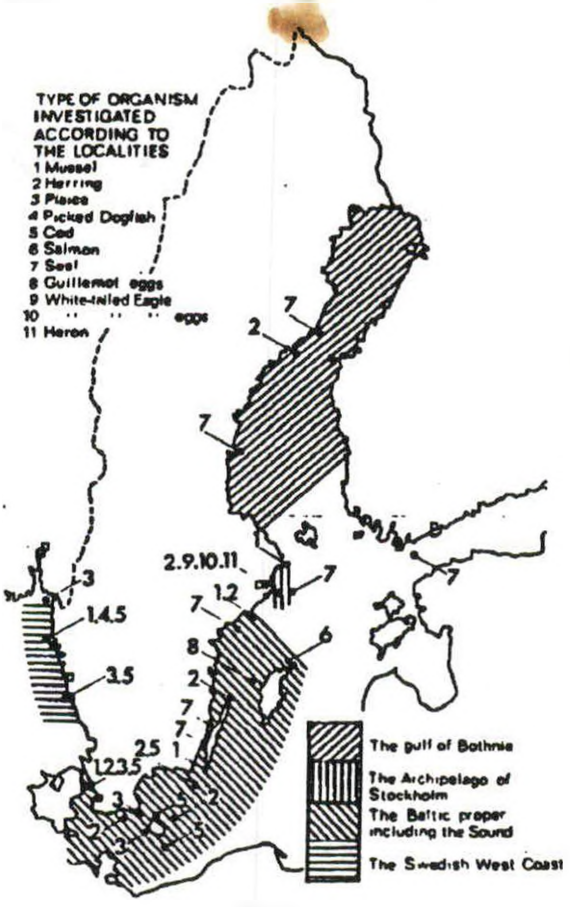


Fig. 1.

DDD was found in small concentrations, not usually more than 10 per cent of the ε DDT, in most samples. (ε DDT stands for the sum of DDT and DDE—DDE was multiplied by 1·11 to correspond to the original DDT.) For seals from the archipelago of Stockholm and for salmon from the Baltic proper which had relatively large amounts of DDD. ε DDT stands for the sum of DDT, DDE and DDD.

We analysed all the samples using gas chromatography and electron capture detection. Confirmations were carried out with double column systems combined with treatments with sulphuric acid and potassium hydroxide[7].

We found that the principal PCB components were PCB numbers 7–14 (low number is equal to a low chlorination degree), but the mussels also contained the lower numbers (the PCB composition being similar to clophen A 50). The PCB amounts given in Table 1 are, nevertheless, the sum of all PCB components found in the samples although the relative amounts of the different numbers vary. The results suggest that the low PCB numbers are metabolized or excreted faster than the higher numbers, so that there is an increase of the latter as it passes through a food chain.

An attempt to quantitate PCB has been made in Sweden[7], but because the method is still rather rough the values may be correct only within a factor of 2. The method is indirect because all the PCB components have not been isolated yet, and it is based on a combination of mass spectrometry, micro-colorimetric and electron capture detection. For each twenty samples a blank on the solvent and a residue-free plaice sample with added pesticides (lindane, aldrin, *pp*'DDE, dieldrin, *pp*'-DDD and *pp*'-DDT) were also analysed. Recovery was above 80 per cent, but as normal in residue analysis[7] we made no correction.

The mean figures in Table 1 are calculated from the average value of each locality within the four regions. The residue values are based both on fresh tissue and on hexane extractable fat. The figures for fresh tissue are comparable with reported values from other countries. We believe, however, that the fat values are of particular interest from an ecological point of view. Fat is important in the transport of energy and as a carrier of the residues between the species in the food chain. Furthermore, there is a great seasonal variation in fat content within the populations. The difference between the greatest and the smallest residue level in the extractable fat of individuals of one species at a given time, in a given place, is less than in fresh tissue. The fat content of herring muscle, for example, varied from about 1 per cent in the spring to about 10 per cent in the autumn. Our discussion will therefore be based largely on residue levels in extractable fat.

Mussels from the west coast of Sweden have lower average values of ε DDT and PCB than from the Baltic proper and the archipelago of Stockholm. The level of ε DDT in mussels from the Dutch, West German and British coasts[8,9] has an upper limit similar to that in mussels from the Baltic proper and the archipelago of Stockholm.

DDT contamination in individual plaice, cod and in fish oil is greater in the Baltic proper than off the west coast of Sweden, and there is little or no overlapping of the residue values. In the case of PCB, a plaice from the very polluted Idefjord in the west coast increases the average value for the west coast samples from 0·69 to 6 p.p.m. Other individual samples of fish from the west coast contain PCB residues of the same magnitude as residues in specimens from the Baltic. This may be the result of coastal contamination. The picked dogfish, which lives more in the open sea, seems to have the same amount of ε DDT, but a smaller amount of PCB than other fish from the west coast of Sweden.

The samples of herring from the Baltic proper, the archipelago of Stockholm and the Gulf of Bothnia had large residues of ε DDT. No herring from the west coast of Sweden has been studied. Recently we analysed eight herrings from the west coast. On fat basis the mean values were: ε DDT, 1·9; DDT, 0·86; and PCB, 0·75, in good agreement with the fish oil values (see Table 1). Juvenile herring from the Dutch Wadden Sea (coastal waters)[8,9] contained DDE residues in fresh tissue with an upper limit of the same magnitude as in herring from the Baltic area.

Residues of PCB and ε DDT in one sample of fish oil from the southern Baltic proper were about five to ten times greater than the three samples from the west coast of Sweden. The figures for the latter are similar. This is in accord with residues in fat in fish from the respective areas.

One herring from the Sound had a much larger content of PCB (23 p.p.m.) than the herring from the rest of the Baltic area. This increased the average value in this area from 4·6 to 6·8 p.p.m. Cod and plaice from the Sound also had a larger PCB content than specimens from the Baltic proper and off the west coast. This suggests that there is local contamination of PCB in the Sound. Furthermore, the mean levels of PCB noted in herring were smaller in the Gulf of Bothnia than in the rest of the Baltic.

The vagrant Baltic salmon had about ten times more chlorinated hydrocarbons residue than a sample reported from Great Britain[8].

The seals from the Baltic proper, the archipelago of Stockholm and the Gulf of Bothnia contained large amounts of residues of both ε DDT and PCB, about ten times greater than amounts found in Great Britain[8], Canada[9] and the Netherlands[10]. One specimen from

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the archipelago of Stockholm had 310 p.p.m. in fat, increasing the mean value for this part of the coast from 117 p.p.m. to 170 p.p.m. The levels of PCB decrease from south to north. This fact, together with lower average values of PCB in herring from the Gulf of Bothnia, indicates decreasing PCB contamination from south to north in the Baltic. Seal pups, one week old, also contained large amounts of ε DDT and PCB residues, and seal milk from the stomach of one of these pups had the same level.

Guillemot eggs from the Baltic proper provided additional information on the contamination of the Baltic. The means of ε DDT and PCB in eggs (wet weight) were 40 p.p.m. and 16 p.p.m. respectively, which for ε DDT is about ten times the levels reported from Great Britain[9,11–13]. The Baltic levels, both for ε DDT and PCB, are about four to five times greater than levels reported from the west coast of the United States[4], if the figures for residues in fat are compared. In guillemot eggs from the Baltic, as much as 87 per cent of ε DDT was DDE.

The population of white tailed eagles in Sweden seems to be on the decline. Only about two of ten pairs nesting in the archipelago of Stockholm succeeded in hatching during the past few years (E. Larsson, personal communication). All specimens of white tailed eagle studied up to the present contained at least three accumulating substances known to be toxic. These are DDT metabolites, PCB and mercury compounds[14]. Figures for four birds are reported in Table 1. A fifth specimen is not included because the fat content was not determined, but the pectoral muscle and brain tissue of this bird (wet weight) contained 190 and 39 p.p.m. respectively of DDT (as DDE), and 230 and 24 p.p.m. of PCB. Two specimens from northern Sweden, one of which died by accident, contained 2·6 p.p.m. (1·8–3·4) of DDT (as DDE) and 2·9 p.p.m. (1·6–3·9) of PCB in muscle tissue, the second having 1·8 p.p.m. DDT (as DDE) and 1·2 p.p.m. PCB in brain tissue. The figures from the archipelago of Stockholm are thus a hundred times larger, suggesting that there is a strong contamination in this area.

It is well known that residues of chlorinated hydrocarbons tend to be greater in the higher trophic levels than in the lower. Some simplified food chain relations can be deduced from the figures in Table 1. These are fish to seal, fish to guillemot, fish to heron and fish to white tailed eagle. In all cases, the increase in residues from prey to predator is at least ten-fold in both whole tissue and fat. In the eagle and heron, the increase is up to 100 times; but for both of these species some important food organisms are missing in this investigation. There are indications (Table 1) that the percentage of DDE and of ε DDT increases as it progresses from lower to higher trophic levels. This may be the result of decomposition of DDT within the organisms. In all the samples from birds, the residues are almost exclusively DDE, while in seals and fishes there is up to 50 per cent of DDT. This difference may be the result of differences in metabolism[15].

As previously mentioned, the seals from the archipelago

Table 1. CONCENTRATION OF ORGANOCHLORINE COMPOUNDS IN SWEDISH MARINE ORGANISMS 1965–68

	No. in sample	P.p.m. in fat			P.p.m. in fresh tissue			Per cent fat
		εDDT	DDT	PCB	εDDT	DDT	PCB	
Swedish West Coast								
Mussel	17	1	0·6	2	0·02	0·007	0·024	1·3
Oct. 1966		(0·4–5)	(0·3–1·3)	(0·6–7·0)	(0·006–0·04)	(0·002–0·03)	(0·011–0·23)	(0·04–2·6)
Dec. 1967								
Flatfish	3	1		5	0·006	0·004	0·021	0·5
Sept. 1966		(0·8–2)	n.s.	(0·4–14)	(0·003–0·009)	(trace—0·006)	(0·002–0·034)	(0·4–0·5)
Cod	4	1		7·2	0·005	0·003	0·019	0·30
Sept. 1967		(0·6–2)	n.s.	(1·6–18)	(0·001–0·008)	(n.d.—0·008)	(0·006–0·030)	(0·19–0·34)
Dogfish	7	1·6	0·81	1·5	0·15	0·091	0·15	9·6
Aug. 1966		(0·29–3·8)	(0·15–2·3)	(0·81–2·4)	(0·028–0·33)	(0·015–0·21)	(0·041–0·30)	(0·7–14)
Fish oil	3	2·1	1·2	0·74				160
Oct. 1966		(1·5–2·6)	(0·89–1·6)	(0·54–1·0)				
Baltic Sea proper incl. the Sound								
Mussel	40	6	1·3	4·3	0·03	0·02	0·03	0·62
Oct. 1966, Dec. 1966		(0·7–10)	(0·5–2·9)	(1·9–8·6)	(0·009–0·07)	(0·003–0·023)	(0·006–0·067)	(0·46–1·6)
Dec. 1967, Jan. 1968								
Herring	16	17	9·7	6·8	0·66	0·49	0·27	6·4
April, Sept. 1966–68		(4·1–27)	(1·5–21)	(0·5–23)	(0·062–2·3)	(0·013–1·3)	(0·008–1·0)	(0·7–12)
Plaice	6	2·7	2·1	2·7	0·016	0·013	0·017	0·65
Sept. 1967		(1·4–7·6)	(0·6–7·2)	(1·7–4·6)	(0·006–0·036)	(0·003–0·029)	(0·010–0·023)	(0·36–0·71)
Cod	5	19	9·6	11	0·063	0·035	0·033	0·32
Sept. 1967		(12–31)	(3·5–19)	(3·2–20)	(0·027–0·11)	(0·008–0·068)	(0·012–0·057)	(0·23–0·44)
Salmon*	11	31	14	2·9	3·4	1·5	0·30	11·0
Autumn 1966		(20–53)	(7·7–20)	(1·1–8·2)	(0·29–7·1)	(0·095–3·1)	(0·014–0·84)	(1·2–20)
Fish oil	1	16	7·3	3·5				100
Oct. 1966								
Seal (grey) liver	1	95	41	44	2·9	1·7	1·3	4·1
Seal (common and grey)	2	130	62	30	66	32	15	52
Sept., Nov. 1966		(110–150)	(57–66)	(16–43)	(56–74)	(31–32)	(8·5–21)	(44–55)
Eggs from guillemot	9	870	20	260	40	1·2	16	7·9
May 1966		(300–780)	(7·6–38)	(110–360)	(20–51)	(0·7–2·8)	(7·9–21)	(3·6–11)
The Archipelago of Stockholm								
Mussel	15	3	1	5·2	0·04	0·02	0·057	1·1
Oct. 1966, Dec. 1967		(1·4–7)	(1–1·6)	(3·4–7·0)	(0·01–0·081)	(0·01–0·024)	(0·032–0·048)	(0·94–1·8)
Herring	4	7·7	3·9	5·1	0·23	0·11	0·17	2·4
May 1965		(4·3–11)	(2·0–5·3)	(3·3–6·6)	(0·094–0·30)	(0·044–0·16)	(0·073–0·23)	(2·2–2·8)
Seal (grey)*	3	170	17	30	26	4·2	6·1	27·1
May 1966		(97–310)	(11–21)	(16–56)	(25–36)	(3·4–6·6)	(5·7–6·4)	(21·5–37·5)
White tailed eagle								
March–June 1965–66	4	25,000		14,000	230		180	1·5
Pectoral muscle		(16,000–36,000)	n.d.	(8,600–17,000)	(190–400)	n.d.	(130–260)	(0·9–2·0)
Brain	3	1,900		910	100		67	5·4
		(1,700–2,100)	n.d.	(490–1,500)	(90–110)	n.d.	(29–70)	(4·6–6·0)
Eggs from white tailed eagle	5	1,600		640				5·6
May–June 1966		(610–1,600)	n.d.	(250–800)	n.e.	n.e.	n.e.	(3·4–9·1)
Heron								
April 1967	1	14,000	n.d.	9,400	71	n.d.	48	0·51
Gulf of Bothnia								
Herring	6	6·2	2·5	1·5	0·28	0·14	0·065	4·4
		(5·2–8·1)	(2·0–4·8)	(0·92–2·0)	(0·15–0·42)	(0·091–0·21)	(0·028–0·091)	(3·1–6·0)
Seal (ringed)	2	120	64	18	66	30	6·8	54
May–Oct. 1966		(110–130)	(54–57)	(9·7–18)	(58–68)	(28–31)	(5·9–6·5)	(52–55)
Gulf of Finland								
Seal pup (grey)	2	42	23	6·5	23	14	3·9	60
March 1966		(41–43)	(22–23)	(6·0–7·0)	(24–26)	(13–16)	(3·4–4·4)	(56–63)
Seal milk								
March 1966	1	86	21	4·5	11	2·5	1·4	31

* εDDT stands for DDT + DDE + DDD. For salmon and seal, there was respectively 41 per cent DDD in εDDT, the mean figure being 17 per cent.
n.e., Not estimated. n.d., Not detected.

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of Stockholm, stored in a non-heated room for six months, had a greater proportion of DDD (up to 40 per cent of ε DDT), and simultaneously smaller levels of DDT itself, than all other seals. This could have been caused by post mortem metabolism by microorganisms[18]. On the other hand, the ringed seal from the Gulf of Bothnia, stored in the same way as far as we know, had only about 5 per cent of DDD, but this low figure may be corrected with the uncertainty of DDD estimation at the time when the other seals were analysed. This difference between the archipelago seals and the other seals, however, could be related to the fact that the large amount of pollution and the land–water relation in the archipelago of Stockholm produce a higher microbiological activity in the water, transforming[19] DDT to DDD and possibly DDE.

Little is known about the toxicity of PCB in the levels found by us. PCB has, however, been proved to cause pathological changes in laboratory animals[20], and was found to be among the ten most potent chemicals among a hundred tested by injection in eggs[19]. Some teratogenic effects have been noted[19]. Effects of DDT, DDE and PCB on hepatic enzymes which increase the metabolism of progesterone, testosterone and oestradiol have also been published[4]. It is worth noting that bald eagles (*Haliaeetus leucocephalus*), fed a diet containing DDT, had between 58–86 p.p.m. DDT and DDD in their brains when they died[20]. Approximately the same values were found in robins and house-sparrows[21]. Brain tissue in white tailed eagles from the Stockholm area contained on average 100 p.p.m. (fresh tissue) of DDE. DDE, on the other hand, is less acutely toxic than DDT itself. The greatest value in North American bald eagles collected in the field in 1965 was 118 p.p.m. (mainly DDE) in muscle tissues[21]. The greatest level for sampled wild white tailed eagles from Sweden is 400 p.p.m. (mainly DDE) and the mean was 330 p.p.m. in muscle tissue (wet weight). Nothing is yet known about the PCB content in bald eagles from North America, but in eagles from our archipelago the mean value in muscle was 190 p.p.m. (brain 47 p.p.m.) and the greatest figure was 240 p.p.m. (brain 70 p.p.m.).

Neither the fresh tissue nor the original fat values were estimated in the addled eggs from white tailed eagles. Sometimes the water content was as low as 8 per cent (normally 70–75 per cent in fresh hen eggs). The values based on the fat content of these eggs are probably more reliable and we only report such figures. The levels, although high, were only 1/25 of those of the eagle fat. The residues of ε DDT and PCB in the guillemot eggs were about 50 per cent lower than those in the white tailed eagle eggs. The guillemots are vagrant in winter but most of the central Baltic population is believed to remain in the Baltic area the year round. It is not known whether the population is decreasing, but no drastic decline has been reported.

All species mentioned here (except mussel) are more or less vagrant, thereby giving a picture of the situation in a large water area. A relatively few analyses of a vagrant animal may not give a very accurate picture, but when different species are shown to contain more residues in the Baltic than in the North Sea and the Atlantic, the situation is more convincing.

In the Baltic proper, the Gulf of Bothnia and in the archipelago of Stockholm, the levels of chlorinated hydrocarbons are approximately ten times greater than the reported sparse figures for comparable species in the North Sea area and the Atlantic. This may be caused by several factors. The Baltic is surrounded by large areas of land and the water volume is comparatively small. Furthermore, the water exchange with the North Sea is very limited as a consequence of the thresholds (18 and 6 m deep) and the narrowness of the Danish sounds. Residues brought into the Baltic from the coasts and from air pollution will accumulate here to a great extent. This development is no doubt favoured by a generally low microbiological activity because of very low temperatures of the intermediate Baltic "winter water" during most of the year, and also of the deep water layers in the northern areas. As a consequence of the rather cold winter, this is also largely true for the upper surface layer.

The brackish water character of the Baltic also favours a concentration of residues in living organisms. The substances in question are probably more readily transported in a horizontal direction by living matter from fresh water to the low salinity surface water (frequently 5–6 per mille or less) of the archipelagos and along the Baltic coasts. In the North Sea, the discrepancy between the salt seawater and fresh water especially when combined with the effect of the tidal movements can result in a faster decomposition of freshwater organisms and of organic matter, including the chlorinated hydrocarbons. The increased and more immediate contact here with the microbiological activity located in the bottom material may be important. Furthermore, there is in the Baltic proper a pronounced stratification of the water. A distinct halocline delimits the deep water of higher salinity upwards (usually in 50–70 m depth). In the warm season, the uppermost surface layer is separated from the "winter water" by a very marked thermocline (usually in 15–20 m depth, sometimes supported by a secondary halocline). As a result of these two discontinuity layers and, especially in coastal areas, of the absence of marked tidal currents, the vertical water exchange and movements are more or less blocked. The contact of sinking organic matter with the bottom material is thus to a great extent delayed. In the discontinuity layers of the Baltic Sea, living and dead plankton and other organic matter are concentrated, as a consequence of differences in the specific gravity of the water. The layers mentioned are important feeding areas for plankton and pelagic fish such as herring and sprat. In the Sound, in the archipelago of Stockholm and in the Idefjord, local sources of pollution can be important as the residue levels indicate.

We thank Mrs Kerstin Widmark, Mr Bruno Nucci, Mrs Elsa Nucci, Miss Gunnel Blomkvist and Miss Margareta Östberg at the Institute of Analytical Chemistry, the University of Stockholm. We also thank Mr Werner Berg and Mr Bengt Wallin at the Museum of Natural History, Stockholm, for their help in this work.

Received May 12, 1969.

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From : Manufacturing Planning
WIN :
Date : January 28, 1976
Subject: INERTEEN/TCB FOR PCA7
TYPE COUPLING CAPACITORS

A. Dennison
R. Luzar
R. Stewart

cc: A. Berg
G. Clogston
W. Kelly
R. Ripplinger

The Inerteen/TCB mixture used to impregnate the PCA7 type coupling capacitor has a strong odor and can be irritating to the employees when there is a high concentration of fumes. By the same token, a high concentration of these vapors may be hazardous to one's health. There may be high concentration of vapors in the oven and immediately over the coupling unit when an employee is working on it. We are in the process of measuring vapor concentrations now, but it will be some time before we will have the results back.

Since we don't know if the vapors are hazardous or not, I believe we need to take precautionary measures to protect the employees in the event that the vapors are hazardous. Even if the vapors are not hazardous, they can irritate the throat over a period of time.

We have, in the Medical Department, respirators and filters that the employees can wear to remove the vapors from the air they breathe. I have tried these out in the oven where the concentration is highest and found the respirator is very effective--no odor or vapor goes through the filter. Since these filters do an excellent job, I believe it is essential that the operators wear the respirators while they load and unload coupling capacitors in the oven and while they work on the individual units.

Therefore, I am requesting the appropriate Foreman or Ray Luzar to let me know the next time an oven is loaded or PCA7's are worked on. I wish to discuss this with the employees involved, provide them with respirators, and show them the benefits of the proper use of the respirator.

R. B. Sawyer, Manager
Manufacturing Planning

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Westinghouse Electric Corporation

June 5, 1972

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JUN 8 1972

Dr. Raymond Borland
Monroe County Health Officer
Bloomington, Indiana 47401

Dear Dr. Borland:

The disposal by Westinghouse of solid waste contaminated with INERTEEN (chlorinated phenyl insulating liquid) in the Monroe County dump located on Anderson Road, will commence Wednesday, June 7, under the following conditions.

As agreed to by Westinghouse to the State Board of Health in November 1968, no liquid Inerteen will be disposed of in the state of Indiana.

The solid waste which includes mainly clay, sawdust, paper, aluminum foil and metal cans, will be disposed of in a special area of the dump as agreed upon by Mr. Marion Young, the contractor for the dump.

The depth of trench and the amount and frequency of cover shall be in accordance with state and county regulations for a sanitary land fill.

It is recognized that Inerteen is not flammable, is not water soluble and it is heavier than water.

Studies show that Inerteen being a chlorinated phenyl compound may be an environmental contaminant. Care must be taken to prevent any entry to the environment.

It is Westinghouse's opinion that if the Inerteen contaminated solid waste is disposed of in the Monroe County dump located on Anderson Road in accordance with state and county land fill regulations, it will not escape into the surrounding environment.

To assure this, Westinghouse will take soil samples at several locations around the dump before dumping commences.

A monitoring program which includes periodical sampling around the dump will be carried out to confirm that Inerteen is not escaping into the surrounding environment.

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Jerry Cravy of the State Sanitation Department feels that the Monroe County dump is a suitable location for disposing of this waste. Sam Via of the State Industrial Waste Department has been informed of the history of our disposal of solid and liquid Inerteen waste.

Jim Hunt of the State Industrial Waste Department was also contacted recently and in February 1969 Westinghouse sent him several technical reports to keep the state informed on Inerteen.

Mr. Cravy recommended that Westinghouse get Monroe County approval and he felt that formal state approval would not be required since the Monroe County dump is already state approved.

Two copies each of this letter signed by Mr. Shoaff of Westinghouse and Dr. Borland, Monroe County Health Officer are being sent to Jerry Cravy and Sam Via requesting that they sign one copy and return it to Westinghouse so that we have on record that they are informed of the contents of this letter.

It has been and will continue to be Westinghouse policy to comply with all local state and federal laws concerning our environment.

MONROE COUNTY HEALTH OFFICER

Date: 6-6-72

WESTINGHOUSE PROCESS ENGINEER 6/5/72

June 9, 1972

Westinghouse Electric Corporation

Box 341, Bloomington, Ind. 47401

June 5, 1972

Dr. Raymond Borland
Monroe County Health Officer
Bloomington, Indiana 47401

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NPC00007874

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It has been and will continue to be Westinghouse policy to comply with all local state and federal laws concerning our environment.

Ray Borland M.D. — MONROE COUNTY HEALTH OFFICER

John L Shoaff 6/5/72 — WESTINGHOUSE PROCESS ENGINEER

Date: 6-6-72

NPC00007875

EXHIBIT 6F

Monsanto

ORGANIC CHEMICALS DIVISION

Monsanto Company
800 N. Lindbergh Boulevard
St. Louis, Missouri 63166
Phone: (314) 694-1000

March 3, 1969

Mr. Robert T. Innis
Westinghouse Electric Corporation
P. O. Box 341
Bloomington, Indiana 47401

Dear Mr. Innis:

On February 24, the San Francisco Chronicle carried a major feature about "a menancing new pollutant" found in the San Francisco Bay area. The article was based on marine life research carried out by Dr. Robert Risebrough of the University of California. It stated that residues of polychlorinated biphenyl (PCB) were killing certain marine birds and posed a long-term threat to humans.

This story has caused considerable comment on the West Coast and its claims may be repeated elsewhere. As you know, Monsanto manufactures polychlorinated biphenyl and markets it under our Aroclor trade name. We, therefore, would like to present some additional facts.

The work done by Dr. Risebrough dates back to earlier research by other scientists to analyze the amount of pesticides in wildlife, soil and water. The initial pesticide research was extremely difficult since any search to detect materials in the parts-per-billion range also brings out other "interferring" substances.

Several years ago, two Swedish scientists at Stockholm University's Institution of Analytical Chemistry, Professor Gunnar Widmark and Soren Jensen, reported they had identified the other substances which were appearing during analysis of chlorinated pesticide residues. They said some of the materials were polychlorinated biphenyls or PCB. The amount reported was in the parts-per-billion range, or less. Since PCB's are not "broadcast" or spread around the land as are pesticides, the scientists theorized that the source must be the industrial wastes of PCB users.

Dr. Risebrough's more recent work reports the identification of PCB, along with DDT and DDE pesticides, in the tissues of birds and fish on the West Coast.

The conclusionsof these scientists are puzzling from several aspects. Polychlorinated biphenyls are stable chemical compounds which are essentially insoluble in water. Their use does not make them easily released into the natural environment.

A principal market for PCB is in electrical applications where they are used as insulating fluids for transformers and capacitors. In this use, the chemical is completely sealed in metal containers. Another market is for heat transfer applications where the PCB fluid functions in a closed system.

PCB's are also used in several "plastic type" applications. Here the chemical is incorporated into the polymer as an integral part of the solid material. This applies whether the polymer is used as an adhesive, an elastomer or a surface coating.

The Swedish and American scientists also imply that polychlorinated biphenyls are "highly toxic" chemicals. This is simply not true. The toxicity of any material, whether it be chemicals, drugs, natural plants or even foods, is relative. Compared to the thousands of industrial chemicals and home products, PCB's are not toxic unless they are mishandled or misused. During more than thirty years of U.S. production and use, cases of any toxic effect have been extremely rare -- and then only where the simple precautions recommended for use were not followed.

NPC00007877

To our knowledge, polychlorinated biphenyls are not sprayed or dusted on crops, woodlands or any other areas, as are pesticides. It is, therefore, not only puzzling, but extremely difficult to conceive how commercially produced PCB can show up in wildlife as DDT and other pesticides appear to be. This raises the question whether the substance identified in the Swedish work, and now in California, is actually PCB -- or whether they are materials which, due to the metabolism of other materials in the marine environment, appears to be PCB.

Unfortunately, even though techniques for analyzing tissue samples have become quite precise, the ability to analyze the possible impact of naturally occurring substances in the food cycle of living organisms has not made comparable advances.

Monsanto has a research program to confirm the identity of the compounds reported to be PCB by the Swedish and California scientists. We also cooperate, on a regular basis, with federal, state and university laboratories in their analysis of chlorinated hydrocarbon residues.

Additionally, Monsanto will continue to exercise the highest degree of control in its manufacturing, shipping and storage of PCB -- as we do with all products. In the functional fluids market, we have carried out a program for several years for the reclamation of used PCB's to avoid disposal of these valuable materials.

The source of the marine life residue identified as PCB is not yet known. It will take extensive research, on a worldwide basis, to confirm or deny the initial scientific conclusions. We will keep you advised of our own research and are available to answer questions as they may arise.

Very truly yours,

Elmer P. Wheeler
Manager Environmental Health

/ecd

NPC00007878

WIRE MESSAGE
WESTINGHOUSE FORM 19K

MAKE IT BRIEF!

DO NOT SEND CLASSIFIED INFORMATION

NAME / DEPT./ACTIVITY OF RECIPIENT	DATE	TIME
TO Mr. L. F. Hart, Gen. Mgr., General Electric Co. CPD	10/9/75	
DIVISION, DISTRICT OFFICE, DISTRIBUTION CENTER, PLANT/ COMPANY		
John Street		
COMPANY NAME (IF OTHER THAN WESTINGHOUSE & AFFILIATES) STREET ADDRESS	CITY	STATE
Hudson Falls, New York 12839		

cc: Bloomington Mgr. R. O. McClain
815 15th St. NW, Suite 538, Wash. DC 20005
cc: NEMA, 155 E. 44th St., New York, New York 10017 - Mr. C. A. Parris

I am surprised you and your legal counsel misinterpreted my letter of 9/17/75 re alternates to PCB's, and incorrectly assumed that the proposed subject matter and letter had not been cleared with NEMA Counsel and W Counsel.

Discussions at the meeting will be on what characteristics chemical, electrical, environmental, health and safety must be available for a fluid to be considered as a r[illegible]cement for 1016 PCB and not how to design a capacitor and not how to evaluate [illegible]nation of capacitor units.

SIGNED	DEPT.	BUDGET
Sauter	Div. Gen. Mgr.	

NPC00007879

770518

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK
SILVER SPRING, MARYLAND

IN REPLY REFER TO:
GS:FCW:emcm

8 October 1959

Safety Director
Westinghouse Electric Corporation
East Pittsburgh, Pennsylvania

Gentlemen:

Concern has been expressed by our personnel who have had occasion to work with your Inerteen oil as to its toxic effects.

In view of this concern, it is our desire to acquire information relative to the following items; the chemical composition of the oil, its hazardous properties, the necessary precautions to be taken when handling the oil from the standpoint of ventilation and personal protective equipment; the hazards involved in the absorption of this oil thru the skin, and the maximum allowable concentration in parts of this oil per million parts of air. Further we would appreciate information on the type gloves and aprons materialwise that can be used when working with Inerteen oil.

Any information of this nature you are able to give us will be of much value.

May I take this opportunity to express our sincere appreciation for your courteous attention.

Very truly yours,

FRANK C. WRIGHT
Safety Engineer

(OVER)

NPC00007880

770519

Mild skin irritant on contact with skin

Prolonged contact may cause dermatitis

Skin absorption can occur.

Chemical cartridge respirator for use in slight above the exposure limit

NPC00007881

770520

Inerteen

Headquarters Medical Dept.
September 15, 1947

CLEVELAND WORKS
Mr. J. W. Wigert
Materials & Process Engr.

I am sorry for the long delay in getting the Safe Practice Data Sheet I-1 prepared. We are still lacking some data on inerteen, but rather than waiting until we get complete information I will send you the following, which takes care of most of the data. I discussed your capacitor installation with several persons at your plant sometime ago, including Mr. T. E. Fuller and Mr. J. Scott. They are familiar with the fact that inerteen is a fairly toxic material which must be handled in such a way as to prevent poisoning.

CONTAINERS AND STORAGE

I believe the type of container is indicated on P. D. Spec. 6935. You can probably determine the exact type of container in which you receive this material from your supplier. There are no special precautions that need be taken in storing the original containers. In case of spillage, the inerteen should be cleaned up promptly so that its vapors will not contaminate the storage area. The use of oil absorbing compound, M6695-1, is recommended since this compound absorbs the inerteen and keeps the floor in a non-slippery condition.

PROPERTIES

Fire - Non-flammable

Explosion - Non-explosive

BREATHING

I do not yet have data on the odor level of this materials. Chronic poisoning may occur where there are repeated or recurring exposures to a sufficient concentration of inerteen (6935) vapor over a period of months or years. Such exposures may produce internal bodily injury which may be disabling or could be fatal. Where people may breathe air containing the

vapor, the Maximum Allowable Concentration is one milligram per cubic meter. This Maximum Allowable Concentration applies to repeated or recurring daily exposures. If the concentration is less than one milligram, there is little chance of poisoning even after years of exposure. When much higher concentrations of vapor are breathed for a relatively short period, there may be irritations of the nose and throat, or, occasionally nausea. If air is saturated with inerteen vapor at room temperature, it will contain a concentration of 176 milligrams of inerteen per cubic meter of air. (Note) I am not entirely satisfied with this figure, although it is the best data that I have available. I expect to check this value before issuing the Safe Practice Data Sheet. Even though this relatively high concentration of vapor could be theoretically reached at room temperature, it must be remembered that the evaporation rate at room temperature is very slow and it would require long periods of time, in a totally enclosed space, to reach this saturated condition.

SWALLOWING

Inerteen is highly toxic if taken internally. The swallowing of approximately one or two ounces may cause serious internal injury or perhaps death.

SKIN IRRITATION

It is a mild skin irritant. Even though it is not very irritating to the skin, it is absorbed through the skin and can produce toxic reactions internally. It may also produce, after exposures of months or years, a skin condition known as chlor-acne. This condition is very difficult to heal.

PERSONAL PROTECTIVE EQUIPMENT

If it is necessary, under emergency conditions, to enter a space containing very high concentrations of vapor or fume, either a universal gas mask, M6759-1, an air-line respirator, or a hose mask with or without blower, may be used. For usual concentrations of vapor, standard chemical cartridge respirator 8883-1, equipped with an activated charcoal cartridge 8883-2, will provide protection. These respirators should be of a type approved by the U. S. Bureau of Mines. Neoprene aprons and gloves 7530-6 may be used where necessary to protect the skin. If for any reason the neoprene gloves do not stand up well on this application, a glove made from Polyvinyl alcohol resin (such as Resistoflex) could be used. Hand cream, such as West 88 (West Disinfectant Company, 42-16 West Street, Long Island City), or Fend O (Mine Safety Appliances Company, Pittsburgh, Pa.) may be

NPC00007883

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of some value as protection for the skin where better methods of protection are not practical.

PRECAUTIONS

Care must be taken to prevent any appreciable contact of this material with the skin, especially when these contacts are repeated. If any appreciable area of the skin becomes coated with the inerteen, it should be removed by washing with soap and water. Butyl stearate is a good solvent for this material and can be used to aid in completely removing the inerteen from the skin. Its use should always be followed by washing with soap and water. The Maximum Allowable Concentration of vapor, previously specified, should not be exceeded under normal working conditions. This can be accomplished either by using a totally enclosed system or by providing adequate ventilation. Where this is not practical, respirators may be used. Proper preplacement and periodic physical examinations should be made by the Medical Department on workers who work with inerteen.

FIRST AID

In cases of swallowing, vomiting should be induced immediately by carefully inserting a finger in the person's throat. In case of any severe exposure, the person should be placed under the supervision of the plant physician.

H. C. Barnes
Industrial Hygiene Engineer

HCB:y

NPC00007884

770523

MEMORANDUM
WESTINGHOUSE FORM 3018L

confidential

TO _____ DEPT., WORKS OR D.O. _____ MR. J. Interteen

From Berberich - Research 4/14/4

The transformer Interteens now contains 40% trichlorbiegen
60% Chlor diphenyl 1260
and 7% tin tetraphenyl

E.C.B.

FROM _____ DEPT., WORKS OR D.O. _____ NAME _____ DATE _____

Make it brief; make it clear; make it legible!

NPC00007885

770524

PITTSBURGH GATEWAY 20
S. R. PITTS

15 6 10 0211

Westinghouse Public Relations

Westinghouse Electric Corporation
Westinghouse Building, Gateway Center
Pittsburgh, Pennsylvania 15222

RECEIVED
JUL 15 1976
LAW DEPARTMENT

Contact: V. J. Rinaldi
Telephone: (412) 255-3320

FOR USE: Immediate

WESTINGHOUSE TO QUIT USING PCBs IN TRANSFORMERS

PITTSBURGH, July 15 -- Westinghouse Electric Corporation here announced, effective today, that it is phasing out of the use of polychlorinated biphenyl compounds (PCBs) as a fire-resistant insulating fluid in transformers. As of today, no new quotations will be made for units filled with PCB for shipment after December 31, 1976. PCBs are known by the industry trade names of Inerteen/Askeral.

Westinghouse customers who have orders placed for delivery after December 31, 1976, are being contacted to determine if existing shipping schedules can be advanced and are being offered alternatives.

Mr. M. J. McDonough, executive vice president of Power Systems Transmission & Distribution Group stated that this announcement covers transformer products where PCB is used. PCBs are a class of chemicals whose individual members have widely differing combinations of physical, chemical and biological properties.

"During the last seven years, a significant amount of our total production has been with PCBs," said Mr. McDonough. "Phasing out of its use

- more -

OSP

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will have a serious impact on future building systems designs, consulting engineers and our customers."

Westinghouse has produced PCB-filled transformers for over 40 years. However, in today's environment the potential liability associated with manufacturing and handling of PCBs is constantly increasing to inordinate levels.

"We do not feel it is in our best interest or our customers to continue producing transformers using this fluid," said Mr. McDonough.

Various forms of legislation have passed or are now pending, all of which either severely regulate, or restrict the use of PCBs.

EPA officials have indicated their intent to put into effect during 1976 proposed rules and regulations covering fines, penalties and controls for spills, discharge and the transport of PCB fluids. A spill is defined as being as little as one pound. In instances involving gross negligence, an individual can be fined $10,000 and/or one year in jail.

Mr. McDonough said, "We are hopeful that our customers realize the potential liabilities and consequences that we all are exposed to if we continue to produce transformers insulated and cooled with PCB fluid."

##2604-13##

-776-

COPY OF WESTINGHOUSE INERTEEN PAPER ENCLOSED.

A series of talks presented at the Westinghouse Distribution Apparatus Division to state and local officials on

April 13, 1976

NPC00007888

Why PCBs in Electrical Equipment

by
D. M. Sauter, General Manager
Distribution Apparatus Division
Westinghouse Electric Corporation
Bloomington, Indiana

For over 40 years, electrical manufacturers have used large quantities of polychlorinated biphenyl compounds (PCBs) for production of electrical capacitors and transformers. PCBs have excellent dielectric properties and fireproof characteristics. Therefore, the unique combination of good electrical and safety properties when used in electrical equipment are key reasons why PCBs have not been replaced over this 40-year time span.

For the moment let's explore the electrical system and the use of capacitors and transformers in the electrical system. The United States is crisscrossed by thousands of electrical transmission lines. These lines act as a vehicle and carry electrical power from the source of power, the electrical generator, to large urban areas, or to centralized areas within rural districts. The electric power is then distributed to homes, offices, factories and farms.

Although the transformer is extremely efficient in performing its function of raising voltages and permitting power to be transmitted over long distances, losses do occur in the transformer and along the transmission line, as the current flows through these circuits. However, all is not lost because the capacitor provides the way of improving efficiency of all of our electrical systems. A capacitor has the same effect as the generator only in a smaller sense. For example, a capacitor can be applied at the electrical load to supply a portion of the current required by motors and transformers. By placing capacitors at the electrical load end of the transmission and distribution line, the current is not required to flow through the transmission line. Less current means high efficiency of the electrical system. Improved efficiency means that less oil, less gas and less coal is required to get the electrical power to each home, or industrial plant. Capacitors have helped make U.S. Power Systems the world's most efficient.

Large capacitors are used in high-voltage electrical systems. Smaller capacitors are applied in television sets, fluorescent lights, air conditioners, and in many of the motors and circuits used in industrial plants and commercial buildings. These alternating-current capacitors are applied at voltages from 110 volts (a normal house voltage) to 500,000 volts (a high-transmission voltage).

Capacitors were first used in power systems in the 1930s. During World War II, the electric utilities began to buy capacitors in large amounts. The reason is that capacitors involved less critical material and provided the simplest way to increase the efficient use of available electrical energy.

Since then, there have been increased applications of capacitors worldwide. Moreover, the recent energy shortage has again focused attention on improving the efficient use of electricity. For instance, capacitors are applied on additional end-use devices, such as washing machines, microwave ovens, room air conditioners, television sets, etc. Capacitors and transformers have always been used on fluorescent lights.

Electricity creates corona. Corona are small impulses similar to lightning. If these impulses are allowed to build up, they will flashover and cause a significant short circuit. To control corona, a liquid is generally added to the other dry dielectrics. This liquid suppresses or restrains the electrons caused by the corona. It allows electrical equipment then to withstand hundreds of thousands of volts without failure.

In 1932, the introduction of chlorinated aeromatic hydrocarbon impregnating compounds (Askarels or PCBs) allowed the electrical industry to use this material because of its high dielectric capabilities, and its important heat-resistant properties that made it nonflammable. Since then, PCBs served for years as a successful fire-resistant transformer and capacitor coolant and insulator.

Most of the transformers used in the United States use mineral oil as an insulating and cooling medium. However, mineral oils have one serious drawback, they are flammable. Where transformer failures may cause fires and explosions threatening life and property, the use of mineral oil is restricted. Fire underwriters will not allow the use of flammable liquids for transformers located indoors, in congested areas, large buildings such as the World Trade Building, Sears Tower, hospitals, schools, or homes. In these instances, the transformer is filled with a nonflammable PCB.

NPC00007889

In every instance, the transformer and/or the capacitor must have the ability to conduct the current and to insulate parts of the equipment from the alternating current. This ability to insulate portions of itself from the alternating current is called the dielectric strength.

Today, capacitors are widely dispersed throughout our total environment. Capacitors are located on power lines, in factories, in buildings and in our own homes. The insulation system of every alternating-current capacitor employ PCBs to prevent the saturated paper, film and aluminum conductor from becoming a hazard if the capacitor fails. It has been the industry's experience that capacitors generally have less life than a transformer. Transformers generally last from 20 to 30 years. Depending on its application, capacitors last from 5 to 12 years.

A more detailed discussion of the properties required of a capacitor dielectric fluid will be discussed later when we talk about substitutes.

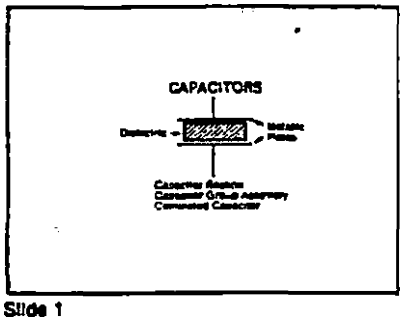
In summary then, we can see that the present proposal to eliminate PCBs from the environment will have a direct bearing on the use of all alternating-current capacitors in the U.S. and on the use of transformers in high-risk areas. So, polychlorinated biphenyls have found acceptance in our electrical systems since they provide safety to the consuming public and to workers in industry. In addition, this electrical equipment permits our country to manage all of its energy sources efficiently. If PCBs are eliminated without suitable alternates, energy use in this country, would climb by approximately 10 percent. This energy increase will cost the consumer of electricity $100 million a week.

Since 1972, the use of PCBs in other areas has been discontinued so that presently transformers and capacitors represent the only application for these chemicals. Recently, it has been proposed that PCB mixtures be eliminated in our electrical equipment as well. The next speaker will show you a capacitor, demonstrate flammability and investigate various alternate measures which are being tested for phasing out or substitution.

Power Capacitors

by
J. B. Brittain, Manager
Engineering
Distribution Apparatus Division
Westinghouse Electric Corporation
Bloomington, Indiana

I will talk for a few minutes about three aspects of power capacitors. First, what a power capacitor is and how they are manufactured. Next, a discussion of what a PCB is, and last, some alternates to PCBs.

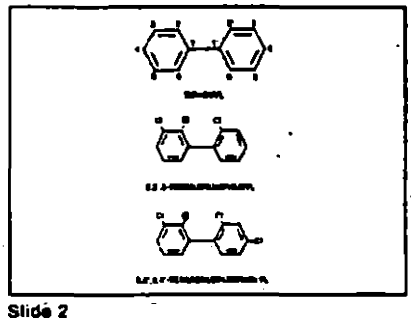


Slide 1

For a few moments, I would like to take you back to your days of high school physics (Slide 1). A capacitor is usually represented as shown on this slide. All capacitors consist of two metallic plates one on each side of an insulator which is known as a dielectric. In the capacitors manufactured here, the two metallic plates are thin aluminum foil, and the dielectric is a high grade of kraft paper and polypropylene film. These elements are wound into sections similar to the one shown here. They are then banded together into groups of sections. The individual sections are then connected together for the proper voltage rating and placed inside a stainless steel can. The two bushings located on top, are there to bring the electrical connection to the outside of the can. The dry capacitor in a can, such as this, is placed inside of a vacuum impregnator. This is a large chamber about one-half the size of this room. The impregnator can be heated, and a high degree of vacuum is applied to it. For several days alternate cycles of vacuum, and heat, are applied to remove all the moisture from the material. The tightly sealed impregnator is then flooded, and the capacitor is filled with PCB. The stainless steel can is sealed, and the capacitor is complete.

Everyone these days seems to be discussing PCBs. I would like to take a few minutes now and explain what a PCB is and point out the fact that there are different kinds of PCBs.

As mentioned, PCB stands for Polychlorinated Biphenyl. This beaker contains a PCB. It looks and feels like any good grade of highly refined oil.

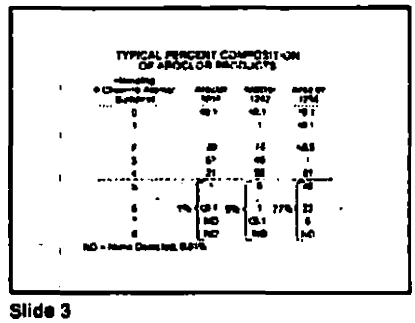


Slide 2

In order to illustrate what a PCB is, I will again have to take you back to your high school days, this time in chemistry.

The first diagram illustrates a benzene molecule. It is a six-sided carbon ring with a hydrogen atom attached at each of the corners. If by chemical process, two of these benzene rings are joined together, we obtain what is called a biphenyl molecule. Again by chemical treatment, we can replace one of the hydrogen atoms by a chlorine atom. This then makes a mono-chlorinated biphenyl. If we replace another hydrogen atom by a chlorine atom, we obtain a di-chlorinated biphenyl. In this stage, the compound could also be referred to as a polychlorinated biphenyl, or a PCB. Chlorine atoms can be added to these rings at different places and in various combinations. Each one of the compounds formed is called an isomer of a polychlorinated biphenyl. There are 209 such isomers. My purpose in developing a PCB in this way is to give you a concept of how a PCB is made and to demonstrate the fact that all PCBs are not the same.

Environmentally, our concern is whether or not PCBs are biodegradable. Biodegradability is related to the number of chlorine atoms, or the amount of chlorination of the biphenyl compound.

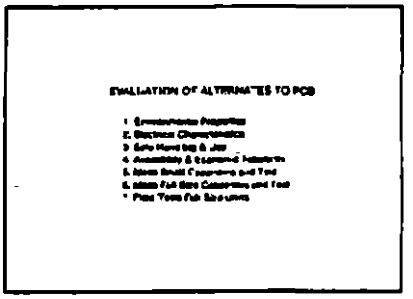


Slide 3

For example, biphenyls with five chlorine atoms and above are the most nonbiodegradable. Monsanto, who is the only manufacturer of biphenyls in the United States, designate their compounds by number as shown on this slide. Note that the compound called 1254 which was used in capacitors until the mid-fifties, has a percent of pentachlorinated biphenyls and higher isomers of 77 percent. 1242 which succeeded 1254 contains only 9 percent of the pentachlorinated biphenyls and higher isomers. When the question of PCBs in the environment surfaced the latter part of the 1960s and early 1970s, Monsanto developed a new liquid which they designated as

1016. 1016 greatly reduced the amount of the higher chlorinated molecules. Note that 1016 contains only one percent of pentachlorinated biphenyls and higher isomers. In other words, the PCB that we use contains 99 percent of the more biodegradable isomers. We started using this material in capacitors the moment it became available. Also, steps were taken to reduce the amount of PCBs escaping from the plant. This will be discussed later by Mr. Sawyer. Mr. Kerns will discuss some of the environmental relationships of these compounds.

What are Alternates to PCBs



Slide 4

PCBs were introduced in 1929 and presently no one has developed a fluid that has all the desirable properties of PCBs for making a power capacitor. With 40 years of experience in capacitors, Westinghouse has evaluated alternate fluids, as shown on this slide.

In scrutinizing the various possible fluids to design and produce a good capacitor, we were extremely sensitive in selecting a fluid that had *no environmental problems*. A prime characteristic of the fluid is that it must make a reliable long-lasting capacitor, and the failure rate must be low. Any fluid selected must be capable of being handled with minimum danger to employes. Another most important consideration is that the capacitor must be safe in performing its function. The fluid must be readily available and it must have reasonable cost.

After a number of tentative fluids are selected, we then make a small capacitor similar to the type that is in your home air conditioner (Exhibit R&D Capacitor). These are run under accelerated test conditions to evaluate failure rate, life, etc. After one or two candidate fluids demonstrate the best properties, we then make full-size capacitors and run them on accelerated tests. If tests are successful, we then build a number of units and install them on our customer's systems. With our customer's cooperation we then evaluate the capacitors' performance.

A number of fluids have been found which exhibit all of the requirements previously outlined except for *safety*. There is no known fluid today that will make a good capacitor, containing the fire-resistant properties of PCBs. A number of alternate fluids have been proposed by Monsanto, Dow Chemical, Shizuki in Japan, the General Electric Company, the Sun Oil Company, and others. Some of these will make better capacitors than others. Some are more readily available than others. Some are more economical than others. But, the one key drawback is that not one of them are as fire resistant as PCB. Our care for safety is the primary reason that we have not switched to a fluid other than PCBs by now.

In 1974 we settled upon an alternate fluid which we designated as F962. This fluid had competitive flammability characteristics but did not have the excellent flammability characteristics of a PCB. We decided, however, that if PCBs were eliminated and we had to go to an alternate fluid, that we would use this fluid in spite of its poorer flammability characteristics. We reached a point in the development schedule and built units for customer field testing. After another review of the handling of this fluid in a large quantity, we decided that because of safety we did not want to expose our workers to the fluid.

You must remember that at this point, we had around one-quarter of a million dollars invested in this alternate fluid. We then renewed our search for a fluid. Today we have settled on another fluid, safer to handle, but with inferior flammability characteristics than PCBs. We have designated this fluid S17 and are presently constructing capacitors for field tests. We have spent over one-half million dollars in arriving at this point.

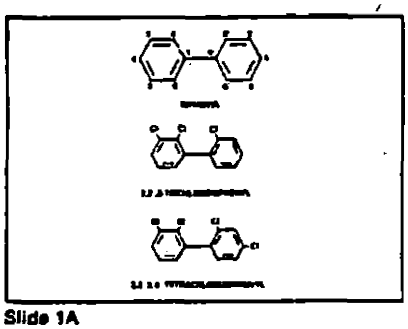
I have talked about the difference in flammability between PCBs and all alternate fluids. I would now like to demonstrae this difference. If we take a piece of the tissue paper from which a capacitor is made, fold it up, saturate it with the liquid being tested, and then strike a match to it, the PCB will flare up and start to burn. However, it will immediately go out. If we take any other known alternate fluid today, and make a similar test, the paper and the fluid will continue to burn until it is all consumed.

Now, what does this mean to you and to the public in general. In your own home, if you have a window air conditioner or a central air conditioner, it probably contains a small capacitor made out of PCBs. Your washing machine also probably contains a capacitor made with PCBs. Your furnace may have a capacitor containing PCBs. If you have some fluorescent lights, they probably contain a capacitor with PCBs. Your television set will probably contain a capacitor made with PCBs. Yet, I would say that no one in this room has ever known of a fire caused when one of those capacitors failed. If the capacitor industry switched to the only alternate fluids known today, when one of those capacitors fail, they could very well start a fire. Today, the entire capacitor industry would like to discontinue the use of PCBs because of environmental concerns. However, the potential fire hazard in homes, schools, hospitals, and businesses could well be more serious than the problem we are trying to correct.

I hope this will give you a little better idea of what a PCB is and how we use them in this plant and in the capacitor industry.

Environmental Relationships of PCB Compounds

by
B. A. Kerns, Manager
Environmental Control
Westinghouse Electric Corporation
Pittsburgh, Pennsylvania



Slide 1A

As you have already heard today, there are 209 possible homologs of PCBs. The mixtures of PCBs used by the electrical distribution equipment industry for the past forty-five years include Aroclor 1260, 1254, 1242, and 1016. Presently Westinghouse uses only Aroclor 1016 for capacitors and Aroclor 1242 for transformers. The basic differences in these materials is in the degree of chlorination. For example:

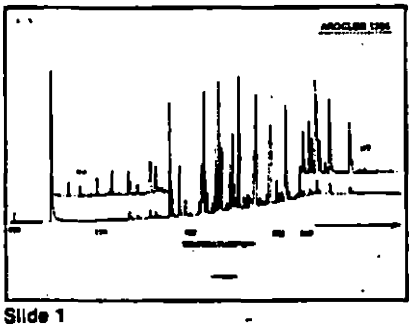
1. Aroclor 1254 contains 54 percent by weight chlorine and is primarily 77 percent five chlorine atoms and higher.
2. Aroclor 1242 has 42 percent chlorine and is only 9 percent five chlorine atoms and higher.
3. Aroclor 1016 contains 41 percent chlorine and is only one percent five chlorine atoms and higher.

For the polychlorinated-biphenyl materials, the level of chlorination appears to be the most significant factor in their relative biodegradability. The rate of biodegradability decreases as the number of chlorine atoms per biphenyl molecule increases. Chromatograms (which I'll explain in a minute) representing samples after exposure to activated sludge (as used for example in the City of Bloomington sewage treatment plant) show significant alterations in the Aroclor 1016 distribution but little for Aroclor 1254.

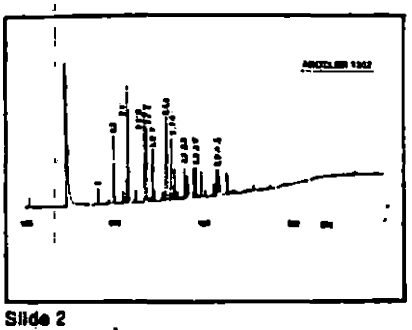
Passage of PCBs through activated sludge has shown that 33 percent of Aroclor 1016 degrades per forty-eight-hour cycle with a semi-continuous treatment method. This compares favorably, since 25 percent of Aroclor 1242 degrades in forty-eight hours, and 15 percent of Aroclor 1254 degrades in forty-eight hours. Results of additional tests with Aroclor 1016 showed that treatment for fourteen days reduces the various mixtures in 1016 from 17 to more than 98 percent. More on this later.

These tests have led to the conclusion that Aroclor 1016 is sufficiently biodegradable to remain in controlled usage.

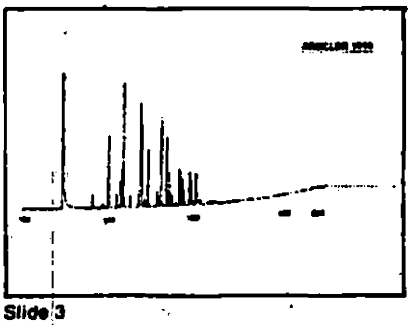
Most analytical data for PCBs utilize chromotography. This is a device to analyze a micro-sample of the material which is injected into a column or coil of tubing under controlled conditions of temperature, injection rate and volume. The heated column selectively releases each isomer. The release is recorded on a chart. Slide 1, 2 and 3 show typical charts or chromotograms for Aroclor 1016, 1242 and 1254. The horizontal axis indicates time while the vertical axis represents the amount present. The total amount of PCBs present is determined by integrating or measuring the area under the curves. You will note that while Aroclor 1016 and 1242 exhibit similar retention times, Aroclor 1254 shows a much greater retention time due to its higher chlorination and higher molecular weight. Slide No.4 shows the small differences between 1016 and 1242. Note additional peaks from time 70 on 1242 also showing some higher chlorination and higher molecular weight.



Slide 1



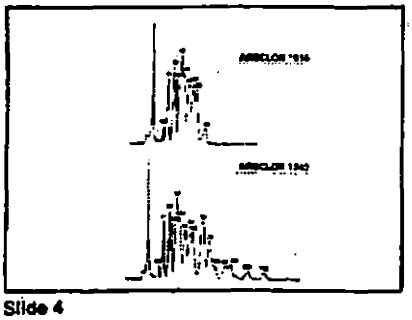
Slide 2



Slide 3

These data on degradation plus the complexity experienced developing analytical tools to correctly identify and quantify the mixtures of PCBs used within our own plants led us to conclude that many of the agencies supervising PCB analyses are arriving at erroneous results.

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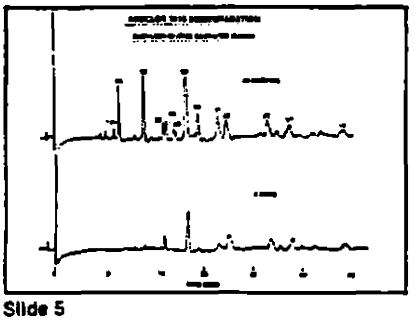
Slide 4

For example, analytical data provided to Westinghouse by agencies in Indiana show amounts of Aroclor 1016 in waters and in fish which could not possibly be there from degradation. In addition, the analyses for PCBs in fish used the whole fish. More commonly, however, only the edible portions are analyzed, allowing a correction factor of about four. In other words, the amount of PCBs in the whole fish should be divided by four to arrive at the concentration in the edible portion.

It seems incongruous that PCB standards are being imposed using as background information an analytical technique which was nonexistent five years ago and is presently, at best, questionable. An analytical technique which stretches technology to the limit and shows error ranges up to plus or minus 50 percent. How can reasonable replies to these important questions be answered, using inaccurate and/or nonexistent data.

In November, 1975, the EPA held a conference on PCBs in Chicago. At this meeting, many papers were presented on research studies, under EPA supervision and support, to determine the effect of PCBs on fish and animals. It was unfortunate that practically all experiments, at that time, were conducted using Aroclor 1254. This material has not been used in Westinghouse transformers since 1968, because of its nonbiodegradability and its possible detrimental effects on the environment. Importantly, Aroclor 1254 has never been used in the Bloomington plant. While a few screening studies were carried out by EPA on Aroclor 1242, no studies on the use of Aroclor 1016 had been planned at that time.

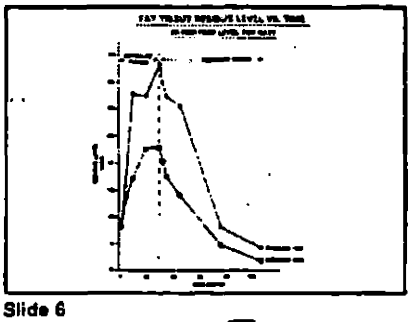
In addition, most of the data reported at this meeting indicated that massive doses of PCBs (not even available for the last two or three years—1248, etc.) given to rats and monkeys had detrimental effects. However, little work was carried out using concentrations as found in the environment. Another critical factor, often overlooked, is that residual PCB levels in the fat tissues of animals do decrease rapidly, following the cessation of exposure to PCBs (See slide No.6).



Slide 5

Fish found to contain the highest levels of PCBs were the bottom dwelling scavangers such as catfish, carp and eel. The game fish showed much lower levels. Factually, in surveys carried out between 1973 and 1975 in Lake Michigan, the number of fish found to contain PCBs decreased. Moreover, we are unaware of any study to measure PCB content in fish after cooking. Cooking should remove fat and fat containing PCBs from edible fish.

Presently EPA has agreed to carry out studies on the effects of Aroclors 1016 and 1242. These data should be available within 12 to 18 months. We feel that these studies will show a dramatically reduced environmental effect from these lower homologs—effects that allow a timely and orderly conversion to other dielectric fluids that will not cause severe penalties in safety and energy use.



Slide 6

Manufacturing

by
R. B. Sawyer, Manager
Manufacturing Planning
Distribution Apparatus Division
Westinghouse Electric Corporation
Bloomington, Indiana

The approach taken to reduce discharges of Aroclor into the environment has been to abate the amount of Aroclor that would come into contact with water. In the late sixties and early seventies, when the potential problem was identified, there was no demonstrated technology, or means, to remove the very small amounts of Aroclor that might be contained in the water. Because of this, we addressed ourselves to the task of reviewing our manufacturing procedures to determine what actions should be taken to prevent this contact with water. Let me explain what we have done.

We use relatively large quantities of this material, from 75,000 to 150,000 gallons per year, depending upon the number and size of capacitor units made. Our first concern was to make sure that large quantities could not escape into the environment. I wish to explain to you how we handle and use this material in our operation.

The fluid is received in 8,000-gallon railroad tank cars. When the tank car arrives, the fluid is pumped into two large storage tanks located on the outside of the plant. To make sure that the fluid could not escape, in the remote event that a tank ruptured, we built a concrete dike around the storage tanks.

Then, the Aroclor is pumped from the storage tanks to treatment equipment inside the plant. Here we remove any minute particles that might contaminate the fluid. After treatment, the pure fluid is pumped into six storage tanks above the impregnators. To make sure that none of this material escapes (in the event of an accident, or tank rupture), we sealed all the floor drains in this area. Large quantities of Aroclor cannot escape into the sanitary or storm sewer.

Now then, the assembled capacitor units are placed inside vacuum chambers to remove all the air and moisture from the units, as discussed by Mr. Brittain. These chambers are about 4 feet wide, 5 feet high, and 30 feet long. These impregnators are completely sealed and under vacuum. After removing the moisture and air, each vacuum chamber is filled with fluid from the overhead storage tanks. The fluid flows into the top of the capacitor and completely fills the unit with Aroclor. This is allowed to soak awhile, and then the excess Aroclor is pumped from the chambers into another group of storage tanks. The excess is pumped back through the purifiers and back up into the pure storage tanks. The floor drains in this entire area are sealed off.

The capacitors are removed from the ovens and placed on roller conveyors. Under the roller conveyors drip trays were installed to catch the fluid that dripped off the outside of the capacitor can. We also put floor dry or sawdust under the drip trays to soak up any fluid that might get through these trays. This will be discussed later. The fill hole on top of the capacitor is sealed by means of a plug and solder.

At this point in the manufacturing cycle, we are faced with two situations:

1. The inside walls of the vacuum chambers have a film of Aroclor on them.
2. The outside of the capacitor has film of Aroclor that must be removed prior to painting.

Part of the vacuum cycle in the vacuum chambers is done with pumps that use water as a seal. As the chambers are heated up, the film of fluid on the wall vaporizes, goes into the pumps, condenses in the water which runs into the sanitary sewer. The capacitor units are hung on an overhead conveyor system which takes the units through a water and soap washing machine—something like a car wash. The rinse water, which contains some of the film of fluid that was on the outside of the can, flows into the sanitary sewer.

As stated earlier, we know of no way to remove the Aroclor from water. So, in 1970 we started looking at the various alternatives that would prevent the Aroclor from making contact with the water. In other words, we needed to keep the ovens dry, or trap the vapors prior to water contact. Moreover, we needed to keep the outside of the capacitors dry, or find a different way to clean the capacitors. We concluded that the ideal way was to keep the fluid in a sealed/plumbers delight/system—don't let it make contact with the oven walls or the outside of the capacitor can. We identified a way to accomplish this and called it the manifold fill system. The assembled capacitors are put in dry vacuum ovens to remove the water from the capacitor unit. Then the capacitor units are removed from the oven. Each unit is connected with a sealed hose connection. A vacuum is pumped on each unit to remove the air. Then the unit is filled through this hose connection.

We spent a quarter of a million dollars on this project. Some modifications were made to improve the operation, and we had some minor cleanup to do. Good progress was made in reducing our small dis-

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charges. By later 1974, we had about 95 percent of our production on the manifold fill process.

Quite to our dismay, in late 1974 and early 1975, reports from the field indicated a very serious quality problem. *Units* filled by the manifold filling process were failing in service at nearly twice the failure rate of flooded units. Worse yet, many of the failures were catastrophic. That is, some cans were rupturing when they failed and, consequently, releasing more Aroclor into the environment. We investigated the problem and concluded that it was possible to have minute pockets of air or vapor inside a capacitor section when it was processed with this system. When this happened and when the unit was in service for a few months, the film and paper would break down wherever there may be air or vapor pockets.

Certainly, customers could not and would not tolerate this excessive failure rate, nor could they tolerate the excessive catastrophic rupture failures with attendant risks to people. As a reliable supplier, we did not want this situation and did not want PCBs entering the environment upon failure. We returned to the proven method of flooding the units under a vacuum in the chambers.

In mid-1971, we changed fluids from Aroclor 1242 to Aroclor 1016. The significance of this change was covered by Mr. Kerns.

In 1970 and 1971, we reviewed our practices on waste disposal. In our manufacturing process, we generate some liquid waste—Aroclor from the drip trays that is so contaminated with impurities that we cannot clean it up. Pump oils also become contaminated with the Aroclor. In addition, floor dry, sawdust, paper towels, solid waste from the purifier, etc., pick up Aroclor in the filling area. Further, we have some units that fail on final testing operations. We have not been able to repair many of these failed units, and we have not been able to reclaim the highly contaminated Aroclor. Prior to 1971, these wastes were placed in local landfills. This was a potential problem. Therefore, since 1971, our liquid wastes have been shipped to companies that have approved thermal oxidation incinerators designed for this material. Also we have shipped solid wastes, failed capacitors, saw dust, etc., to scientific landfills. Landfills that are designed and controlled to handle unique wastes of this type.

Our customers have been advised by instructions to the field and with nameplates on the capacitors that the users of these capacitors needed to take the same precautions in disposing of failed and/or obsolete units.

Professional people from our plant shared this knowledge and experience with other manufacturers and users. Mr. Wills will be telling you of our work in establishing voluntary standards for handling PCBs.

Over the years, we have invested research and development time and money to improve capacitor designs and manufacturing technologies. The object was and is to use less and less Aroclor to produce capacitor units and still maintain an equivalent performance.

Let's review what has happened since 1970. At the start of 1970, we were producing capacitor units, called Mark I series. During 1970, we introduced the Mark II series of capacitor units. These units used 42 percent less Aroclor than used in the Mark I. In 1973, we introduced the Mark III and Mark IV series. These units required 26 percent less Aroclor than used in the Mark II units. In June of this year, we will introduce the Mark V series. The Mark V will use approximately 20 percent less material than used in the Mark IV. Significantly over a six-year period we reduced the amount of Aroclor per capacitor rating by 66 percent.

We are now faced with the problem of discharges from the water seal pumps and from the washer. Our first attempt to correct this problem failed. However, we are working on the problem and again reviewing the alternatives, and will take another approach—hopefully, with considerably more success than the last attempt.

Our basic objective is to prevent the Aroclor from coming into contact with the water. We will be exploring new technology some of which may have been proven in a laboratory environment, but may not have been proven in a production environment. In any event, we expect to reduce discharges, but it will not happen overnight. As our plans are formulated, we will be reviewing them with the appropriate agencies. Others will be kept advised of our progress in technology. We will remain constantly alert to techniques others might develop to improve our own processing.

Voluntary and Regulatory Control

by
R. E. Wills, Jr., Attorney
Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

At the present time the use and control of PCBs has resulted from voluntary actions by industry. After four years under the Federal Water Pollution Control Act Amendment (FWPCA) of 1972, the U.S. EPA has not established justifiable standards for the discharge of PCBs based upon an adequate basis. I will set forth the activities Westinghouse and the electrical manufacturing industry have taken since 1970. After which I will review those actions taken by governmental bodies as they relate to PCBs.

The accumulation of proof, in 1971, indicated that uncontrolled industrial applications of polychlorinated biphenyl compounds (PCBs) was contaminating the environment. Consequently, in the absence of federal and state action, industry was required to begin appropriate restraints. The single domestic supplier of PCBs restricted sales for use in only "closed-system" electrical applications, such as the capacitor demonstrated here. This voluntary effort removed approximately 40 percent of the PCBs used in the United States.

Additionally, manufacturers initiated specific control measures that Mr. Sawyer covered. However, to strengthen and supplement these control measures, the electrical industry, through the National Electrical Manufacturers Association (NEMA), started to develop standards and guides to prevent the inadvertent loss of PCBs to the environment. NEMA appropriately included all stages from initial manufacture of PCBs to ultimate disposals. This work resulted in an industry document Official Standard Proposal which was published January 25, 1973.

Guidelines for plant housekeeping, bulk fluid shipment, receiving and transfer, employe safety, control of water effluent, labeling and scrap disposal procedures are significant areas covered by the Official Standard Proposal. Further, the guide listed known facilities with capability to incinerate PCBs, or to maintain a regulated chemical and scientific landfill area.

Furthermore, the proposal recommended that PCBs used in capacitors should consist of homologs and isomers of chlorinated biphenyl with a low concentration of the higher chlorinated homologs, Aroclor 1016. These guidelines were formally adopted in January, 1974, as an American National Standards Institute (ANSI) of standards. On April 1, 1976, the U.S. EPA published a notice of recommended disposal procedures that are substantially in accordance with the ANSI guidelines. Unfortunately, the EPA did not indicate that this guidance had already been furnished to the industrial community on their own initiative.

Westinghouse also established preventive measures in handling and storage of new and scrap PCBs to prevent and/or control accidental spills of PCBs. These techniques are similar to those that have become requirements for oil under the provisions of Section 311 of the Federal Water Pollution Control Act Amendments of 1972. We have recently reviewed and updated these procedures, and they will probably not require substantial modification when EPA finally announces regulations for the control and containment of hazardous substances.

The EPA has also attempted to develop regulations that would control the discharges of polychlorinated biphenyls under the provisions of Section 307(a) of the Federal Water Pollution Act Amendments of 1972. This method of control seems to be a proper procedure, because regulations that develop will be based on complete scientific information. It will not subject industry to inconsistent or unrealistic requirements. Thus, on December 27, 1973, the EPA proposed effluent limitations for the control of PCBs. A major problem developed, however, during the course of the hearings.

Section 307(a) of the Act required EPA to establish the basis of the scientific information to justify the limits set. In addition, EPA was to consider the toxicity, the persistence, the biodegradability, the importance of affective organisms, and the effect on organisms, of the pollutant. As discussed by Mr. Kerns, PCBs are a class of chemicals whose individual members have widely differing combinations of physical, chemical and biological properties. The published literature clearly showed that the types of Aroclors that contained higher proportions of the five or more chlorine atoms per molecule were more persistent in the environment. The published data also stated that the lower chlorinated isomers were more rapidly metabolized or biodegraded. Therefore, it did not have the same accumulation potential.

However, EPA did not recognize these essential differences and used data related to the higher chlorinated homologs or isomers and some mixtures the electrical industry had terminated 10 years before. In fact, the EPA stated that it did not

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have an adequate basis upon which to promulgate justifiable standards which would have carried out the purposes of Section 307(a). There was almost no information submitted in the "Basis and Purpose" document that related to Arocior 1016 even though manufacturers of electrical capacitors had used this improved material for more than two years. Thus, at the end of the hearing and after expert witness from both sides had been examined, the proposed limitations were withdrawn. Later, during subsequent litigation, officials of the EPA stated that the record of the proceeding would not support their proposed limitations.

Since the conclusion of these hearings, the EPA has indicated that they intend to propose new effluent standards for PCBs. There is no indication that they have initiated any new studies to determine the toxicity and biodegradability of Arocior 1016. They, however, have pursued the course of public statements to use "public pressure" to eliminate PCBs used as dielectric fluids. Only after these public statements, has EPA begun to collect information on the use and need of PCBs in the United States and the extent to which they are discharged into the environment.

The Food and Drug Administration also took action in 1972 to limit the amount of PCBs that may be lawfully present in food, resulting from unintentional contamination. The tolerances were established in July, 1973. This provided that the edible portion of fish was limited to a concentration of 5 ppm. Based upon recent information, the FDA is reviewing this tolerance limit and published this decision on February 26, 1976. However, the FDA also stated that:

> "Surveillance data gathered by FDA and the U.S. Department of Agriculture subsequent to the effective date of the temporary tolerances...have shown that, with the exception of certain fresh water fish, the presence of PCBs in those foods subject to the tolerances continues to be sporatic, and that there has been an overall and substantial decline in frequency and levels. These data further show that the average daily dietary intake of PCBs is quite low and well within the margin of safety."
> (41 Fed. Reg. 8409, Feb. 26, 1976)

The States of Michigan and Indiana have taken action to eliminate PCBs from items, products or materials used in these states. Although Monsanto's ban in 1971 was voluntary, there was nothing to prevent some individuals from obtaining these compounds from overseas suppliers. Hence, these laws will effectively limit through a sliding scale of prohibition of PCB content over the next three years. Nevertheless, they recognize, as did the Interdepartmental Task Force on PCBs in 1972, that PCBs used in the electrical equipment industry continues to be indispensable. Accordingly, an exemption was provided for their use in a closed system as the dielectric fluid for an electrical transformer or capacitor. This exemption is to continue until it is documented that there are available substitutes to meet performance standards and environmental acceptance.

Westinghouse concurred with the Indiana proposal since it provides for statutory control over the use of PCBs in nonelectrical uses. It recognizes that substitutes must be available to minimize the risk of fire and explosion and the disruption of electrical service that might result if PCBs were banned before alternatives were found. Also, Monsanto has publicly stated that they will cease the manufacture of PCBs when there are adequate substitutes. Westinghouse and the entire capacitor industry will be willing to work with the Indiana Board of Health to implement this law as we have with the Underwriters Laboratory, Consumer Product Safety Commission, the Department of Commerce, and the Federal Energy Administration with respect to the welfare of the general public.

The electrical industry and Monsanto have taken the lead in reducing the amount of PCBs that may enter into the environment. These decisions have been based upon the criteria that have eventually become statutory requirements and have not resulted in subjecting the general public to increased risks of fire. In addition, these actions have not deprived the general public of energy during this period of energy conservation.



Distribution Apparatus Division
Westinghouse Electric Corporation
Bloomington, Indiana

NPC00007899

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John Eddy FYE POW

STATEMENT OF THE ELECTRONIC INDUSTRIES ASSOCIATION (EIA) BEFORE WISCONSIN'S DEPARTMENT OF NATURAL RESOURCES

AUGUST 29, 1975

RECEIVED
SEP 12 1975
LAW DEPARTMENT

EIA is a national association for the manufacture of electronic components and end equipment. I speak on behalf of that body today and represent 14 companies that operate 16 plants for the manufacture of capacitors in this country. None of these plants is located in Wisconsin.

1. What are capacitors and transformers?

   Capacitors and transformers are devices to store, control and direct the flow of electrical power efficiently and economically. PCBs are used as an insulating fluid in these devices.

2. Where capacitors and transformers are used

   PCB-filled capacitors are found, among other places, in outdoor lighting, fluorescent lighting, air conditioning and television receivers. PCB-filled transformers are found, among other places, in railroad cars, apartment houses, large office buildings, industrial plants, and utility substations.

3. Why are PCBs used?

   The primary reason for the use of PCBs in capacitors and transformers is their quality of nonflammability. While certain present alternatives do have other needed characteristics, no present alternative provides the nonflammability demanded by our customers and by due regard for public safety.

   Governmental agencies have recognized the need for the continued use of PCBs in restricted circumstances - namely, sealed electrical applications:

   > In 1972, the Food and Drug Administration exempted "the safe use of PCBs in electrical capacitors and transformers from the requirement that PCBs no longer be permitted in food-related establishments". (38 Federal Register 18096)
   >
   > In 1972, a federal interdepartmental task force found that continued use of PCBs in transformers and capacitors was "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". (Federal Report No. ITF-PCB-72-1; Accession No. Com-72-10419)

4. How we limit the discharge of PCBs

   While recognizing the need for continued use of PCBs in electrical applications, one may not ignore the need for strict control over the discharge of PCBs. Thus, our membership has implemented controls resulting in a total daily discharge of less than 11 pounds (.014% of the 79,000 pounds used daily).

   Our handling and disposal practices are in accordance with guidelines established by American National Standards Institute (ANSI). See ANSI-C107.1 [illegible]

Presentation by Richard Rollins
Vice-President, Engineering,
JARD Company, Bennington, Vermont

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770539

Westinghouse Public Relations

Westinghouse Electric Corporation
Westinghouse Building, Gateway Center
Pittsburgh, Pennsylvania 15222

Contact: James P. Daley
Telephone: (412) 255-3363

FOR USE: Immediate

WESTINGHOUSE DEVELOPS NON-PCB FLUID FOR USE IN CAPACITORS

BLOOMINGTON, Ind., Nov. 8 -- Westinghouse Electric Corporation announced today it has developed a fluid that does not contain PCBs (polychlorinated biphenyls) for use in power capacitors.

D. M. Sauter, general manager, distribution apparatus division, said capacitors using the new fluid will be phased into production in Jan. 1977.

"We are converting our manufacturing processes as rapidly as possible and will phase out the use of PCBs completely during 1977," Mr. Sauter said. "Orders for capacitors using the new fluid can be processed now for delivery starting in February."

Mr. Sauter said the new fluid, used as a coolant and insulator in capacitors, is biodegradable and has good environmental characteristics similar to mineral oil.

"We have been testing the new fluid for nearly a year in capacitors throughout the United States and feel it is the best substitute we could find for PCB fluids," he said. "This new fluid is combustible,

- more -

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In this important respect, capacitors using the fluid will differ from PCB power capacitors."

PCBs, which have been used in a wide variety of industrial and commercial applications for more than 40 years in the United States, are now considered an environmental problem.

The recently passed toxic substances control act bans the use of PCBs in 1979.

The new Westinghouse fluid, designated WEMCOL, is basically a simple hydrocarbon with the complex chemical name isopropylbiphenyl. It is a chemical commodity already in volume production for other uses.

In July Westinghouse announced that it would also discontinue the use of PCB fluids in power transformers.

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U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Form Approved OMB No. 44-R1367

MATERIAL SAFETY DATA SHEET

April 11,1975

Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SECTION I

MANUFACTURER'S NAME	EMERGENCY TELEPHONE NO.
Westinghouse Electric Corp.	412-256-5847
ADDRESS (Number, Street, City, State, and ZIP Code) Headquarters Industrial Hygiene, R&D Center, Pittsburgh, Pa. 15235	
CHEMICAL NAME AND SYNONYMS	TRADE NAME AND SYNONYMS Inerteen Coolant
CHEMICAL FAMILY	FORMULA

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
Chlorinated diphenyl (42% chlorine)	99.8	1 mg/m³
Phenoxypropene Oxide	0.2	10ppm

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)	594°F	SPECIFIC GRAVITY (H_2O=1) 60°F/60°F	1.381 to 1.392
VAPOR PRESSURE (mm Hg.) 4 mm 30 mm	at 302°F at 302°F	PERCENT, VOLATILE BY VOLUME (%)	--
VAPOR DENSITY (AIR=1)	--	EVAPORATION RATE (_____=1)	Very slow evaporating
SOLUBILITY IN WATER	Insoluble		
APPEARANCE AND ODOR	Nearly water white. Odor - characteristic.		

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used)	FLAMMABLE LIMITS	LEL	UEL
355°F Pensky Martins Closed Tester ASTM D93-66			
EXTINGUISHING MEDIA Dry Chemical			
SPECIAL FIRE FIGHTING PROCEDURES			
UNUSUAL FIRE AND EXPLOSION HAZARDS			

(Continued on reverse side)

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SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE
1 mg/m^3

EFFECTS OF OVEREXPOSURE
Irritation of eyes, nose, throat, and upper respiratory tract.

EMERGENCY AND FIRST AID PROCEDURES
Swallowing -- induce vomiting. Breathing -- remove person from vapor exposure area into fresh air. Administer artificial respiration if breathing has stopped. Eyes--irrigate with large quantities of water for 15 minutes. Skin--Thoroughly wash with soap and water. Remove contaminated clothing.

SECTION VI - REACTIVITY DATA

STABILITY	**UNSTABLE**		**CONDITIONS TO AVOID** Decomposed by hot surface
	STABLE	X	(600°C) and by electric arc.

INCOMPATABILITY *(Materials to avoid)*
--

HAZARDOUS DECOMPOSITION PRODUCTS
Hydrogen chloride, carbon monoxide, carbon dioxide, and small amount of phosgene.

HAZARDOUS POLYMERIZATION	**MAY OCCUR**		**CONDITIONS TO AVOID**
	WILL NOT OCCUR	X	

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Released or spilled--absorb in diatamaceous earth or Fuller's earth absorbent compounds.

WASTE DISPOSAL METHOD
(1) Do not pour into sewers or streams. (2) Incinerate at 2000°F or higher in incinerator with acid gas scrubber. (3) State approved waste disposal area. (4) Return liquid inerteen in drums to Monsanto Chemical Co., Dept. 246, Sauget, Illinois, W. G. Krummrich Plant.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION *(Specify type)*
Organic vapor respirator

VENTILATION	**LOCAL EXHAUST** if heated	**SPECIAL** Good general ventilation if used at normal room temperature.
	MECHANICAL *(General)*	**OTHER**

PROTECTIVE GLOVES Neoprene coated	**EYE PROTECTION** Monogoggle -

OTHER PROTECTIVE EQUIPMENT
Neoprene aprons to prevent work clothing from contamination.

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Store in area that is cool, dry, and well ventilated.
Prevent moisture from entering drum.

OTHER PRECAUTIONS
Do not heat unnecessarily.

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Polychlorinated Biphenyl- and Triphenyl-Induced Gastric Mucosal Hyperplasia in Primates

Abstract. Polychlorinated biphenyl or triphenyl ingestion by subhuman primates for 3 months produced hyperplasia and dysplasia of the gastric mucosa. The concentration of the biphenyl within the experimental diet was less than an order of magnitude greater than that occurring in random food samples sold in the United States and less than levels which have occurred in food products as a result of industrial accidents. The increased cellularity, abnormal dysplastic growth pattern, and invasion of the adjacent tissue region indicate compromised gastric function and are suggestive of an eventual neoplastic transformation.

Polychlorinated biphenyls (PCB's) have been widely used in industry for over 40 years as sealants, heat transfer agents, plasticizers, adhesives, and dielectric fluids in capacitors and transformers. Global environmental contamination (*1*) and their presence within the food chain have occurred through industrial accidents and improper disposal and misuses of the compounds (*2*, *3*). Polychlorinated biphenyls were reported in the United States in coho salmon in 1969 and then in milk fat (28 parts per million), poultry and eggs (4.2 ppm), fish (35 ppm), and cereals (less than 1 ppm) (*2*). The Food and Drug Administration is presently removing from the market known contaminated food samples which exceed 5 ppm. However, as a result of occult environmental and food exposure, significant levels of PCB's (over 1 ppm in adipose tissue) are present in over 30 percent of random samples taken from the general population of this country (*4*). Two separate, well-documented industrial accidents resulted in high concentrations of PCB's in rice oil (2000 to 3000 ppm), which was subsequently consumed by over 1000 people (*5*), and in fish meal (14 to 30 ppm) used for poultry feed (*2*). The effects of PCB's on humans include acneform skin eruptions, pigmentation of nails and skin, eye discharge, generalized swelling, weakness, vomiting, diarrhea, weight loss, and fetal toxicity (*5*). Additional effects observed in experimental animals fed the compounds include hepatic porphyria in chickens and rabbits (*6*), proliferation of hepatic smooth endoplasmic reticulum in rats (*7*), mice, and monkeys (*8*), increase in certain hepatic enzyme activities in rats (*7*) and kestrels (*9*), neuropathy in rats (*10*), lymphopenia and immunosuppression in rabbits and guinea pigs (*6*), and estrogenic activity in the rat uterus (*11*). In the study reported here dermatologic alterations including alopecia, edema, and acneform lesions and hepatic alterations including organ hypertrophy and proliferation of the endoplasmic reticulum were observed in the subhuman primate. In addition, a previously unreported lesion, hyperplasia and dysplasia of the gastric mucosa, occurred in all animals that were fed diets containing the chlorinated biphenyls and triphenyls (PCT's).



Fig. 1. (A) Normal pyloric glands of the gastric mucosa (*M*) are separated from the submucosa (*S*) by the muscularis mucosae (*m*). (B) Following polychlorinated biphenyl ingestion the hyperplastic mucosal glands penetrate the muscularis mucosae to form mucus-filled cysts of the submucosa. Cells lining cyst similar to area indicated by arrow (→) are magnified in Fig. 2. (×40; scale represents 500 μm).

Male rhesus monkeys ranging in age from 1½ to 2 years and having an average weight of 2.9 kg were used in this study. Six animals were fed a diet containing 300 parts of PCB (Aroclor 1248) per million and six were given 5000 parts of PCT (Aroclor 5460) per million in the diet, for 3 months. The remaining three animals served as controls. During the course of the experiment the animals were given access to 400 g of the experimental diet daily. The animals continued to eat throughout the experimental period, although there was a decrease in body weight of approximately 15 percent in both of the experimental groups. Within 1 month, all of the PCB-fed animals, and within 6 weeks, the PCT-fed animals, had hair loss from the head, neck, and back. A progressive, generalized, subcutaneous edema, particularly of the face, was manifested as swollen eyelids and lips. A purulent discharge exuded from the eyes, and isolated acneform lesions were present on skin areas devoid of hair. Liver hypertrophy (2.3 percent of the body weight in controls; 4.5 percent in the PCB group; 5.6 percent in the PCT group) was attributed mainly to a proliferation of the smooth endoplasmic reticulum observed electron microscopically. Edematous thickening of the stomach wall and marked hypertrophy of the pyloric and fundic gastric mucosa occurred.

The hypertrophic gastric mucosa was several times thicker than the control mucosa and was composed of greatly elongated hyperplastic glands containing mucus-secreting cells (Fig. 1). The cells containing basilar positioned nuclei, abundant slightly acidophilic cytoplasm, large vacuoles, and a microvillous border abutted on a basal lamina. Prevention of discharge of the secretion owing to the depth and apposition

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of the glands predisposed to the development of large mucous cysts. Glands of the fundic area which normally contain a variety of secretory cell types consisted primarily of mucus-secreting cells.

Widespread penetration of the muscularis mucosae and invasion of the submucosa by the mucosal epithelium (Fig. 1) was observed in the stomach of each experimental animal. Large cystic areas filled with mucus and lined with elongated mucus-secreting epithelial cells predominated in the submucosa. Other cells assumed a glandular pattern. Serial sections of the submucosal cysts demonstrated stratified arrangements of proliferating epithelial cells which penetrated the basal lamina and invaded the surrounding connective tissue of the submucosa (Fig. 2). Epithelial origin of the stratified cells was determined by the presence of nucleoli and similarity of the nuclei in size and shape to the nuclei of the epithelial cells lining the cysts. Occasionally, irregular hyperchromic nuclei and pleomorphic cells with mitotic figures were present in the cells of the stratified areas. The presence of inflammatory cells in the submucosa in proximity to the glandular and cystic changes was common.



Fig. 2. Glandular epithelial cells that have extended from the mucosa into the submucosa encompass large cysts (*C*). In some areas (→) the epithelial cells are stratified and penetrate into the connective tissue of the submucosa. The cell nuclei of the stratified area is similar in size and appearance to that of the simple columnar epithelium that lines the remainder of the cyst (see inset). Serial sections of the tissue confirmed the stratified arrangement of the epithelial cells (×250, inset ×640; scale represents 50 μm).

The increased cellularity of the mucous glands with invasion of the muscularis mucosae and accompanying inflammation noted above is histologically described as a hypertrophic gastritis. The extension of the mucosal epithelial cells into the submucosa and the presence of irregular stratified arrangements of epithelial cells within the submucosa are distinctly dysplastic patterns. The experimental concentration of biphenyls (300 ppm) within the diet which was sufficient to produce these conditions in subhuman primates in 3 months is about ten times the levels that have occurred in samples of milk (28 ppm) and of fish (35 ppm) reported by the U.S. Food and Drug Administration (2). This concentration is much less than the levels that have occurred in food products due to industrial accidents (2000 to 3000 ppm) (5).

The magnitude of the chronic effects which could be produced by PCB-induced hypertrophic gastritis is as yet undetermined. The nausea and vomiting following human consumption of PCB's are possibly a result of the gastric irritations. Weight loss by the experimental monkeys and human patients exposed to the PCB's may be related to gastritis. Replacement of the parietal cells by the mucus-secreting cells which occurred in the fundic glands of the more severely affected animals may result in achlorhydria and eventual pernicious anemia owing to the lack of intrinsic factor necessary for vitamin B_{12} absorption. Invasion of the muscularis mucosae and submucosa by the epithelial elements may lead to loss of integrity of the gastric wall with eventual erosion, ulceration, and hemorrhage, as was the case in monkeys fed chlorinated biphenyl dioxins (*12*).

Because interest in these environmental contaminants is only recent, investigative efforts have not yet determined the long-term carcinogenic potential of PCB's and PCT's. The association of chronic irritation with cancer, particularly of the stomach, cervix, oral mucosa, and bronchial epithelium, is well documented. These dysplastic cellular abnormalities of the hypertrophic gastric mucosa are likely due to chronic irritation but are at present short of neoplastic transformation. The development of hypertrophy, hyperplasia, and dysplasia of the gastric mucosa of subhuman primates necessitates clarification of the carcinogenic potentials of these compounds.

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Distribution and Metabolism of ^{3}H-2,5,2′,5′-tetrachlorobiphenyl in Rats[1] (38610)

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Recently, the effects of isomeric mixtures of polychlorinated biphenyls (PCBs) have received considerable attention. It has been reported (1, 2) that humans develop chloracne and subcutaneous edema and exhibit lethargy and nausea as a result of PCB intoxication. Nonhuman primates exhibit similar effects as well as pathological changes which include hypertrophy of the hepatic smooth endoplasmic reticulum (ER) and mucosal lining of the stomach (3–5). Alterations in protein levels and hepatic enzyme activity have also been observed in nonhuman primates after PCB intoxication. No gross abnormalities have been observed in rats, although similar hepatic ER and enzyme alterations have been noted (6, 7). In addition, it has been shown that the effect on hepatic function is increased as the chlorine content of the PCB isomers increases (8).

The necessity for further understanding of the distribution and metabolism of these compounds is evident. Since the complexity of the PCB mixtures makes such studies difficult, it has been necessary to use pure components. The compound 2,5,2′,5′-tetrachlorobiphenyl (TCB) has been shown to be one component of the PCB mixtures presently in use (9, 10).

Hutzinger *et al.* (11) were first to report hydroxylated metabolites of TCB in the excreta of rats and pigeons. However, structural confirmation of these findings was lacking. Yoshimura and coworkers (12) identified monohydroxy-tetrachlorobiphenyl among several phenolic metabolites of 2,4,3′,4′-tetrachlorobiphenyl in rat feces. Recently, Gardner *et al.* (13) have isolated and characterized three metabolites of TCB in rabbits. Two of the metabolites were identified as monohydroxy-TCB with the hydroxyl group located in the three or four position, while the third metabolite was identified as trans-3,4-dihydro-3,4 dihydroxy-TCB.

The presently reported study was undertaken to establish the distribution of TCB in the tissue and excreta of rats using ^{3}H-TCB. Further information was sought as to the amount of TCB metabolized and confirmative identification of these metabolites.

Materials and Methods. ^{3}H-TCB was prepared from 2,5,2′,5′-tetrachlorobenzidine by the method of Hutzinger and Safe (14). The compound was shown to be greater than 99% pure by gas liquid chromatography, with a specific activity of 1.15 μCi/mg after dilution with TCB. The compound was dissolved in corn oil as final preparation for dosage.

Four groups (three animals per group) of male Sprague–Dawley rats, weighing 92–103 g initially, were housed in metabolism cages and allowed to acclimate for 3 days prior to dosage. The rats were subsequently given a single dose of ^{3}H-TCB by gastric intubation. Each animal received 50.0 mg (56.5 μCi) of the compound in 0.5 ml corn oil. The animals were given access to unlimited food and water throughout the experiment. Feces and urine were collected at 24-hr intervals. The animals were sacrificed at 1, 3, 7, and 14 days and tissue samples collected for radioactivity analysis and histologic evaluation. All tissue and fecal samples (200–500 mg) were oxidized in a Packard Model 306 sample oxidizer, collected in Monophase 40 (Packard) scintillation cocktail, and the radioactivity measured in a Packard Tri-Carb liquid scintillation counter. Samples of blood and

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urine (0.5 ml) were treated similarly. In addition, subcellular fractions of the liver were prepared by the method of Hogeboom (15) and analyzed as described above.

Isolation and identification of metabolites were done on fecal and urine samples from the first 48 hr after dosage. Urine was freeze-dried and extracted with hexane and ethyl ether by two different methods. The first method involved hydrolyzing the sample after hexane extraction with glucuronidase-sulfatase (G-S) by the method of Reid *et al.* (16), followed by extraction with ethyl ether and a subsequent acid hydrolysis before a second ether extraction. The second procedure was similar to the above except no G-S hydrolysis was performed. Feces was extracted continuously first with acetone and then with methanol. TCB and metabolites were purified from the hexane extract of urine and acetone and methanol extracts of feces by thin layer chromatography and the samples analyzed by gas liquid chromatography, mass spectrometry, and infrared spectrometry. Ether extracts of urine could not be purified by TLC. These samples will be analyzed in future experiments upon development of a system for purification.

TLC samples were applied to silica gel 1B, flexible plates (J. T. Baker Chem. Co.) and developed with hexane, hexane:ethyl acetate (8:2), or hexane:acetone (1:1). The plates were scanned on a Model 7201 Radiochromatogram Scanner (Packard) and the peaks eluted with methanol for further analysis. GLC was done on a Model 7620A Hewlett–Packard gas liquid chromatograph fitted with an EC detector. Glass columns (⅛" id × 6') containing 2% Apiezone L on Gaschrom Q (100–120 mesh) at 215° were used. Argon-methane was used as carrier gas at approximately 40 cc/min. Samples for mass spectral analysis were collected from the GLC in capillary tubes which can be inserted directly into a MS-9 mass spectrometer (Associated Electrical Industries, Ltd.) equipped with a direct insertion probe. Samples for IR analysis were collected from the GLC on KBr in capillary tubes. A 1.5 mm KBr pellet was made with a KBr Ultra Micro Die (Perkin-Elmer Corp) and the IR spectrum measured on a Hitachi Model 247 Grating Infrared Spectrometer fitted with a beam condenser (Perkin-Elmer Corp.).



FIG. 1. Excretion of ^3H by rats for the first 8 days following a single oral dose of ^3H-2,5,2',5'-tetrachlorobiphenyl. Each point represents mean ± 1 SD for three rats. Daily excretion values for feces and urine after 8 days were less than 0.2% of dose.

Results. A. *Distribution.* The experimental animals appeared normal, exhibited normal weight gain, and in general showed no deleterious effects from the TCB dosage. Microscopically, the tissues showed no abnormalities. The greatest percentage of the recovered tritium was found in the excreta (Fig. 1). Approximately 66% of the tritium was excreted in the feces by 72 hr with an additional 10% recovered in the urine. At 14 days the total tritium in the feces and urine was 72.5 ± 5.7% and 12.9 ± 4.0%, respectively. Through the first 7 days the largest internal concentrations of tritium were located in the adipose tissue, blood, liver, and skin (Table 1). Significantly high concentrations of tritium were found in several other tissues at 24 hr (including the thymus, brain, lung, spleen, heart, small intestine, and muscle), but these values decreased rapidly and at 3 days were less than 2% of that present in the tissue containing the highest concentration, i.e., adipose tissue (0.243 ± 0.18% of dose/g). Although the specific activity of the blood (0.009 ± 0.002% of dose/g) was slightly higher, the levels throughout the body were generally constant (average: 0.004 ± 0.002% of dose/g) at 14 days.

In addition to the tritium present in the

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TABLE I. TISSUE CONCENTRATIONS[a] OF ^3H IN RATS AT 1, 3 AND 7 DAYS FOLLOWING A SINGLE ORAL DOSE OF ^3H-2,5,2',5'-TETRACHLOROBIPHENYL.

	1 day[b]	3 days[b]	7 days[c]
Adipose tissue	1.345 ±0.680	0.243 ±0.180	0.058 ±0.044
Blood[d]	0.593 ±0.193	0.126 ±0.017	0.044 ±0.019
Liver	0.281 ±0.055	0.035 ±0.001	0.008 ±0.002
Stomach	0.792 ±0.613	0.013 ±0.009	0.004 ±0.001
Kidney	0.540 ±0.082	0.010 ±0.002	0.005 ±0.00
Testes	0.143 ±0.037	0.012 ±0.006	0.005 ±0.003
Large intestine	0.445 ±0.147	0.011 ±0.004	0.003 ±0.001
Skin	0.344 ±0.144	0.026 ±0.007	0.005 ±0.002

[a] Percent of dose per g tissue ± standard deviation.
[b] Mean for three rats.
[c] Mean for two rats.
[d] Percent dose per ml.

excreta and specific tissues evaluated, 2.1 ± 0.57% of the original radioactivity was detected in the remaining tissues of the animals on the 14th day of the experiment. Total recoveries for 1, 3, 7 and 14 days were 36.8 ± 6.4%, 79.9 ± 11.2%, 82.6 ± 4.0%, and 87.6 ± 7.8%, respectively. The low recovery obtained for the 24-hr animals was probably due to the large quantity of tritiated compounds in the intestinal tract which was not measured. This conclusion is substantiated by the fecal excretion value for the 24- to 48-hr period.

Subcellular fractions of the liver showed the largest specific activity of tritiated compounds in the microsomal fraction (Fig. 2). Significant specific activities were also found in the mitochondrial fraction with relatively low specific activity in the nuclei.

B. *Metabolites.* The procedures employed in metabolite extraction and TLC separation produced six purified compounds of metabolized TCB. Since complete identification of all these compounds was not possible, it is not known if any are identical and hence each will be termed a metabolite.

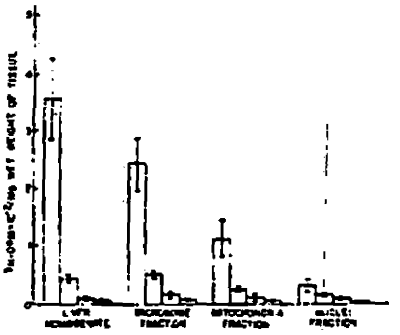


FIG. 2. Distribution of ^3H in liver homogenates and subcellular fractions of liver 1, 3, 7, and 14 days (L to R) following a single oral dose of ^3H-2,5,2',5'-tetrachlorobiphenyl. I signifies mean ± 1 SD.

TABLE II. DISTRIBUTION[a] OF TRITIUM IN EXTRACTS OF 24- AND 48-HOUR URINE FROM RATS GIVEN A SINGLE ORAL DOSE OF ^3H-2,5,2',5'-TETRACHLOROBIPHENYL.

Extract	24 hr G-S[b]	48 hr G-S[b]	24 hr	48 hr
Hexane	49.05	47.14	37.22	34.14
Ether-1[c]	33.71	20.67	11.11	7.37
Ether-2[d]	7.01	17.10	29.03	21.53
Aqueous	4.93	9.38	11.99	17.67

[a] Percent of freeze-dried urine.
[b] Glucuronidase-sulfatase-treated.
[c] Before acid hydrolysis.
[d] After acid hydrolysis.

Freeze-drying of the urine samples caused a loss of radioactivity between 50 and 65%. Table II shows the distribution of radioactivity remaining in the freeze-dried urine for the 24- and 48-hr urine samples. The percentage of radioactivity remaining after extraction is reported as percent in the aqueous phase. Glucuronidase–sulfatase treatment yielded a slightly improved recovery over the samples that were only acid hydrolyzed. No significant difference was noted between the 24- and 48-hr samples as to the amounts extracted or the metabolites found. A single metabolite (Metabolite 1) was isolated from the hexane extracts of the urine samples. No unmetabolized TCB was found in these samples.

The tritium recoveries in the acetone and methanol extracts of feces were 77.4%

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TABLE III. CHROMATOGRAPHIC DATA FOR METABOLITES OF 2,5,2',5'-TETRACHLOROBIPHENYL ISOLATED FROM 24 AND 48 HOUR FECES AND URINE SAMPLES FROM RATS GIVEN A SINGLE ORAL DOSE OF ^{3}H-2,5,2',5'-TETRACHLOROBIPHENYL.

Metabolite	Origin	Fraction	TLC solvent*	R_f	GLC retention time (sec)
I	Urine	Hexane	A	0.8	120
II	Feces	Acetone	B	0.4	125
III	Feces	MeOH	B	0.0	
			C	0.4	124
IV	Feces	MeOH	B	0.25	
			C	0.34	122
V	Feces	MeOH	B	0.0	
			C	0.0	
			A	0.6	134
VI	Feces	MeOH	B	0.0	
			C	0.0	
			A	0.45	137

* TLC solvents were: A—hexane:acetone (1:1); B—hexane; C—hexane:ethyl acetate (8:2).

and 18.4% respectively. It was found that 8.7% of the acetone fraction was unmetabolized TCB, while no unmetabolized TCB was found in the methanol extract. Of the remaining activity in the acetone fraction only one metabolite was isolated (Metabolite II) which after purification comprised 47.3% of the total radioactivity in the fraction. TLC of the methanol extract of feces yielded four additional metabolites (Metabolites III–VI). The TLC and GLC data for the six metabolites are given in Table III. Mass spectra were identical for Metabolites I, II, IV and V with a molecular ion at 306 a.m.u. indicative of monohydroxy-TCB. Low quantities of Metabolites III and VI made it impossible to purify these samples in sufficient quantities for mass spectral analysis. Metabolite II was identified on the basis of the mass spectrum and IR spectrum as 3-OH-TCB. The IR spectrum compared extremely well with that for 3-OH-TCB reported by Gardner *et al.* (13), although minor differences occurred due to the use of KBr pellets instead of CCl_4 solutions of the metabolites. No other metabolites could be purified in sufficient quantity for IR analysis. The identical mass spectra, however, led to the conclusion that metabolites I, II, IV and V are all monohydroxy-TCB, although the positions of the hydroxyl groups were indeterminable. The mass spectrum and IR spectrum for Metabolite II are given in Fig. 3.

Discussion. The data indicate that over 95% of the recovered tritium was in the excreta of which over 90% was metabolized. The unmetabolized TCB found in the feces was probably the portion of the initial dose which was not absorbed. The loss of radioactivity in the urine from freeze-drying is probably due either to loss of tritium during hydroxylation of TCB or to a greater ability of the hydroxylated metabolites to exchange tritium with water. At least 60% and probably a considerably larger fraction of the metabolites are in the form of monohydroxy-TCB. However, the possibility of dihydroxy-TCB as a major metabolite as reported by Gardner *et al.* (13) cannot be ruled out from these data.

Allen *et al.* (17) have reported significantly higher concentrations of Aroclor 1248, a mixture of polychlorinated biphenyls, in the lipid of chronically treated rats than was observed for similarly treated rats given 2,5,2',5'-tetrachlorobiphenyl. Furthermore, the proliferation of the hepatic endoplasmic reticulum and alterations of other hepatic functions are more severe for Aroclor 1248 than for the single isomer.

The present study shows that TCB is rapidly metabolized to one or more hydroxylated metabolites and excreted. There is apparently no appreciable storage depot for the compound within the animal, as the specific activities in the tissues are all reduced to very low values after 14 days. The relatively high specific activity in the blood of the animals indicates that the compound remains mobile until metabolized and excreted.

Gardner *et al.* (13) has reported that the probable mechanism for formation of hydroxylated metabolites of TCB is through an epoxide intermediate. It is likely that the components of Aroclor 1248 with higher chlorine content which cannot form epoxide intermediates are the cause of these major differences between Aroclor 1248 and TCB.

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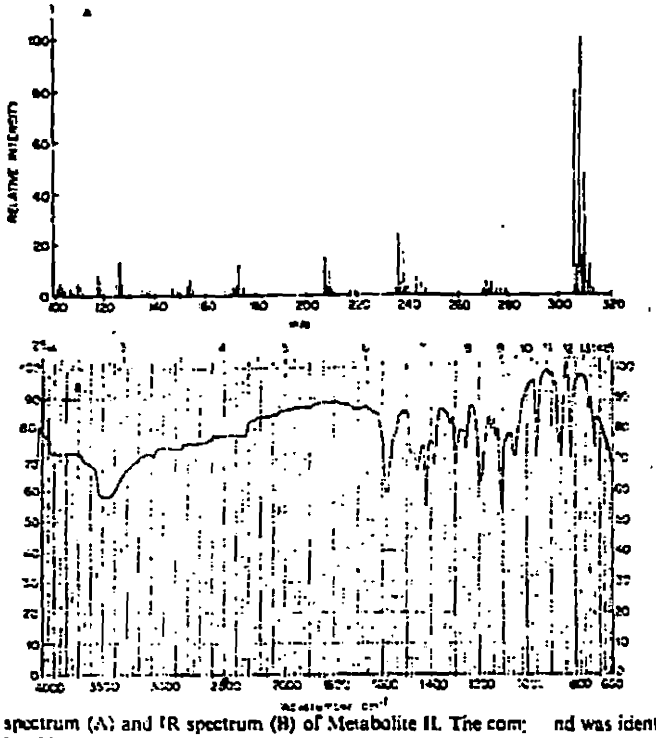


FIG. 3. Mass spectrum (A) and IR spectrum (B) of Metabolite II. The compound was identified as 3-OH-2,5,2′,5′-tetrachlorobiphenyl.

Acute lethal doses of TCB and Aroclor 1248 have been reported to be approximately 1.2–1.5 g/kg body wt. Further evidence of the importance of metabolism to toxicity is that both Aroclor 1248 and TCB were shown to be lethal to rats at significantly lower doses than 1.2 g/kg when metabolism was inhibited by administration of SKF-525A. Furthermore, no mortality was observed in rats at doses of 1.25 g/kg when metabolism was enhanced by treatment with phenobarbital (17). It thus appears that metabolism of polychlorinated biphenyls in rats is a method of detoxification of these compounds.

Summary. Distribution and metabolism of an isomeric polychlorinated biphenyl were determined in rats. Over 70% of a single dose of ^{3}H-2,5,2′,5′-tetrachlorobiphenyl was excreted in the feces and another 13% in the urine during a 14-day period. Adipose tissue, blood, skin, and liver were found to contain low levels of the compound. Over 90% of the excreted tritiated compound was found to be metabolized, the major metabolite being identified as 3-OH-2,5,2′,5′-tetrachlorobiphenyl. All of the unmetabolized 2,5,2′,5′-tetrachlorobiphenyl was eliminated by the alimentary route.

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Metabolic Fate of ^{3}H 2,5,2',5'-tetrachlorobiphenyl in Infant Nonhuman Primates

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During the past 40 years environmental contamination by polychlorinated biphenyls (PCBs) has become a serious problem because of their extensive uses in industry. Severe PCB intoxication in humans was reported in Japan following consumption of contaminated rice oil (KURATSUKE 1969). The majority of the research to date on the biological effects of the PCBs has been conducted on commercially prepared mixtures of these compounds. PCBs are a mixture of many chlorinated isomers; hence, the utilization of a pure individual isomer was more appropriate for the evaluation of their metabolic fate and biological effects. Recently, VAN MILLER et al. (1975) have reported that over 76% of a single dose of tritiated 2,5,2',5'-tetrachlorobiphenyl (TCB) was excreted by rats within 72 hours. In addition, most of the radioactivity in the urine was monohydroxy TCB. Because the primate is far more susceptible to the toxic effects produced by PCBs than the rat (ALLEN et.al. 1974) it was deemed important to evaluate the metabolic fate, site of localization, and excretion rate of the PCB isomers in the primate. In the presently reported experiment it was determined that the metabolic fate of TCB in the infant nonhuman primate was decidedly different than in the rat. At 72 hours a large percentage of the TCB was retained in the body in an unmetabolized form and was primarily associated with the serum proteins and cellular macromolecules. That portion of the TCB excreted in the urine was metabolized to dihydro-TCB diol which is not the case in rats.

MATERIALS AND METHODS

Tritiated TCB was prepared from 2,5,2',5'-tetrachlorobenzidine by the method of BUTZINGER and SAFE (1972). Specific activity of the tritiated TCB was adjusted to 6.1 uci/mg with TCB. Seven infant rhesus monkeys initially weighing 600-800 g were divided into two groups and housed individually in metabolism cages. The 4 monkeys of the experimental groups were given a single dose of tritiated TCB (500 mg/kg) dissolved in 1.5 ml of corn oil by gastric intubation. The 3 monkeys of the control group were given 1.5 ml corn oil. The animals had free access to water throughout the experiment and were intubated with 20 ml 5% glucose solution at 24 and 48 hours. Feces and urine were collected at 24 hour intervals. The animals were anesthetized, perfused intercardially with physiological saline, and sacrificed at 72 hours.

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Feces, blood, and urine (100-200 mg) samples were oxidized in a Packard Model 306 sample oxidizer with Monophase 40 (Packard) as the scintillation cocktail. The radioactivity was measured in a Packard Tri-Carb scintillation counter. Representative tissue samples were fixed in neutral buffered formalin and processed for light microscopic examination in a manner previously described (ALLEN et al. 1973).

Gas liquid chromatography (GLC) and thin layer chromatography (TLC) were employed to evaluate the metabolites in the extracts of urine and tissue homogenates. Samples for TLC were applied to silica gel, flexible plates (J.T. Baker Chemical Co.) and developed with methylene chloride. The plates were then scanned on a Packard Model 7201 radiochromatogram scanner. GLC was done on a Hewlett-Packard Model 7620A gas liquid chromatograph fitted with an electron capture detector. Two microliters of sample solutions were injected into a glass column (1/8" x 6') containing 3% SE-30 on Gaschrom Q (100-200 mesh) at 200°C.

The presence of trans-3,4-dihydro-3,4-dihydroxy-2,5,2',5'-tetrachlorobiphenyl (dihydro TCB diol) in the urine was determined by the method of GARDNER (personal communication). Urine was extracted twice with equal volumes of ether. The ether extracts were concentrated and chromatographed by TLC. Dihydro-TCB diol was converted to monohydroxy tetrachlorobiphenyl in methylene chloride containing 2 to 3 drops of concentrated H_2SO_4.

For determination of binding between TCB or its derivatives and tissue components (REID et al. 1973), 1 g liver was homogenized in a Potter-Elvehjem tube with 4 ml of water. Skin was homogenized in a Polytron (Brinkman Instruments) with 4 volumes of lytic solution (STEWART and FARBER 1973). The homogenates were extracted with hexane (5 ml x 3) and then an equal volume of 20% trichloroacetic acid was added to the aqueous phase at 4°C for 1 hour. The resulting precipitates were washed with methanol (5 ml x 4). The residues were air dried and weighed. About 100 mg of the residue was oxidized in the sample oxidizer, and the radioactivity was measured as described above. Aliquots of each fraction were added with 10 ml Scintisol Complete (Isolab) for measuring radioactivity.

Aliquots of blood serum (0.2 ml) or liver solution (0.1 ml liver homogenate + 0.2 ml lytic solution) were chromatographed by application to a Sephadex G-25 column (1 x 26 cm). The samples were eluted with distilled water with about 2 ml of the eluent collected in each fraction. The amount of nucleic acid and protein in the eluent was determined by measuring the UV absorption at 260 or 280 nm. One ml of solution from each fraction was added with 10 ml Scintisol Complete for counting the radioactivity.

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For polyacrylamide gel electrophoresis 8%-3% polyacrylamide gel was prepared. After serum samples were applied directly on the 3% gel which was covered with only a buffer layer, electrophoresis was performed at 4°C, pH 9.0 with 0.065 Tris borate as tank buffer and was continued for about 50 minutes at 280 volts (capacitance 1.0, pulse rate 200 pulse/second, Ortec 4100 pulsed constant power supply). The gels were stained for 1 hour in 7.5% acetic acid solution with 1% amido black 10B and destained overnight in 7.5% acetic acid solution. For measuring binding of TCB with serum proteins the gels were sliced into 0.5 cm sections which were then oxidized by a sample oxidizer for scintillation counting.

RESULTS

During the 72 hours following administration of TCB the animals were inactive, the skin was flushed and the hair had an oily appearance. At necropsy the livers of the experimental animals were enlarged and pale. Microscopically, there was a decided hypoplasia of the bone marrow, a decrease in the size of the Malpighian corpuscles of the spleen, a regression of the cortex of the thymus and a moderate fatty infiltration of the liver. Less than 2% of the tritium was eliminated in the urine and 1% in the feces by 72 hours. Skin, adrenal and bone marrow had the highest concentration of radioactivity (Table I). The concentration in the blood was low as opposed to relatively high concentrations reported by VAN MILLER et al. (1975) for rats. In addition to the blood, the radioactivity in the lungs, spleen, heart, thymus, brain, testes, lymph node and bladder were low; therefore, the results are not listed in the Table.

TABLE I

Tissue Concentrations[a] of ^{3}H in Infant Monkeys Following A Single Oral Dose of ^{3}H TCB

Tissue	Animal No. 301	302	303	304
Liver	3.5	3.5	8.4	1.6
Kidney	2.1	3.8	9.0	2.1
Large Intestine	0.9	2.7	5.2	15.3
Adrenal gland	5.4	1.4	18.3	10.6
Skin	8.9	6.8	7.5	14.8
Muscle	2.0	1.6	1.2	2.4
Pancreas	1.8	0.4	2.9	5.4
Salivary gland	1.5	6.6	---	4.8
Bone marrow	6.7	12.6	4.9	16.3
Blood[b]	0.2	0.7	0.2	0.3
Fat	---	---	---	3.0
Stomach	0.6	2.2	2.2	2.9

[a] Percent dose per g tissue (x100); [b]Percent dose per ml blood

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There were two radioactive bands with R_f values of 0.02 and 0.05 (Fig. 1) on TLC of the ether extracts of urine (30-40% radioactivity of urine). The methanol eluted substances from the band with R_f 0.5 did not show any significant peak on GLC for 30 minutes even when the oven temperature was set at 160 or 240°C. The labeled compound in this band is a new, unidentified metabolite. The second band with R_f 0.02 was eluted with methanol. Following the injection of the methanol eluent, a single peak with a relative retention time (RRT) of 3.09 (retention time of this compound [251 sec]/retention time of TCB [81 sec]) was seen on GLC. When the methanol solution was dehydrated, dried and dissolved in 1 ml methylene chloride containing 2 to 3 drops of concentrated sulfuric acid, the metabolite was converted to another substance with R_f 0.8 on TLC and RRT 1.94 (retention time 161 sec) on GLC. The ratio of retention time of this compound before and after dehydration was 1.54. GARDNER et al. (personal communication) reported similar values for dihydro TCB diol. These values were R_f 0-0.1 before dehydration with R_f values after dehydration of 0.9 and 0.8 for 3-OH TCB and 4-OH TCB, respectively. In addition, the reported value for the ratio of retention time is 1.52, agreeing well with the value given above.

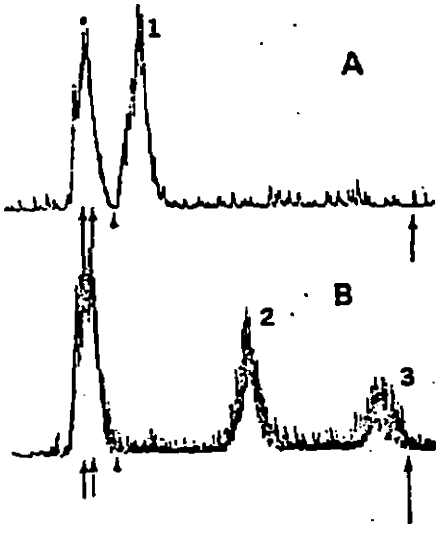


Fig. 1. TLC radiochromatogram of urine ether extracts from rats (A) and infant nonhuman primates (B) given a single oral dose of ^{3}H-2,5, 2',5'-tetrachlorobiphenyl (TCB). (1) 3-hydroxy TCB, (2) Unknown, (3) dihydro TCB diol. Δ = solvent front, ↑ = sample application, ↑↑ = tritium marker.

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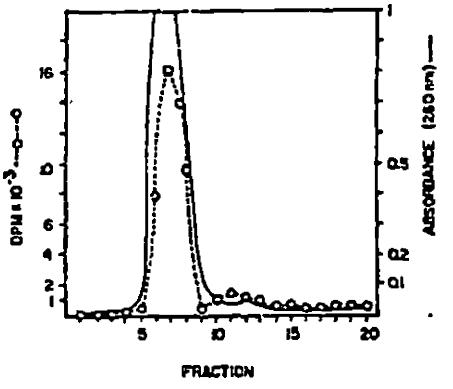


Fig. 2. Sephadex G-25 column chromatography of liver solution from infant nonhuman primates given a single oral dose of ^{3}H 2,5,2',5'-tetrachlorobiphenyl. ——— = absorbance at 260 nm; -o-o- = DPM per ml.

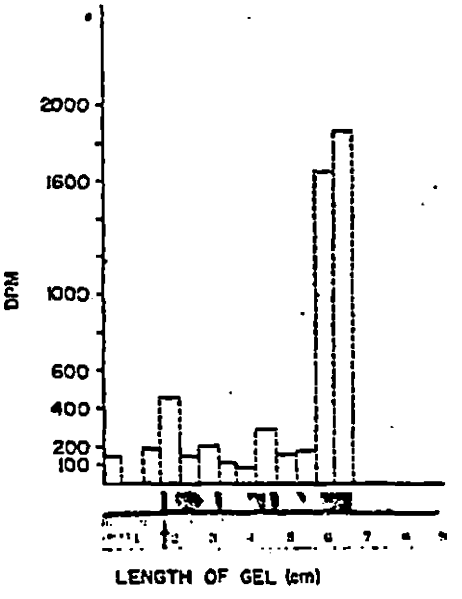


Fig. 3. Polyacrylamide gel electrophoresis of infant monkey serum 72 hr following a single oral dose of ^{3}H 2,5,2',5'-tetrachlorobiphenyl. † = junction of 3% and 8% gel (ORTEC 1973).

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For evaluation of the interaction of TCB and cellular components, Sephadex G-25 column chromatography and polyacrylamide gel electrophoresis were employed. Most of the radioactive labeled material was found to be associated with the cellular macromolecules and the serum proteins. As shown in Figure 2 more than 90% of the tritium was eluted from the Sephadex G-25 column, with most eluted with the protein and nucleic acid fractions of the liver homogenate. Further binding studies of serum by polyacrylamide gel electrophoresis showed (Fig. 3) that the radioactivity was primarily associated with serum albumin. When the liver homogenates were extracted with hexane, about 57% of the radioactivity was removed; 2.6% by trichloroacetic acid, and 27% by methanol, leaving only 1.1% of the radioactivity in the residue. A similar result was seen in the extraction of skin homogenates (Table II). It was estimated by GLC that more than 95% of the chlorinated compounds in the hexane extracts was unmetabolized TCB.

TABLE II

Percent of Radioactive Material in Various Solvent Extracts of Skin, Liver and Serum

Tissue	Percent of Total Radioactivity			
	hexane extract	TCA supernate	methanol extract	residue
Liver	57.0	2.6	27.0	1.1
Skin	85.1	4.2	6.2	0.38
Serum	50.3	---	----	----

DISCUSSION

The metabolic fate and toxicity of aromatic hydrocarbons have recently been reviewed by JERINA and DALY (1974). Direct hydroxylation (DALY et al. 1968) and hydroxylation through the arene oxide intermediate are the two major metabolic pathways of the aromatic ring. Metabolic formations of arene oxides which are capable of alkylating with a variety of nucleophils, including cellular macromolecules such as DNA, RNA and protein, explain many toxic and carcinogenic properties of aromatic hydrocarbons. Because of the identification of dihydro TCB diol (GARDNER et al. 1974) as one of the metabolites in rabbits after TCB administration the arene oxide 2,5,2',5' tetrachlorobiphenyl-3,4 oxide (TCB oxide) has been suspected of being a precursor of the hydroxylated metabolites and the active metabolites which cause biochemical and pathological

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changes in experimental animals. In the present study, a substantial fraction of the radioactivity in the urine is in the form of dihydro TCB diol. This result suggests that at least some of the TCB is metabolized through an arene oxide intermediate and further suggests that alkylation of the macromolecules should occur. Due to the slow rate of metabolism, as evidenced by the low level of radioactivity in the excreta and the high level of unmetabolized TCB in the tissues, it is likely that the amount of TCB covalently bound to the macromolecules is low. This is substantiated by the low levels of radioactivity in the residues of extracted tissue (Table II). This metabolic pathway may not cause significant acute toxic effects in monkeys. However, during long term exposure this arene oxide may be responsible for toxicity and possible tumor induction in monkeys. Indeed, induction of hepatomas by PCBs has recently been reported by KIMBROUGH and LINDER (1974). Since man and nonhuman primates show similar symptoms and lesions resulting from PCB exposure, they likely metabolize PCBs in the same manner. Due to the carcinogenic and toxicological potential of PCBs and their widespread presence in the environment, the human health significance of these compounds is of great importance.

It is of interest that there is a decided difference in the metabolism of TCB by rats and nonhuman primates (Fig. 1). Over 12% of the tritium was recovered in the urine of rats within 72 hours, most of which was metabolized as monohydroxylated TCB (VAN MILLER et al. 1975). The criteria of arene oxide formation are (1) occurrence of NIH shift; (2) appearance of glutathione conjugates; (3) formation of trans-dihydro diols or catechols (JERINA and DALY 1974). Arene oxides of halogenated compounds are usually more stable thus allowing the formation of glutathione conjugates or trans-dihydrodiol (DANSAY et al. 1972). However, only monohydroxy TCB can be found in the urine extracts of rats. Therefore, in rats hydroxylation of TCB appears unlikely through an arene oxide intermediate but rather through direct hydroxylation. The hypothesis is further supported by the evidence that direct hydroxylation of 2,4,5,2',4',5'-hexachlorobiphenyl occurs in rats (JENSEN and SUNDSTROM 1974). Since rats showed no deleterious effects from doses of TCB capable of producing distinct lesions in the nonhuman primate, direct hydroxylation in rats seems to be responsible for the detoxification and rapid excretion of these compounds.

The high specific activity of radioactive labeled material in the adrenal gland and skin of monkeys in this experiment is noteworthy because acne, skin lesions, and disturbance of steroid hormone metabolism, which occur in long term experiments (BARSOTTI and ALLEN 1975) may relate to the localization of TCB in those tissues.

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SOME OF THE RECENT FINDINGS CONCERNING YUSHO

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Abstract

Analysis of Yusho disease, which was first detected in 1968, has been limited and analyses have produced varying results. Yusho oil has been determined to contain a high level of polychlorinated dibenzofurans (PCDF's). Nagayama et al. found that PCDF levels in the oil were especially high when the oil was contaminated with PCB's used as a heat transfer medium. Their studies also showed that the concentration of PCDF's is much closer to that of PCB's in liver than in adipose tissues in patients with Yusho.

The current clinical state of patients with Yusho is dicussed at length. Subjective symptoms, dermatological findings, serum triglyceride levels, liver conditions, mortality rates, and the effects on children born to mothers with Yusho are all reported.

INTRODUCTION

More than 7 years have passed since the outbreak of an epidemic of Yusho in 1968. According to the latest tabulation, Prof. Omae, current chief of the Study Group for the Therapy of Yusho, reported that a total number of 1,291 patients have been registered as Yusho in 22 prefectures of Western Japan by April 30, 1975 (ref. 1).

We would like to describe some of the recent findings concerning Yusho which we think to be particularly relevant for understanding of toxicity of PCB's. For more detailed information, readers are advised to refer to original papers appearing mainly in the fourth and fifth reports of the study on Yusho and PCB (ref. 3). Most of the patients described in these reports are those living in Fukuoka prefecture. Published information of patients living in other areas are unfortunately very few, so with a few exceptions no reference will be made to them.

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PCB's IN THE BODIES OF PATIENTS WITH YUSHO

1. *Tissues*

First of all, the concentration of PCB's retained in the tissues and fluids of patients with Yusho should be referred to before their current clinical state will be discussed.

Although no accurate estimation is feasible because of the very limited number of analyses so far made, the concentration of PCB's in adipose tissues of patients seems to have been fairly high soon after the occurrence of poisoning—that is, in November 1968, at least 1 month after the discontinued use of the toxic rice oil by patients, as shown in table 1. The corresponding concentrations were considerably lower in 3 patients who died in the next year, 1969. However, no such marked difference could be seen between those who died in 1969 and the subsequent decedents, although cases 7 and 10, who died in 1970 or 1975, showed quite low levels of PCB's in adipose tissues. As compared with the figures available from a nationwide survey on residual PCB's in autopsied tissues, the levels noted in the recent decedents are considered to be fairly close to the usual level of ordinary autopsied materials. Similar facts were also noted for PCB concentration in the skin and liver.

2. *Blood*

Since the analysis of PCB's in blood started only after 1972, no figures are available in regard to the blood levels of PCB's in patients in the earlier stage of poisoning. As shown in table 2, however, it is clear that the blood levels of patients had approached the level of ordinary persons already in 1972, although they were still significantly higher than that level. This fact as well as the previous fact of lowered tissue levels of PCB's in recent decedents seem to be rather surprising if we consider also that the majority of patients are still showing various clinical symptoms, as will be discussed later.

3. *Gaschromatographic Patterns of PCB's in the Bodies of Patients*

Masuda first noted a peculiar common gas-chromatographic pattern of PCB fractions isolated from various tissues, blood, and breast milk of patients with Yusho and called the attention of the Study Group for the Therapy of Yusho to it in early 1972. Figure 1 shows a typical example of such a pattern in comparison

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Table 1. PCB's concentration in tissues of patients with Yusho and other diseases

Case	Time of death, operation	PCB's (ppm) Skin Whole basis	Skin Fat basis	Adipose tissue Whole basis	Adipose tissue Fat basis	Liver Whole basis	Liver Fat basis	Reference
Case 1 High school boy	Nov. 1968			76 (face) 13 (abdomen)				
Case 2, 3 Adult male, female	Nov. 1968			32, 46 (cheese-like substance from acneform eruptions)				10
Case 4 Boy, 13 yr	July 1969			1.3 (mesentery)	3.7	0.14	9.5	
Case 5 Male, 25 yr	July 1969	1.2	8.7	2.8 (mesentery)	15.1	0.2	10.4	
Case 6 Male, 73 yr	Nov. 1969	1.0	4.4	3.8 (mesentery)	8.4	0.07	3.1	11, 12
Case 7 Female, 48 yr	Dec. 1970	0.6	0.8	0.7 (mesentery)	0.9	0.07	1.3	
Case 8 Male, 46 yr	May 1972	1.8	3.2	4.3	6.5	0.08	8.4	
Case 9 Female, 33 yr	Sept. 1972			1.9 (subcutaneous)	2.9			
Case 10 Male, 72 yr	April 1975			0.19 (mesentery)	0.4	0.04	3.0	14
National survey Males and females 25 - 49 yr	1973	0.04 - 1.7 (n = 54)		0.2 - 4 (n = 47)	0.3 - 6.4 (n = 48)	0.01 - 0.6 (n = 51)	0.02 - 3.1 (n = 30)	13

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Table 2. PCB's in blood patients with Yusho, workers and ordinary persons

Material	No. of subjects	Time of examination	PCB's (ppb) Whole basis mean ± S.D.	Range	Reference
Whole blood					
Yusho patients	41	March - August 1973	7	2-26	7
Ordinary persons	37	1972	3	1-7	
Plasma					
Yusho patients	15		6.3 ± 4.0	2-15	
Normal persons	82		3.0 ± 1.3	1- 7	
Whole blood		Jan. 1972			8
Yusho patients	25		4.8 ± 2.9	1-12	
Normal persons	11		2.8 ± 1.5	1- 6	
Whole blood					
Workers[a]	23	1972	364 ± 262	60-920	9

[a]Workers engaged in the production of Kanechlor 200-600 in the air containing 0.05 to 0.2 mg/m^3 of PCB's [Kanechlor-300 + Kanechlor-400 (1:1)]. Two of them showed dermal signs.

with the common one seen in ordinary persons, which is very much close to that of a mixture of Kanechlor 500 + 600 (1 : 1). It is easily notable that the peak 1, which appears immediately after p,p'-DDE in the gas chromatogram in figure 1, is very low in patients with Yusho as compared with ordinary persons, while the peak 5 is much more prominent in Yusho than in ordinary persons. Masuda and his associates observed this peculiar pattern (designated as type "A") in blood of about 60 percent of patients with Yusho, and a somewhat similar pattern (designated as type "B") in about 37 percent (refs. 4,7,11,12).

Takamatsu et al. also observed the same peculiarity in the blood of patients with Yusho (ref. 8). It was further demonstrated that those patients who show the peculiar gas-chromatographic pattern as designated as pattern A by Masuda et al. have a higher average concentration of PCB's in their blood than do other patients (refs. 4,7). Abe et al. (ref. 23) examined in 1974 the PCB residues in the plasma of 30 children born to 18 mothers who had consumed Yusho oil at Goto Islands, Nagasaki prefecture. The specific gas-chromatographic pattern of type A was seen among 24 percent of the children and 44 percent of their mothers, but the peculiarity seemed somewhat less marked as compared with the one seen among patients in Fukuoka prefecture.

The chemical and toxicological nature of the compound or compounds yielding the above-mentioned peak 5 must be clarified but have not yet fully been examined. Masuda, however, considers the peak 5 to be 3,4,2',3',4',5'-hexachlorobiphenyl, judging from its retention time on the Apiezon L column developed by Jensen and Sundström (ref. 22).

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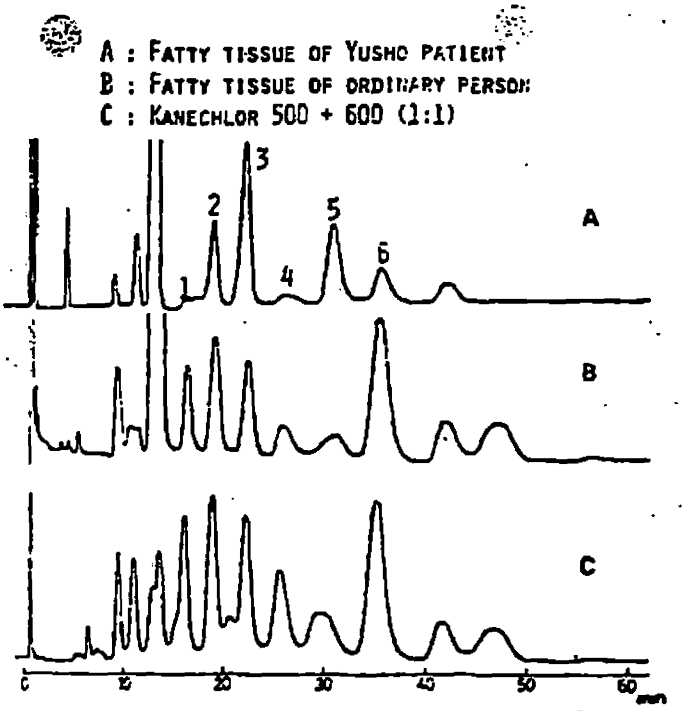


Figure 1. Gaschromatograms (ECD) of PCB's on SE-30.

POLYCHLORINATED DIBENZOFURANS IN KANECHLORS, "YUSHO OIL," AND TISSUES OF PATIENTS

1. *Polychlorinated Dibenzofurans in Kanechlors and "Yusho oil"*

Recently Nagayama et al. analyzed Kanechlors and three samples of toxic "Yusho oil" used by three independent families with Yusho for polychlorinated dibenzofurans (PCDF's) and polychlorinated dibenzo-p-dioxins (PCDD's) (ref. 16). They did a column chromatographic fractionation of PCDF's and PCDD's from a bulk of PCB's by using activated alumina as adsorbent, and n-hexane, n-hexane containing 20 percent carbon tetrachloride, or n-hexane containing 20 percent methylenchloride as eluent. The fractions thus obtained were subjected to gas-chromatographic and mass-spectrometric examination. Quantitative estimation of PCDF's and PCDD's was made by two methods, namely by measuring the gas chromatographic peak heights and by measuring the gas chromatographic peak area of perchlorinated derivatives of these compounds.

Although no PCDD's were found in any of these samples, PCDF's were found in all of them. As shown in table 3, KC-400 contained the highest concentration of PCDF's, about 18 ppm of PCDF's consisting of dichloro- up to pentachloro- dibenzofurans. A peak with the same retention time as that of 2,3,7,8-tetrachlorodibenzofurans, which was kindly provided by Dr. J. G. Vos, was noted in its gas chromatogram. All of the three samples of "Yusho oil" also contained about 5 ppm of PCDF's, the major constituents of which were tetra- and pentachlorodibenzofurans. Here again, the peak with the same retention time as 2,3,7,8-tetrachlorodibenzofuran was noted. Kashimoto also found 1.6 ppm of PCDF's in another batch of "Yusho oil," as shown in table 5 (ref. 18). Table 4 summarized the concentrations of PCDF's in Kanechlor-400, reported by several authors. As clearly noted, there is a fairly large discrepancy in their findings. Whether or not it was due to their analytical procedures or to batch difference cannot be decided at the present time.

Another important fact was disclosed by Nagayama et al. They determined the concentration of PCB's in "Yusho oil" as approximately 1,000 ppm or slightly less than 1,000 ppm, as shown in table 3. Since "Yusho oil" is known to have been contaminated with Kanechlor-400, the ratio of the concentration of PCB's to that of PCDF's in "Yusho oil" is expected to be about 1,000:0.018. The observed ratio, approximately 1,000:5,

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Table 3. PCDF's and PCB's in Kanechlors and Yusho oil

Sample		PCDF's (ppm)		PCB's (ppm)	
		Peak height method	Perchlorination method	Peak height method	Perchlorination method
Kanechlor	300	1	1.5	-	-
	400	18	16.6	-	-
	500	4	2.5	-	-
	600	5	2.7	-	-
Yusho oil	A	5	4.4	830	870
	B	4	5.1	900	920
	C	5	5.2	1030	980

Table 4. Reported concentrations of PCDF's in Kanechlor-400

Authors	Year	Concentration (PPM)
Roach et al.[a]	1974	1
Nagayama et al.[b]	1975	18
Kashimoto et al.[c]	1975	33

[a]Ref. 17.
[b]Ref. 16.
[c]Ref. 18.

was thus about 250 times higher than expected (table 5). The reasons for this great discrepancy are not clear yet. It should be noted, however, that the sample of Kanechlor-400 analyzed was an "unused" one, while the Kanechlor-400 present in "Yusho oil" was "used" as heat transfer medium. This fact suggests a practically important possibility that Kanechlor-400 and probably other commercial PCB's, too, will increase their PCDF concentrations when used as heat transfer medium.

2. *PCDF's in Tissues of Patients with Yusho*

Nagayama et al. (ref. 24) further examined the tissues of patients with Yusho for their possible content of PCDF's. Table 6 summarized their findings. Adipose tissues and liver from two ordinary persons who died of accidents contained no detectable amount (< 0.1 ppb) of PCDF's, but those from three patients with Yusho who died in 1969 or 1972 were all shown to contain PCDF's. Figures 2 and 3 show their gas-chromatograms and mass spectra. The concentration on a whole basis was 0.009 ppm on average for adipose tissues and 0.013 ppm for liver. This seems to be a rather surprising fact because in the case of PCB's the concentration on a whole basis is usually much lower in liver than in adipose tissues. When compared on fat basis, another interesting fact was noted that PCDF concentration was much higher in liver than in adipose tissue. Although the number

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Table 5. Concentrations of PCB's and PCDF's and their ratios in various materials

Materials		PCB's (ppm)	PCDF's (ppm)	PCB's / PCDF's	Reference
Kanechlor-400		1,000,000	ca. 20	50,000	16
Yusho oil	A[a]	ca. 1,000	5	200	
	B[b]	134	1.6	84	18
Patient with Yusho	Adipose tissue	1.3	0.009	144	24
	Liver	0.05	0.013	4	

[a]Samples of the rice oil produced on February 5 or 6, 1968.

[b]A sample of the rice oil produced on February 10, 1968.

Table 6. PCB's and PCDF's in tissues of patients with Yusho and ordinary persons

Subjects	Tissue	Case No.	Time of death	PCB's (ppm) Whole basis	PCB's (ppm) Fat basis	PCDF's (ppm) Whole basis	PCDF's (ppm) Fat basis	Ratio PCB's/PCDF's Whole	Ratio PCB's/PCDF's Fat
Yusho patients	Adipose	1	1969	1.4	3.4	0.013	0.03	108	113
		2	1969	1.3	8.5	0.006	0.04	217	213
		3	1972	1.2	2.1	0.007	0.01	171	210
		Avg.		1.3	4.7	0.009	0.003	144	157
	Liver	1	1969	0.05	4.7	0.025	2.3	2	2
		2	1969	0.06	5.6	0.010	1.1	6	5
		3	1972	0.03	3.5	0.003	0.3	10	12
		Avg.		0.05	4.6	0.013	1.2	4	4
Ordinary persons	Adipose	1	1975	1.0	1.4	ND	ND		
		2	1975	0.4	0.7	ND	ND		
	Liver	1	1975	0.08	1.3	ND	ND		
		2	1975	0.02	1.0	ND	ND		

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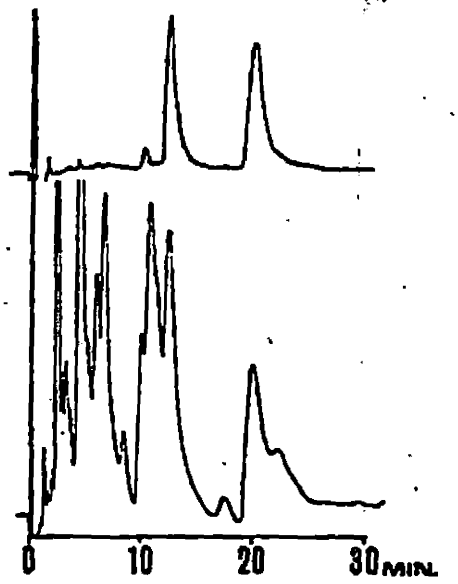


Figure 2. Gaschromatograms of PCDF fractions from liver of patient with Yusho and from "Yusho oil."

of analyses made is quite limited and nothing can be said with certainty, this fact seems to deserve attention. As shown in table 6, these different behaviors in tissue distribution of the compounds caused a remarkable difference in ratio of PCB's to PCDF's between adipose tissues and liver. It was thus demonstrated that the concentration of PCDF's is much closer to that of PCB's in liver than in adipose tissues in patients with Yusho. The PCDF's identified in liver were mainly penta- and hexachlorodibenzofurans; containing only a trace of tetrachloroisomers.

CURRENT CLINICAL STATE OF PATIENTS WITH YUSHO

In 1974, Prof. Urabe (ref. 2), former chief of the Study Group, reported that the dermal and mucosal signs that were most marked at the incipient stage of the poisoning had gradually been improved, while symptoms such as general fatigue, poor appetite, in constant abdominal pain, heavy headedness and headache, feeling of numbness and pain at the limbs, and cough and expectoration of sputum, all of which are considered to be due to some internal disturbances, have become more prominent year by year. In view of these tendencies together with the discovery of a characteristic gas-chromatographic pattern of PCB's remaining in the blood and tissues of patients, the diagnostic criteria for Yusho was revised in 1972 (ref. 2), as shown in table 7. As compared with the former one, the revised criteria describe briefly the dermal and mucosal lesions but newly refer to other noncutaneous objective signs and findings from several laboratory tests. It should be noted, however, that the new criteria do not refer to any specific liver function tests.

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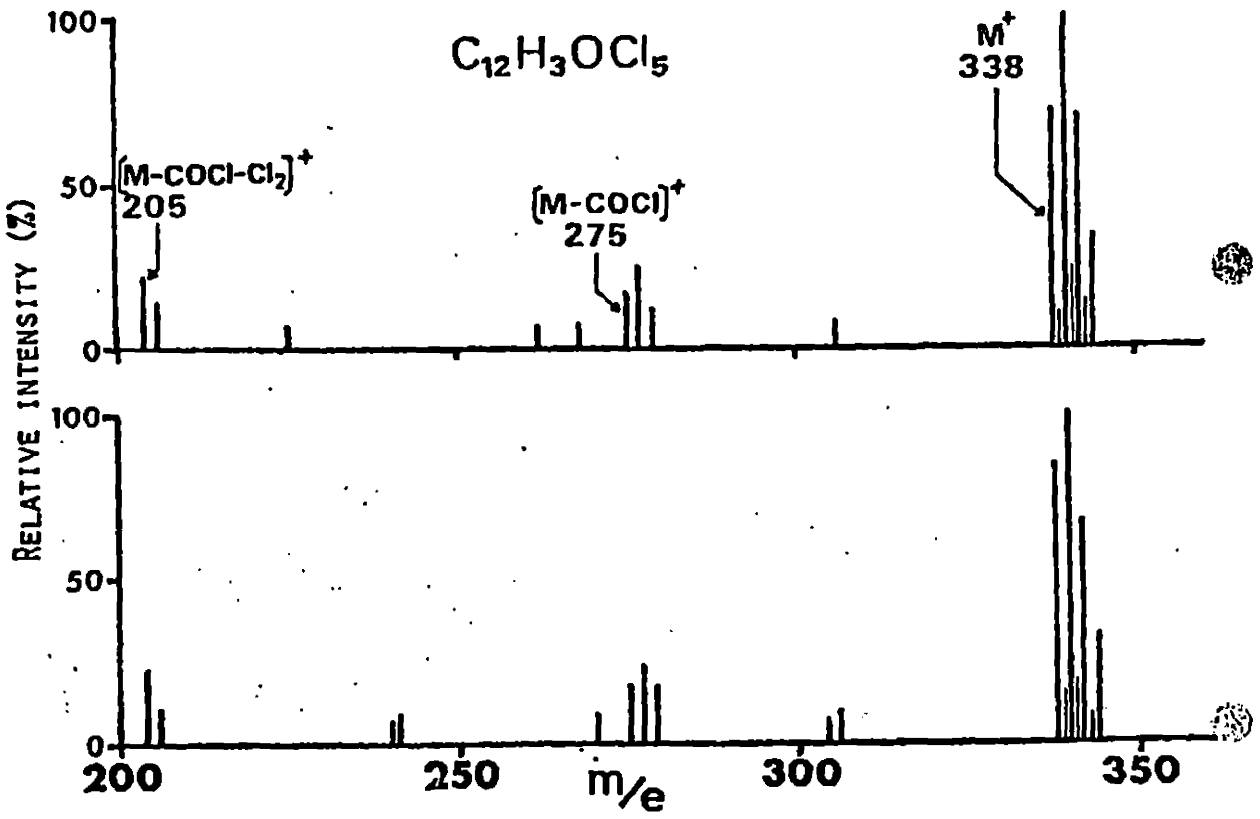


Figure 3. GC-MS of PCDF's fraction from liver of patient with Yusho (upper) and of synthesized PCDF's (lower).

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1. *Subjective Symptoms*

Table 8 shows that a considerable portion of the patients are still suffering from various subjective symptoms in recent years. Koda and Masuda examined their possible association with PCB concentrations in blood, finding no positive association at all (ref. 4). Umeda also reported on various symptoms due to disturbances of higher nervous activities (e.g., forgetfulness) complained of by most patients, but no definite association between such symptoms and the blood levels of PCB's was observed (ref. 5).

2. *Dermatological Findings*

Koda and Masuda examined 72 patients with Yusho for dermatological signs and PCB levels in the blood from April 1973 to March 1974 (ref. 4). As shown in table 8, the majority of patients were still suffering from skin lesions such as pigmentation, deformation of nail, and hypersecretion of Meibomian gland even 5 years after the poisoning. They also demonstrated another important fact that group A, consisting of patients whose blood shows the gas-chromatographic pattern A, had significantly higher prevalences of dermatologic signs such as pigmentation, acneform eruption, and deformed nails than did group B, which consisted of patients showing no such typical gas-chromatographic pattern.

Since group A had a higher average concentration of PCB's than group B, the dermal lesions seen among current patients, contrary to the subjective symptoms, seem to be causally associated with the current level or pattern of PCB's remaining in their blood. However, no conclusion could be readily made in this regard. First of all, the current excess of PCB's in the blood of patients is not remarkable in degree and is almost negligible as compared with the enormous elevation seen among the occupationally exposed workers, who nevertheless showed a rather low prevalence of dermal symptoms (table 2).

It seems rather hard, therefore, to explain the persisting dermal lesions by elevated PCB levels in blood alone. The chemical peculiarity of such PCB's and the presence of PCDF's in the bodies of current patients seem to be particularly important in this connection. However, our present knowledge does not allow us to continue discussion of the matter along this line without speculation. Furthermore, an entirely different explanation might also be possible. The skin lesions currently seen may merely be the persisting original skin lesions, the severity of which must have been determined primarily by the amount of intake of PCB's; such intake must in turn be reflected by the current PCB levels in blood of patients. According to this explanation, the

Table 8. Frequency of subjective symptoms complained by patients with Yusho from 1973 to 1974

Symptoms	Proportion[a] %
Fatigue	51.4
Headache	41.7
Phymata in articular region	8.3
Fever	2.8
Cough and sputum	56.9
Digestive disorder	40.3
Numbness of extremities	33.3
Menstrual disturbance	26.9
	(7/26)

[a]Calculated by Kuratsune from original figures published by Koda and Masuda (ref. 4).

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[a]Calculated by Kuratsune from original figures published by Kōda and Masuda (ref. 4).

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Table 9. Prevalence of dermatological and other signs among patients with Yusho from April 1973 to to March 1974, in connoction and gaschromatographic pattern of PCB's in blood

Signs		Prevalence (%)[c] Group A (43 cases)	Group B (26 cases)	Group C (33 cases)	Total (72 cases)
Pigmentation	Skin	51.2[b]	0	0	30.6
	Palpebra	72.1[b]	19.2[b]	0	50.0
	Gingiba	95.3[b]	57.7[b]	66.6	80.6
	Nail	74.4[b]	34.6[b]	0	56.9
Acneform eruption		34.9[b]	0[b]	0	20.8
Comedo		34.9	23.1	0	29.2
Infection of skin		32.6	11.5	0	23.6
Deformation of nail		65.1[a]	38.5[a]	0	52.8
Alopecia		0	3.8	0	1.4
Disorder in teeth		18.6	7.7	0	13.9
Dypersecretion of Meibomian gland		93.0	80.8	100.0	88.9
PCB's in blood	Conc. (ppb) Avg. ± S.D.	7.2 ± 4.9	4.3 ± 3.1	1.7 ± 0.2	5.9 ± 4.5
	Pattern	A[d]	B[d]	C[d]	

[a]Significant ($P < 0.05$) difference.

[b]Significant ($P < 0.01$) difference.

[c]Calculated by Kuratsune from figures published by Kōda and Masuda (ref. 4).

[d]"A" means the characteristic gaschromatographic pattern of PCB's remaining in the body of most patients with Yusho. "B" means gas chromatographic patterns somewhat similar to "A". "C" means patterns indistinguishable from those of normal persons.

observed association of the dermal lesions with current blood levels of PCB's is considered as a phenomenal one but not as a causal one. In order to evaluate these different possibilities, it seems essential to examine chemically and toxicologically the PCB's and PCDF's still remaining in patients' bodies.

3. *Serum Triglyceride*

One of the most dominant objective signs seen at the incipient stage of Yusho was a markedly increased concentration of serum triglyceride. Okumura and his associates reported recently the results of their extensive followup study on 40 patients who were examined for

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serum triglyceride at least once a year successively for 6 years from 1969 to 1974 (ref. 19). As shown in table 10, a group of 14 male patients has shown no significant change in serum triglyceride levels since 1969, still maintaining levels as high as 160 ± 118 mg/100 ml even in 1974. For 26 female patients, however, a significant decrease was seen in 1973 and 1974 when compared with the levels in the previous years. However, 42 percent of them still showed higher levels than 110 mg/100 ml in 1974.

Okumura et al. (ref. 20) examined the possible association between serum triglyceride levels and PCB concentrations in blood in patients. As shown in table 11, they observed a significantly higher mean level of serum triglyceride in a group of patients who showed the characteristic gas chromatographic pattern A, as compared with other patients who did not show such a typical pattern. They also observed a significantly positive correlation between serum triglyceride levels and PCB concentrations in blood ($r = 0.485$).

Table 10. Results of followup study on serum triglyceride levels in patients with Yusho[A]

Subjects	PCB's pattern	No. cases	Age mean	PCB's in blood (ppb)	Triglyceride mg/100 ml	Reference
Patients with Yusho	A	20	31.9	8.6 ± 5.2[b]	134 ± 60.0[a]	
	B	14				
	C	2	21.4	3.8 ± 2.2[b]	91 ± 39.8[b]	20
Controls	C	37	34.5	2.8 ± 1.6		
Controls					74 ± 29	19.21

[a] $P < 0.05$.

[b] $P < 0.005$.

Table 11. PCB's concentrations in blood and serum triglyceride levels in patients with Yusho in 1973

Patients			Triglyceride (mg/100 ml) Mean ± S.D.					
Sex	Age	No.	1969	1970	1971	1972	1973	1974
Male	11 - 73	14	159 ± 57	166 ± 55	169 ± 60	174 ± 69	164 ± 68	160 ± 118
Female	7 - 59	26	155 ± 75	161 ± 70	155 ± 80	153 ± 63	129 ± 50[b]	111 ± 56[b]

[a] Cited from a report by Okumura et al. (ref. 19).

[b] Significantly lower than in 1969, 1970, 1971, and 1972 ($P < 0.05$).

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Here again, a similar question can be raised in regard to such observed correlation, as already discussed in connection with the dermal lesions. Are the current elevated levels of PCB's in blood and their peculiarities in gas-chromatographic patterns causally connected with the abnormally high serum triglyceride levels found in patients? Since, as mentioned, the female patients started to decrease in serum triglyceride concentration in recent years, a followup examination of PCB's in their blood might give a good clue to answer the above question.

4. *Liver of Patients with Yusho*

Both PCB's and PCDF's are well-known toxic agents to the liver. PCDF's seem to be particularly toxic because a single oral administration of PCDF's as small as about 1 mg/kg could kill rabbits by severe liver necrosis (refs. 28,29). Therefore, it is reasonable to expect that patients with Yusho would have a severe liver damage. Okumura et al. (ref. 30) performed detailed medical examinations on 24 patients soon after the onset but, unexpectedly, obtained no objective findings to indicate definite liver disorders. No patients presented jaundice and only three of them had palpable livers. However, an electron microscopic examination of liver biopsy specimens conducted on a patient in February 1968 revealed a marked hypertrophy of smooth endoplasmic reticulum, indicating stimulated enzyme induction in the liver (ref. 31).

Okumura examined 38 patients with various subjective symptoms for serum enzymes, including isozymes from 1971 to 1972 (ref. 32). An increase in a fraction of lactate dehydrogenase (LDH-5) and high titers in thymol turbidity tests were observed in some of the severe cases but no definite evidence for liver disorders was obtained. Recently Hirayama et al. (ref. 33) examined 121 adult patients with Yusho and 257 healthy adult controls for serum bilirubin, demonstrating a significant lower average concentration in the patient group than in the control. They also showed significantly negative correlations between serum bilirubin and blood PCB's in concentration ($r = -0.349$, $p<0.025$) and similarly between serum bilirubin and serum triglyceride ($r = -0.215$, $p<0.05$). They considered that a lowered concentration of serum bilirubin in patients seemed mainly due to an accelerated bilirubin disposal from the blood.

Hirayama et al. investigated 125 patients for Australia antigen and antibody by the immunoelectro-osmophoresis in 1971 (ref. 34). The antigen was positive in three, while the antibody was negative in all of them, indicating no difference at all in the prevalences between the patients and healthy controls. This finding seems to be important in connection with the future risk of cancer which patients might experience.

In view of all these findings, liver function tests currently available do not readily detect serious liver lesions in the patients, but it is highly desirable that adequate caution will continuously be paid to this well-known target organ of chlorinated hydrocarbons.

CHILDREN BORN TO MOTHERS WITH YUSHO

The birth of unusual babies from mothers who took "Yusho oil" during pregnancy is already well known (refs. 25,26). Their clinical features were dark brown pigmentation of the mucous membrane and the entire skin, gingival hyperplasis with pigmentation, a tendency to be small for the date, eruption of teeth at birth, hypersecretation of the Meibomian gland, and edema of the orbital area. Pigmentation of the skin disappeared in 2 to 5 months, followed by growth similar to that of normal babies.

It seems noteworthy, however, that babies with the dark brown pigmented skin continued to be born for a few years after the intake of "Yusho oil" was discontinued by mothers. Yoshimura reported on nine babies with such skin who were born to mothers with Yusho in Nagasaki prefecture from 1969 to 1972 (ref. 27). Three of such babies had been delivered by a patient from 1969 to 1971. Abe et al. (ref. 23) recently reported on PCB levels in the plasma of 30 children (aged 0–7) born to 18 mothers with Yusho in Nagasaki prefecture. Their examination was made in 1974. As shown in table 12, the PCB levels of these children were significantly higher than those of ordinary children but lower than the levels of their mothers. Their gas-chromatographic patterns of PCB's in plasma were already referred to earlier in this paper. Children fed on breast milk from mothers with Yusho tended to show a higher plasma concentration of PCB's than those who were not fed on such milk.

Yoshimura also reported an interesting case, where a baby was thought to have suffered from Yusho due exclusively to intake of PCB's through breast milk from a woman with Yusho (ref. 27). Very few data are available in regard to the concentration of PCB's in breast milk of mothers with Yusho. Masuda et al. found 0.03 – 0.06 ppm of PCB's in 5 samples of breast milk collected from a woman with Yusho within 5 days after delivery in 1973 (ref. 12). Masuda also found about 0.03 ppm of PCB's in another sample of breast milk collected a few days after a woman with Yusho delivered a baby with no dermal signs (ref. 14). The PCB levels in breast milk from patients with Yusho were therefore just within the normal range. However, the gas-chromatographic patterns of these samples were quite unique, the same as that characteristic for Yusho.

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Table 12. Concentration of PCB's in plasma of children born to mothers with Yusho

Subjects	PCB's in plasma (ppb)			Reference
	Subjects	Range	Mean ± S.D.	
Mothers with Yusho	18	3-33	11.2 ± 7.32	
Children born to above mothers	30	1-20	6.7 ± 4.28	23
Ordinary children	14	1-8	3.7 ± 1.97	

Table 13. Deaths seen among patients with Yusho[A]

Cause of death	Number
Malignant neoplasms	9
Stomach cancer	2
Stomach cancer + liver cancer	1
Liver cancer + liver cirrhosis	1[b]
Lung cancer	1
Lung Tumor	1
Breast cancer	1
Malignant lymphoma	2
Cerebrovascular lesion	3
Amyloidosis	1[b]
Osteodystrophia fibrosa	1[b]
Myocardial degeneration + pericarditis	1[b]
Status thymicolymphaticus	1[b]
Liver cirrhosis	1
Suicide	1
Senility	1
Traffic accidents	3
TOTAL	22

[a]Cited from a report by Urage 1974 (ref. 2).

[b]Autopsied cases.

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MORTALITY OF PATIENTS WITH YUSHO

Omae reported in 1975 that 29 deaths occurred among 1,291 patients with Yusho up to April 30, 1975 (ref. 1). Causes of these deaths were not given, however. Urabe also reported on 22 deaths seen among 1,200 patients until September 13, 1973, and referred to their causes (ref. 2). As shown in table 13, 9 of 22 deaths were caused by malignant neoplasms, suggesting a possible excess of deaths from cancer. Since some essential information needed for epidemiological analysis is not available to us, no further reference can be made with certainty to such a possibility at the present time.

CONCLUSION

As mentioned earlier, we demonstrated the presence of PCDF's in "Yusho oil" at a much higher concentration than expected. We also showed that PCDF's are relatively more concentrated in liver. Although neither the chemical nature nor the toxicity of PCDF's contained in "Yusho oil" and in the bodies of patients are known yet, our findings clearly indicate the necessity to pay greater attention to PCDF's for clarification of the nature of Yusho. Furthermore, our studies suggested the possible formation of PCDF's from PCB's when used as heat transfer medium. Beside this, another possibility that PCDF's might be formed by heating PCB's with peroxides, which are well known to be formed during heating cooking oils, should also be investigated.

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DISCUSSION

MR. ALLEN GREY (IIT Research Institute, Chicago, Illinois): Do you have any feel whether dibenzofurans concentrating in the body are more rapid in metabolism than the result of polychlorinated biphenyls?

DR. KURATSUNE: Unfortunately I have no definite idea. It is a more potent compound than PCB, I guess. I really cannot say.

DR. ORVILLE PAYNTER (EPA, Washington, D.C): Are there any reproductive problems or irregularities continuing for many years after the ingestion of these materials?

DR. KURATSUNE: There is some disturbance of menstruation. There have been some disturbances and there have been some related problems.

MS. DEBORAH A. BARSOTTI (University of Wisconsin, Madison, Wisconsin): Were there are doings that suspected any widespread gastic ulcerations or an erosion in the patients—gastric ulcers?

DR. KURATSUNE: No, I do not think so. Some of the patients had very persistent disorders of the intestines, disorders of the digestive system, but I do not know if they were suffering as a result of this or not.

VOICE: Any residual changes in the sebaceous gland during the autopsy?

DR. KURATSUNE: No, I do not know very much about it.

VOICE: I would like to ask one more question. Have you been able to specifically identify any of the dibenzofurans other than those in the body?

DR. KURATSUNE: You are asking if we could identify any of the dibenzofurans? No.

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Westinghouse

Inerteen Capacitors

INSTRUCTION BOOK

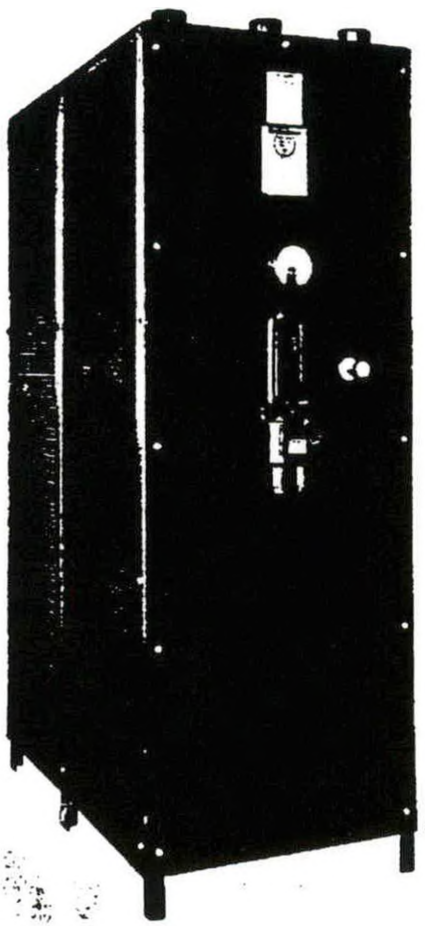


FIG. 1—LARGE GROUP TYPE FP INDOOR CAPACITOR WITH AMMETER AND TRANSFER SWITCH

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Inerteen Capacitors

GENERAL INFORMATION

1 -**Power Factor** Power [illegible] be defined as the ratio of the [illegible] to the apparent power [illegible] watts and volt amperes. [illegible] With a pure resistance [illegible] power expressed in watts [illegible] equal to the apparent power [illegible] in volt amperes so that the [illegible] is unity. A circuit having [illegible] and resistance takes a [illegible] lags behind the applied [illegible] power factor is less than [illegible] power circuit having [illegible] capacity takes a current [illegible] the applied voltage and [illegible] itself a power factor less [illegible] However, a combination [illegible] resistance and capacity [illegible] combined current which [illegible] with the applied voltage [illegible] or lagging. This is the [illegible] we approach or even [illegible] of paralleling capacitors [illegible] which inherently takes a [illegible]

2 -**Causes of Low Power Factor**—A low power factor is [illegible] equipment as induction [illegible] tion furnaces, transformers, [illegible] apparatus which take [illegible] magnetizing current.

3 -**Disadvantages of Low Power Factor**—Low power factor causes [illegible] rents, therefore the required [illegible] the lines and generators [illegible] comes large in proportion [illegible] load and hence to the kw [illegible] sold. It follows then that [illegible] ment in generating, transmitting, [illegible] distributing apparatus [illegible] necessarily increased.

High line currents mean [illegible] losses in the line and [illegible] carrying parts of all apparatus [illegible] in the production and [illegible] power.

Low power factor also causes [illegible] line drop and therefore poor [illegible] regulation.

4 -**Corrective Measures**—[illegible] factor may be improved [illegible] with the load, equipment [illegible] itself take a current which [illegible] applied voltage and thus [illegible] the lagging current of the load the leading current necessary to bring the line current more nearly in phase with the applied voltage. This equipment which provides the necessary leading current may be either a synchronous machine or a capacitor.

5 **The Capacitor**—The capacitor is composed of a system of metal plates and a dielectric in which electric energy is stored. Whereas the electro-magnetic system stores energy with a resulting lag in the current behind the voltage, the electrostatic system stores its energy with a resulting current leading the voltage. When proper proportions of magnetic fields and static fields are operated in parallel there follows a continual transfer of electro-magnetic and electrostatic energy from one to the other. The magnetic field [illegible] energy for the static field [illegible] vice versa. The wattless current [illegible] confined to the portion of the circuit between the electrostatic and the electro-magnetic apparatus. The power factor of the combination then becomes unity or near unity depending upon the size of the capacitor relative to the load.

In order to conveniently subject the dielectric material to uniform voltages, it is divided into many sheets spaced by metal, alternate layers of metal foil being connected together to form terminals. Various numbers of sheets are used between the foils depending upon the voltage. The kv-a. capacity of a given capacitor is a function of the area of dielectric material and the voltage per unit thickness applied to this material. The working voltage per unit thickness has been determined by [illegible] investigation. Factors of safety have been adopted which place this apparatus on the same basis of reliability as similar apparatus where insulation is a particularly important factor, as cables and transformers. Units for 2300 volts and above are tested at twice rated voltage plus 2000 volts for a minute, those for voltages below 2300 are given a one minute test at [illegible] rated voltage.

6 **Location of Equipment**—As [illegible] stated above, the wattless current is confined to the portion of the line between the capacitors and the load. This means that the apparatus should be placed as near the load as possible. The capacitor equipment is therefore supplied either as Group Correction capacitors or as Individual Motor Correction Capacitors.

7- **Results to be Expected.**

I. **Group Capacitors**

(a) The addition of the capacitor will raise the power factor if lagging.

(b) The current in the line from the point where the capacitors is connected to the power source will be less than before.

(c) Due to less current in the line, the line drop will be smaller and the line regulation will therefore be better.

(d) The addition of the capacitor will raise the line voltage slightly if it was previously low due to poor power factor.

(e) If the capacitors are connected on the load side of the power transformer the losses in these transformers will be less for the same kw load.

(f) The capacitor will take a current from the line, but this is practically all reactive, and therefore represents very little energy charge. The capacitor actually consumes an average of 3½ watts per kv-a. which may be considered negligible.

II. **Individual Motor Capacitors**—In addition to the results enumerated under "Group Capacitors."

(a) Line losses within the distribution system of the manufacturers plant will be reduced.

(b) Voltage will be raised at the motor terminals if it was previously low due to the reactive current taken by the motor.

In this case the motor performance will be improved by the increased voltage.

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8. Individual Capacitor Fuses Each type FP 3-phase unit is to be protected with type BA fuses and capacitor fuses one on single phase and two on two and three-phase units. This fuse is designed especially for use with and only with capacitors and is an adaptation of the well known high voltage boric acid or de-ion fuse.

A discharge condenser chamber is a part of the BA fuse that is used with units of 2300 volts rating and above. This condenser chamber, filled with copper wool, offers an extremely large surface to the expelled gases thereby acting as a surface condenser cooling, condensing and de-ionizing the evolved gases. This gas is steam, is inorganic and non-combustible.

This fuse is of such capacity that it will operate when and only when that particular capacitor unit is damaged. These fuses have sufficient interrupting capacity to remove a damaged unit from service without interruption in service of the remainder of the equipment. These fuses require no limiting resistance and will clear the circuit in ½ to 2 cycles under short circuit conditions. A fuse operation is indicated by a red button being blown out of the top end. This is the only capacitor fuse with an indicator of condition.

Distinctive Characteristics

1. Fire proof capacitor units.
2. Welded cases of .05 sheet steel for capacitor units.
3. Hermetically sealed capacitor units.
4. Soldered porcelain terminal bushings.
5. Welded frames. Sectional assemblies easily handled.
6. Boric Acid fuses (individual indicating type) Mounted on terminals—no fuse clips.
7. Completely enclosed circuit breaker.
8. Wire wound inductive type discharger.
9. Braided copper connections which avoid strain on terminals and loose connections where there is vibration.
10. Rugged terminal studs ½" diameter 13 threads to the inch.
11. Ample creepage over porcelain terminals and external flash over according to standard accepted factor of safety for the service.
12. Low in height and smaller volume and floor space due to terminal mounted fuses.

Service Conditions

Capacitors are designed for the usual service conditions as follows:

(a) When the ambient temperature or cooling medium does not exceed 40°C.

(b) When continuous operating voltage does not exceed the rated voltage by more than 15%.

(c) When temporary over-voltages do not exceed rated voltage more than 20%.

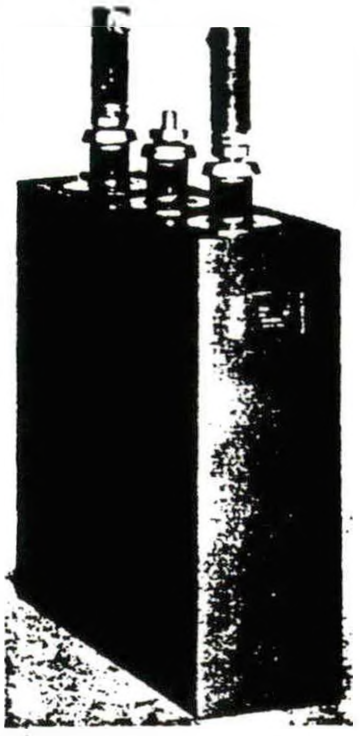


Fig. 3—10 Kva., 440 Volt, 3 Phase, Type FP Rack Type Capacitor Unit With Boric Acid Fuses Mounted on Two Sides

(d) When there are no damaging fumes conducting deposits, salt deposits. Such exceptional conditions require special precaution in the design.

(e) Where the wave form of the circuit does not depart from a sine wave sufficiently to give a total current which exceeds the sine wave current by more than 15%.

(f) Normal working voltage is taken as the average voltage over a 24 hour period.

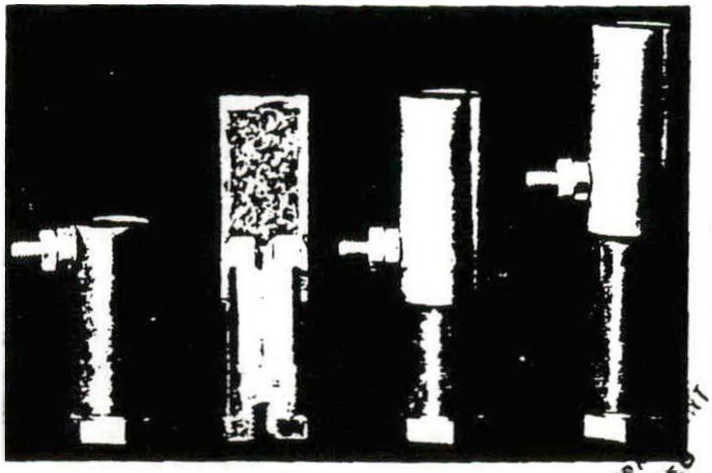


Fig. 2—Boric Acid Fuses—Sizes, Low Voltage 1100 Volt Cutaway and Solid, and 4600 Volt

CAPACITOR EQUIPMENTS

Standard Capacitor Equipment

All Westinghouse type FP capacitor units are impregnated with the non-inflammable Westinghouse capacitor liquid known as **INERTEEN** which prevents the installation from becoming a fire hazard if a unit is destroyed. These units are available in two forms (1) Rack and (2) Cabinet units.

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The Rack Type Capacitor Units – are to be installed in frames or housings that completely enclose the unit preventing accidental contact with their exposed terminals. They are supplied in 1 or 3 phase; 5 kv-a. at 230 volts and 5 and 10 kv-a. at 460, 575, 2300, 4000, 4600, 6000 volts.

The Cabinet Type Capacitor Units – are for separate mounting without supporting structure and consists of a Rack Unit mounted in an additional box with chamber enclosing the unit and the terminals. This terminal chamber has a removable cover and knockouts in the side for conduit connections. These capacitors may be connected directly to the motor terminals or they may be connected to the line with fused safety switches or circuit breakers to be supplied and installed by the customer. Discharge devices are mounted on the terminals for discharging the residual voltage. These units are available in 1, 2, 3 phase; $\frac{1}{2}$, 1, 2, 3, and 5 kv-a. at 230 volts and 1, 2, 3, 5 and 10 kv-a. at 460 and 575 volts.



FIG. 4—LARGE GROUP TYPE FP OUTDOOR CAPACITOR EQUIPMENT WITH OIL CIRCUIT-BREAKER AND HOUSING FOR 84 CAPACITOR UNITS.

LARGE GROUP TYPE FP CAPACITORS

Figures 5 and 6

230–460–575 Volt—3 Phase—60 Cycle

Kv-a.	WEIGHT IN POUNDS												DIMENSION A IN INCHES				Watts Loss
	230 VOLTS				460 VOLTS				575 VOLTS				230 VOLTS		460 OR 575 VOLTS		
	INDOOR		OUTDOOR		INDOOR		OUTDOOR		INDOOR		OUTDOOR						
	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.	Net	Ship.	Indoor	Outdoor	Indoor	Outdoor	
60	1300	1700	1500	2500									23	49			200
90	1800	2050	2100	2900									28¼	54⅝			300
120	2200	2450	2500	3300	1200	1700	1350	2500	1200	1700	1350	2500	34⅝	60⅝	23	49	400
150	2700	2800	3100	3700	1450	1900	1750	2700	1450	1900	1750	2700	41½	67⅛	28¼	54⅝	500
180	3050	3200	3500	4100	1600	2100	1900	2900	1600	2100	1900	2900	47	73	28¾	54⅝	600
240	4100	4300	4600	5300	2000	2400	2300	3300	2000	2400	2300	3300	58½	84⅛	34⅛	60⅛	800
300	5100	5100	5600	6100	2200	2900	2800	3900	2200	2800	2800	3700	71	97	41½	67½	1000
360					2700	3200	3150	4100	2700	3200	3150	4100			47	73	1200
420					3300	3900	3700	4900	3100	3900	3350	4900			52⅞	78⅛	1400
480					3650	4300	4050	5300	3650	4300	4050	5300			58½	84½	1600
540					4200	4700	4700	5800	4200	4700	4700	5800			65⅝	91⅝	1800
600					4500	5700	5000	6100	4500	5100	5000	6100			71	97	2000

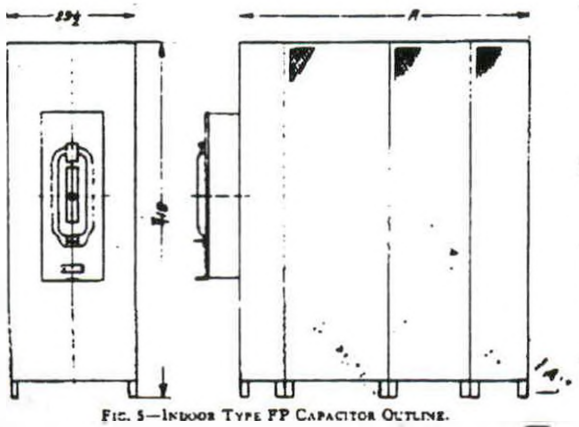


FIG. 5—INDOOR TYPE FP CAPACITOR OUTLINE.

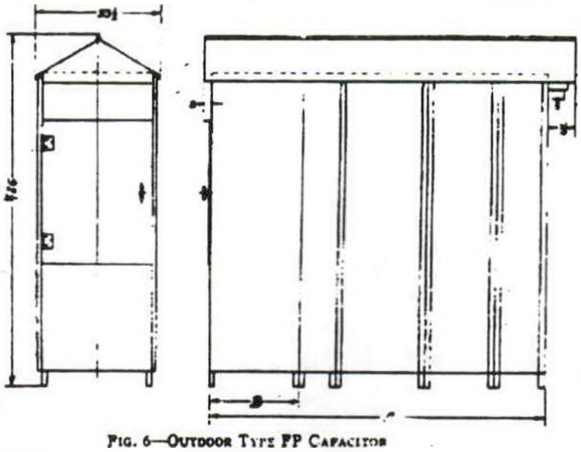


FIG. 6—OUTDOOR TYPE FP CAPACITOR

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LARGE GROUP TYPE FP CAPACITORS

2300–4000–4600–6900 Volts—60 Cycles

Figures 7 and 8

Kv-a.	2400 Volts—Wye Line				4800 Volts—Wye Line				Dimensions	
	Indoor		Outdoor		Indoor		Outdoor		A	Watts Loss
	Net	Shipping	Net	Shipping	Net	Shipping	Net	Shipping		
120	1300	2100	1450	2700	1400	2300	1550	2700	41	4000
150	1500	2300	1600	3000	1650	2600	1850	3050	46½	5000
180	1650	2500	1900	3400	1800	2800	2050	3400	46½	6000
240	2000	2700	2400	3600	2250	3200	2550	3600	52½	8000
300	2450	3200	2800	4100	2750	3700	3100	4500	59½	10000
360	2800	3500	3150	4400	3150	4100	3500	5000	65	12000
420	3100	3900	3500	4900	3500	4600	3900	5500	70½	14000
480	3450	4200	3850	5200	3900	5000	4300	6000	76½	16000
540	3900	4600	4350	5700	4450	5400	4800	6500	83½	18000
600	4250	5000	4700	6000	4850	5800	5200	7000	89½	20000
720	5050	6000	5550	7000	5750	7100	6250	8000	101½	24000
840	5700	6800	6250	8000	6550	8100	7100	9200	113½	28000
960	6400	7500	7000	8600	7350	8900	7950	10000	125½	32000
1080	7300	8500	8000	9700	8400	9900	9000	11000	137½	36000
1200	8000	9100	8700	10300	9200	10600	9900	11900	148½	40000

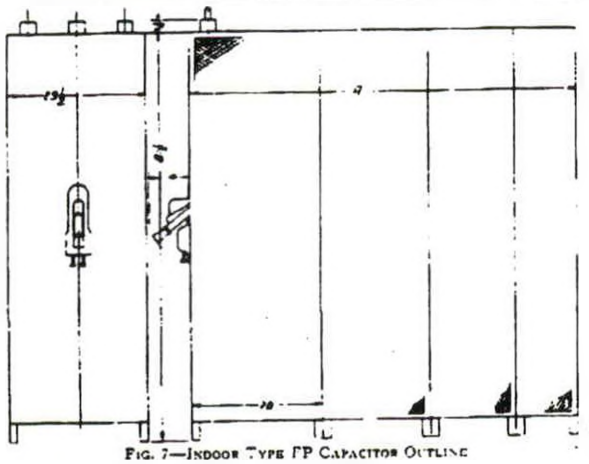


FIG. 7—INDOOR TYPE FP CAPACITOR OUTLINE

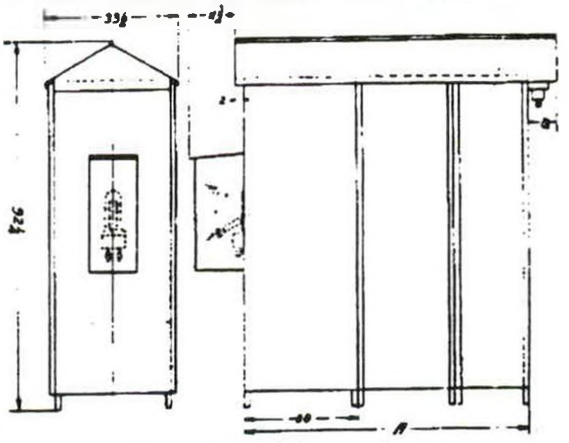


FIG. 8—OUTDOOR TYPE FP CAPACITOR OUTLINE

SMALL INDOOR GROUP TYPE FP CAPACITORS

Figure 9

2300–4000–4600 Volts—60 Cycles						
Kv-a.	Weights		Dimensions			Watts Loss
	Net	Ship	L.	W.	H.	
15	218	350	15	15	51	50
20	246	370	15	15	51	60
25	266	410	15	15	51	85
30	284	490	15	15	51	100
35	334	590	24	15	51	110
40	352	610	24	15	51	135
45	387	650	24	15	51	150
50	408	670	24	15	51	165
60	448	730	24	15	51	200
90	632	940	41	15	51	300
108	690	1000	41	15	51	335
120	776	1120	41	15	51	400

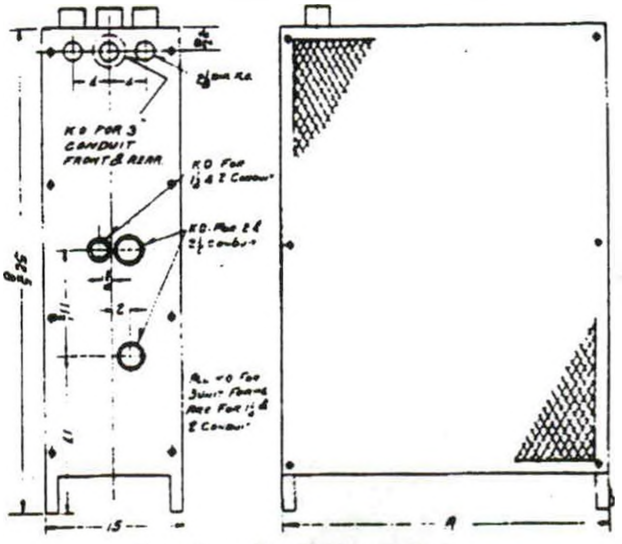


FIG. 9—INDOOR TYPE FP CAPACITOR OUTLINE

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CABINET TYPE FP CAPACITOR UNITS

Figure 10

1, 2 or 3 Phase 60 Cycles

Kvar.	Volts	Dimensions in Inches			Weights		Loss Watts
		Width	Length	Height	Net	Ship.	
5	230	43	14½	13½	45	90	10
5	460	43	14½	18½	55	100	17
5	460	43	14½	13½	45	90	17
10	460	43	14½	18½	65	110	34
5	575	43	14½	13½	45	90	17
10	575	43	14½	18½	65	110	34

POLE TYPE FP CAPACITORS

Figure 11

2300-4000-4600 Volts -60 Cycles Single or 3 Phase

Kvar.	Dimensions in Inches				Weights		Loss Watts
	A	B	C	D	Net	Ship.	
5	23½	19½	22½	41½	240	175	17
10	23½	19½	22½	41½	260	200	33
15	23½	19½	22½	61½	300	225	50
20	23½	18½	22½	61½	430	350	67
25	23½	18½	22½	61½	500	400	84
30	23½	18½	22½	61½	560	450	100
60	39½	34½	22½	61½	635	800	200
90	39½	34½	22½	61½	940	1100	300
120	39½	34½	22½	61½	1120	1500	400
150	56½	51½	22½	61½	1450	1700	500
180	56½	51½	22½	61½	1630	2000	600
240	51	46	22½	94½	2090	2500	800

SMALL INDOOR GROUP TYPE FP CAPACITORS

230-460-575 Volts 3 Phase—60 Cycle

Kvar.	Weights in Pounds				Dimensions in Inches				Loss Watts
	230 V.		460-575 V.		230 V.		460-575 V.		
	Net	Ship.	Net	Ship.	Dim. A	Fig.	Dim. A	Fig.	
15	240	320	140	210		12		12	50
20	480	580	160	230	23½	13		12	66
25	460	640	190	270	23½	13		12	84
30	520	600	210	270	23½	13		12	100
35	600	670	340	380	35	13	23½	13	116
40	660	660	360	380	35	13	23½	13	133
45	720	740	390	440	35	13	23½	13	150
50	780	800	410	440	35	13	23½	13	166
60			460	500			23½	13	200
100			680	800			35	13	333

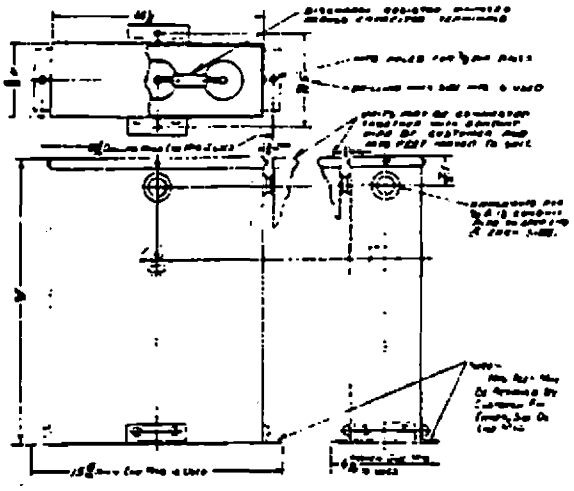


Fig. 10—Cabinet Type FP Capacitor Outline

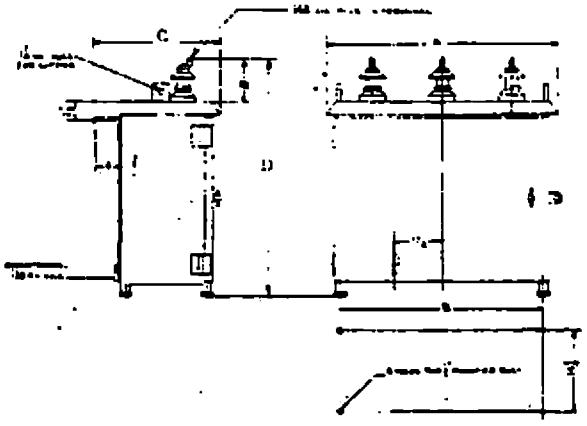


Fig. 11—Pole Type Capacitor Outfit Outline

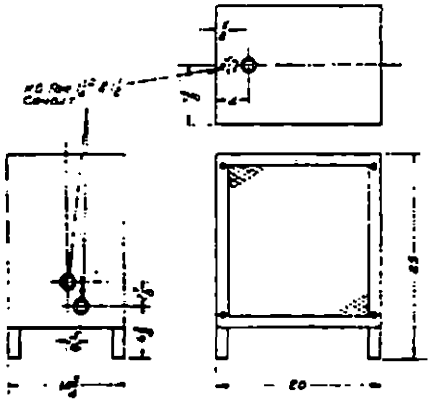


Fig. 12—3 Unit Power Capacitor Outline

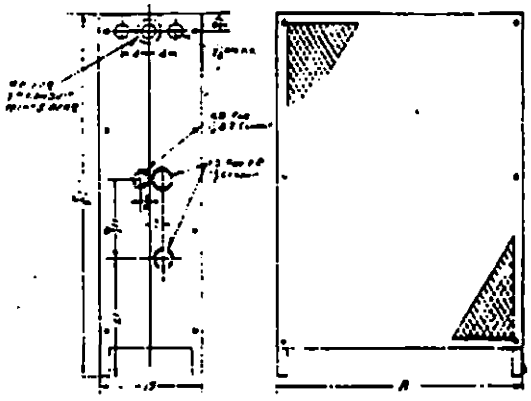


Fig. 13—Indoor Type FP Capacitor Outline

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TABLE OF NORMAL LINE CURRENTS

Current Per Phase in Amperes for Capacitors

Kv-a Rating	2 Phase—60 Cycles							3 Phase—60 Cycles						
	230 Volts	460 Volts	575 Volts	2400 Volts	4000 Volts	4600 Volts	6600 Volts	230 Volts	460 Volts	575 Volts	2400 Volts	4000 Volts	4600 Volts	6600 Volts
1	2.17	1.09	.87	...	...	...	....	2.51	1.26	1	...	...	...	..
3	6.52	3.26	2.61	...	....	....	....	7.54	3.77	3	...	...	...	..
5	10.8	5.4	4.4	1.09	.62	....		12.55	6.28	5	1.25	.72	.62	..
10	21.7	10.8	8.7	2.18	1.25	1.09	.75	25.1	12.55	10	2.51	1.44	1.21	...
15	32.6	16.3	13.0	3.27	1.87	....	....	37.7	18.9	15	3.77	2.16	1.88	...
20	43.5	21.7	17.4	....	....	....	....	50.2	25.1	20	5.02	2.89	2.50	..
25	54.3	...	...	...	...	....	....	62.8	31.4	25	...	...	...	...
30	65.2	32.6	26.1	6.5	3.75	3.26	2.27	75.4	37.7	30	7.54	4.34	3.77	2.61
35	76.0	....	....	....	....	....	....	88.0	...	...	...	...	...	...
40	87.0	43.5	34.8	8.7	5.0	4.35	....	100.5	50.2	40	10.05	5.78	5.02	...
45	97.7	48.8	39.2	9.77	5.61	4.9	....	113.0	56.5	45	11.3	6.5	5.65	..
50	108.9	54.4	43.5	10.9	6.25	5.45	....	125.5	62.8	50	12.5	7.22	6.28	...
60	130.4	65.2	52.2	13	7.5	6.53	4.35	150.8	75.4	60	15.1	8.66	7.54	5.25
70	....	76.0	60.9	15.2	8.75	7.6	....	....	88.0	70	17.6	10.1	8.74	..
80	....	87.0	69.5	17.4	10.0	8.7	....	....	100.5	80	20.1	11.5	10.05	...
90	195.5	97.7	78.2	19.6	11.3	9.8	....	226.2	113.0	90	22.6	13.0	11.4	..
100	....	108.8	87.0	21.8	12.5	10.9	....	....	125.5	100	25.1	14.4	12.5	....
120	261.	130.4	104	26.1	15.	13.1	9.1	302.	150.8	120.5	30.2	17.4	15.1	10.5
150	326.	163	130	32.6	18.8	16.3	11.4	377	188.5	150.6	37.7	21.7	18.8	13.15
180	391	195.5	156	39.1	22.5	19.6	13.6	452.	226.2	180.7	45.2	26.0	22.6	15.75
240	522.	261.	208	52.2	30.	26.1	18.2	602.	302.	241.	60.3	34.7	30.1	21.0
300	652.	326	260	65.2	37.5	32.6	22.7	754.	377.	301.	75.5	43.4	37.7	26.3
360	782.	391	313	78.2	45	39.2	27.2	905.	452.	361.5	90.5	52.	45.3	31.5
420	911	456	364	91.2	52.5	45.7	31.8	1055.	528.	422.	106.	60.7	52.8	36.8
480	1042.	522	416	104.	60.	52.2	36.4	1205.	602.	482.	121.	69.4	60.3	42.0
540	1172.	587	468	117	67.5	58.8	40.8	1356.	678.	542.	136.	78.	67.8	47.3
600	1304.	652	522	130.	75	65.2	45.5	1507.	754	602.	151.	86.8	75.4	52.5

Normal Line Current—Delta Connection—The normal line current for capacitor installations as given in the above table is...



FIG. 14—5 KV-A. AT 230 VOLTS OR 10 KV-A. AT 460 OR 575 VOLTS TYPE FP CABINET CAPACITOR UNITS

Capacitor Unit Construction

Each unit consists of a number of sections, assembled in a sheet steel box with connecting leads brought out through porcelain bushings.

The sections are connected in parallel groups and the leads are braided.

Single phase units have all sections connected in parallel with the leads brought out to two terminals. See Fig. 15.

Two phase units have two groups entirely separate from each other with the leads brought out to four terminals.

Three phase units have three internal units connected in delta inside the case and the leads are brought out to three terminals.

The solder seal type of bushing together with the welded tank construction effectively prevents leakage of the impregnating material.

Choice of Cable Leads—When choosing cable leads for capacitor installations, see N. E. Code for cable ratings and select size of cable on the basis of 125 per cent of the normal line current values listed in table above.

Standard and Special Connections—Unless otherwise specified the capacitor equipment is delta connected, each capacitor receiving the full line voltage. In some special cases, a star connected capacitor is desired and supplied on special orders. The star connected capacitor requires a special bus-bar compartment, but in other respects there is no difference from the standard delta connected capacitor equipment.

Ground Connections—One set of ground leads is supplied for each housing frame and consists of flexible leads with eyelets to be fastened tightly under the screw in the ground lug. The entire frame should be properly grounded.

Possible Difficulty—Units are rugged in construction and designed with a large factor of safety electrically, and therefore operating difficulty is seldom experienced. A defective unit will operate the fuse or will cause an arcing noise internally, or possibly if short circuiting results, it generates enough gases to expand the sides of the box to such a point that it may be detected by visual inspection.

Maintenance

Capacitors require practically no maintenance other than occasional inspection, to note if circuit-breaker is opened by a sustained overvoltage or if a capacitor fuse has operated. The absence of the red button on top of the fuse indicates an operation. The breaker should receive the routine inspection for oil level, etc., ordinarily specified for such apparatus.

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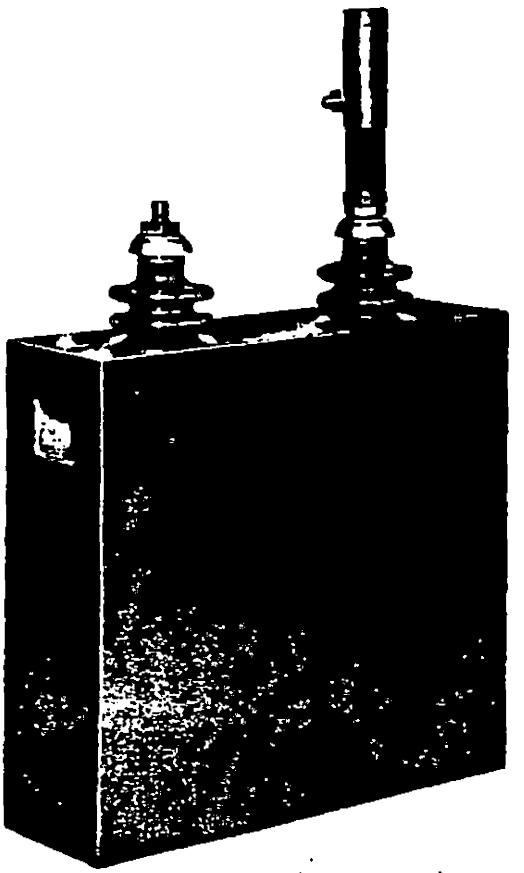


FIG. 15—10 KV.-A., 2300 VOLT, 1 PHASE, RACK TYPE FP CAPACITOR UNIT WITH BORIC ACID FUSE MOUNTED ON TERMINAL STUD

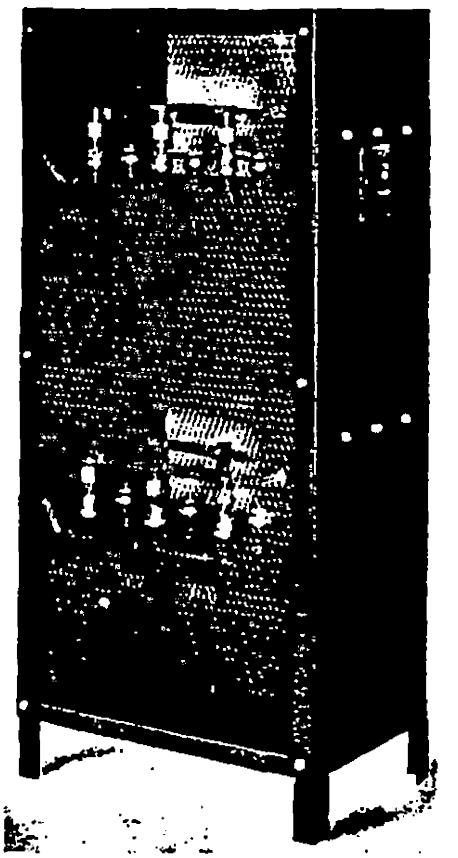


FIG. 16—6 UNIT LOW VOLTAGE INDOOR TYPE FP FRAME

Placing Capacitor in Service—After the capacitor equipment and switch have been installed, completely assembled and connected, the overload trip should be set to trip at between 130 and 160 percent of the normal capacitor current. In cases where line fuses are used they should be rated at between 150 and 200 percent of the normal capacitor current. If on placing the capacitor in service the breaker trips out, inspect the wiring. If the wiring is correct, the line voltage is probably too high and should be metered.

The capacitor should run without any magnetic or mechanical noises. If it is desired to check power factor with the capacitor, such measurements should be made between the line, and capacitor and load in parallel.

Disconnecting—Capacitors should be removed from the line by opening the circuit-breaker. **Before touching any of the connections wait five minutes for the units to discharge through the discharge devices.** These discharge devices are put on to serve as an automatic discharger. As an additional check for stored energy, each phase should be short circuited before touching the connections. Use a piece of wire insulated for the operating voltage of the capacitor with ends bare for about one inch.

Capacitor Unit Assembly

The capacitor units are to be placed in the frame distributing them on each shelf as shown on assembly drawing and wiring diagram. The fuses should be assembled on the capacitor unit terminal stud by screwing them down in place and then tighten the jam nut. Single phase units require one fuse and three phase units require two fuses. The units should then be connected with flexible strap connectors and then to the bus bars as shown in wiring diagram. For the large group equipments, connectors connecting a row of units in one frame to a row of units in another frame should be joined mid-way between the frames with a bolt and nut to avoid making this contact connection at the capacitor or fuse terminal stud.

On the larger ratings of low voltage equipments where large currents are encountered, two flexible connectors are used in parallel to carry the current. Spacers in the frame are provided to separate the capacitor units to obtain good ventilation.

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INSTALLATION OF CAPACITOR EQUIPMENTS

Capacitor equipments are divided into three groups (1) Small group type equipments, (2) Large group type equipments and (3) Pole type equipments.

PART 1

Small Indoor Group Type Equipments—Three frame sizes are available for 3, 6, or 10 units at 230, 460 and 575 volts and 3, 6 or 12 units at 2300, 4000 and 4600 volts. The six unit frames are shown in Figs. 16 and 17. These frames are of welded sheet steel and angle iron construction, covered on the sides with expanded metal screens, on the bottom with perforated sheet steel, on the top, rear, and front with sheet steel. The 230, 460 and 575 volt frames are provided with conduit knockouts, the locations of which have been chosen for ease in mounting the AB "De-ion" breakers on the front panel. Terminal outlet bushings are supplied with the 2300, 4000 and 4600 volt frames and may be inserted in knockouts at the top of the front panel or at the front of the flat roof.

Bus bars are a part of the frame and are mounted on strong porcelain insulators at the rear of the front panel as shown in Fig. 17.

Flexible connectors are supplied for connecting the units to the bus bars as shown in Fig. 17. Flexible ground leads are supplied for grounding the capacitor cases to the frame.

Two wire wound discharge coils are supplied for each frame. These coils are to be mounted in the frame and permanently connected to the bus bars. These automatically discharge the capacitor within five minutes after the switch is opened, **however, as an added precaution each capacitor unit should be discharged before handling** by using a piece of wire insulated for the operating voltage of the capacitor, with ends bare for about one inch.

Installation of Small Indoor Group Type Equipments

The frames are shipped completely assembled except for the capacitor units, discharge coils, and fuses. After uncrating all parts, remove the side screen by loosening the bolts and lifting the screen until the notched hole clears the bolt heads. Assemble the discharge coils to the front panel and connect them to the bus bars. Locate the capacitor units in the frame and

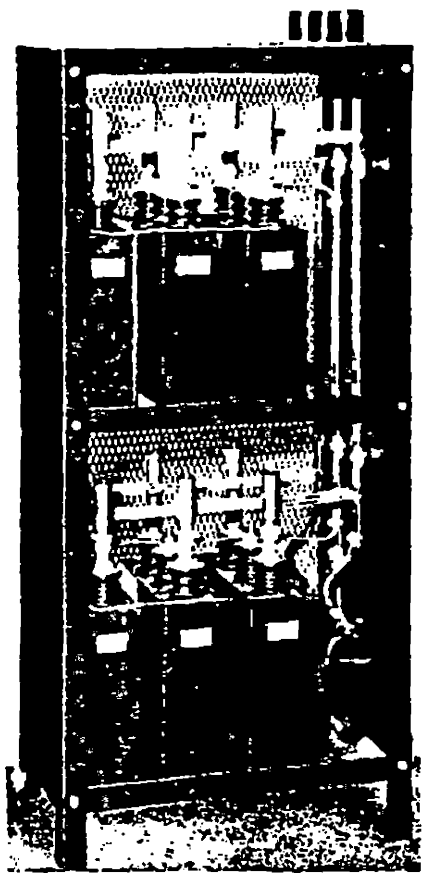


FIG. 17—6 UNIT, 2300 VOLT, INDOOR TYPE PP FRAME

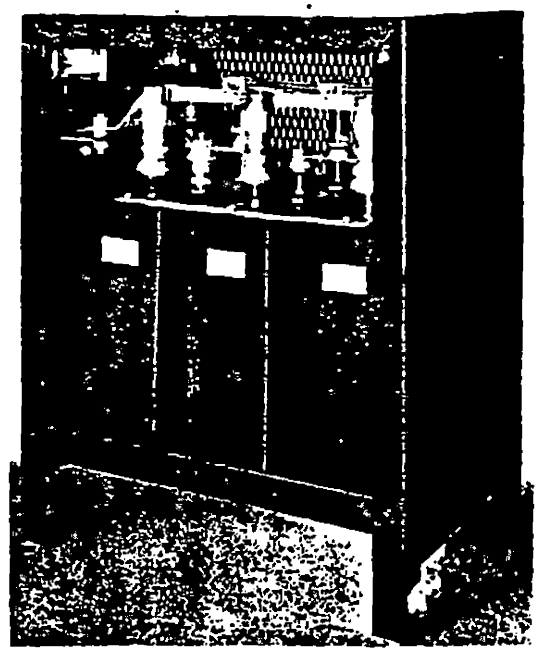


FIG. 18—3 UNIT, [illegible] LOW VOLTAGE FUSE W[illegible]
REMOVED SHOWING [illegible]

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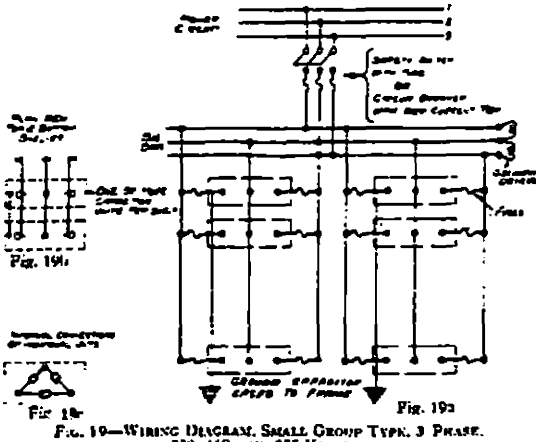


FIG. 19—WIRING DIAGRAM, SMALL GROUP TYPE, 3 PHASE, 230, 460, AND 575 VOLTS

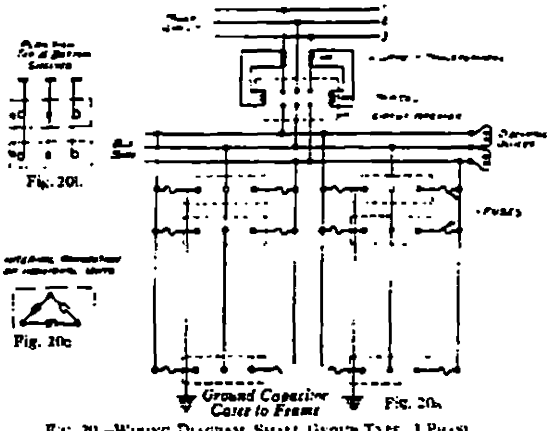


FIG. 20—WIRING DIAGRAM, SMALL GROUP TYPE, 3 PHASE, 2300, 4000 AND 4600 VOLTS

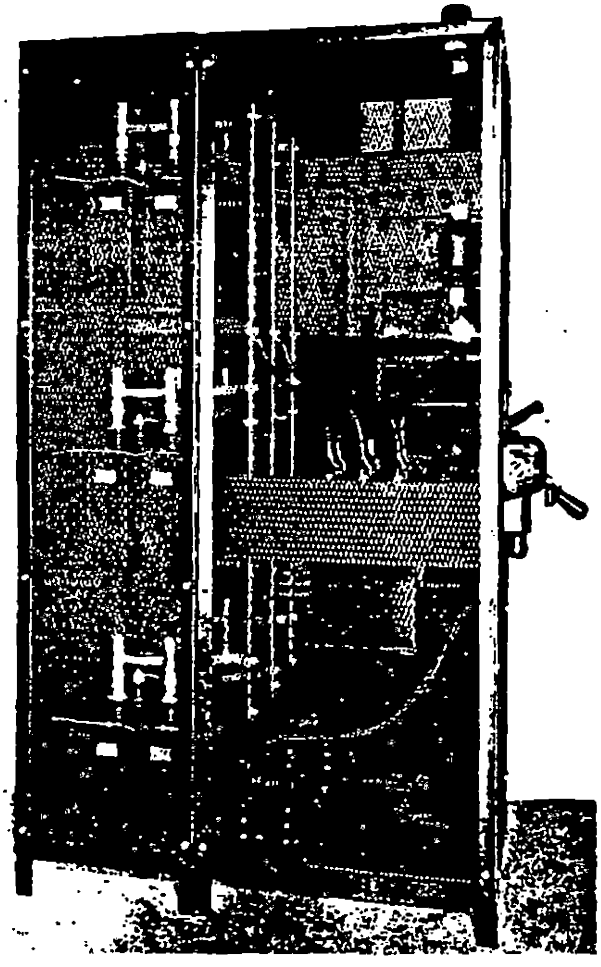


FIG. 21—LARGE INDOOR GROUP TYPE FP CAPACITOR SHOWING BUS BARS, CIRCUIT BREAKER, CAPACITOR UNITS AND FUSES

assemble the fuse on the capacitor terminal by screwing down on the stud until it is in position, then tighten jam nut. Spacers in the frame are provided to separate the capacitor units to obtain proper ventilation. Connect the capacitor units to the bus bars and ground capacitor cases to frame as per wiring diagram.

The 230, 460 and 575 volt equipments may be connected to the line with fused safety switches or AB "Design" breakers to be supplied and installed by the customer. The front panel has been arranged with conduit knockouts so that they may be conveniently mounted on the front panel by drilling the necessary mounting holes.

The 2300, 4000 and 4600 volt equipments may be connected to the line with oil circuit-breakers to be supplied and installed by the customer; where it is desired an enclosed breaker compartment with oil breaker can be supplied assembled to the capacitor frame. This is a special feature and supplied only when ordered.

Small Outdoor Group Type Equipments.—The outdoor low voltage equipments are similar to the indoor equipments except that the side screens are replaced by plates of solid steel and the entire assembly is covered with a pitched roof. Ventilating louvers are provided throughout the assembly, thus assuring a good circulation of air about the capacitor units.

In many cases it will be desirable to have a housing for a safety switch or an AB breaker assembled to the capacitor frame. **This is an added feature and supplied only when ordered.**

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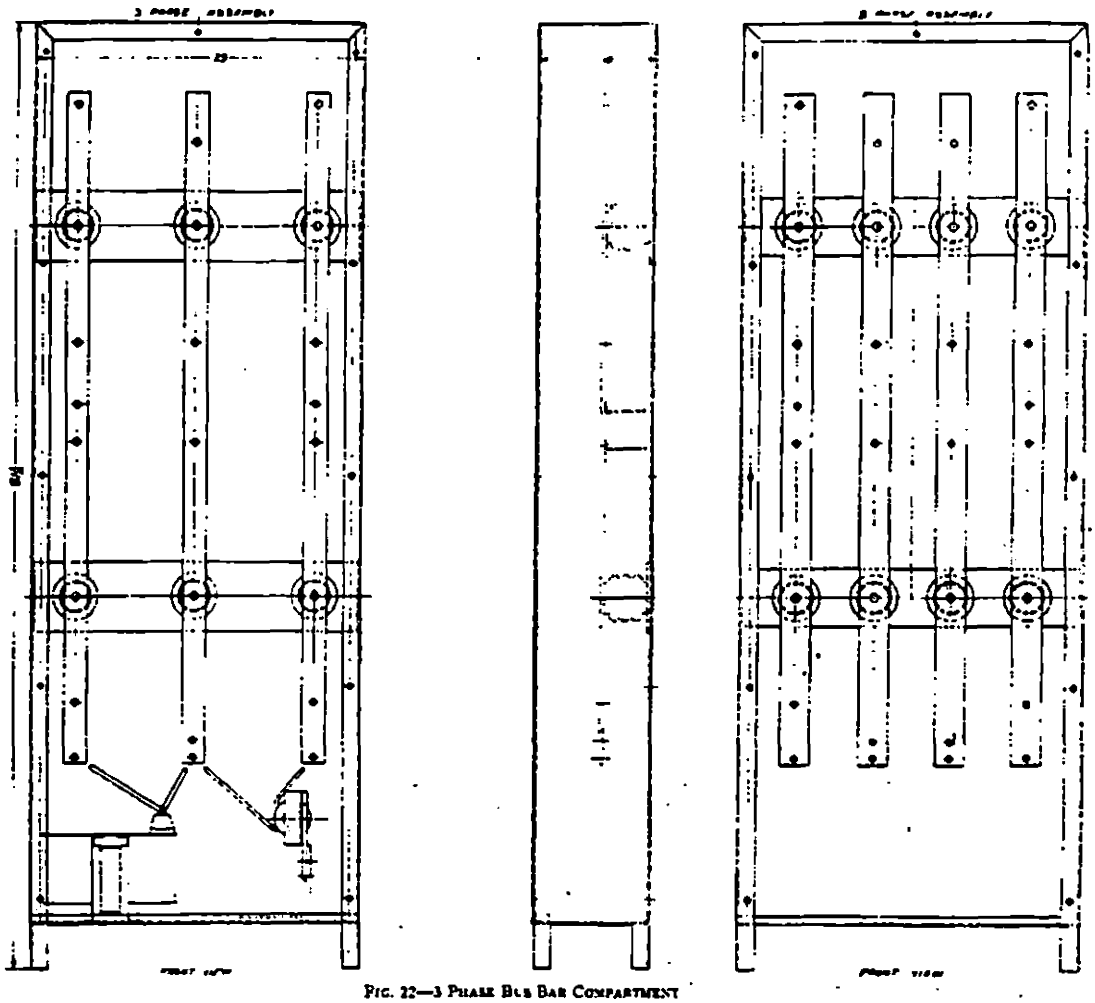


FIG. 22—3 PHASE BUS BAR COMPARTMENT

These equipments are shipped completely assembled except for the capacitor units and fuses. The purchaser is required to install the capacitor units and fuses and properly connect them to the bus bars as shown in wiring diagram.

PART II

Large Indoor Group Type Equipments — Large group type equipments are available for any number of frame type units from 120 to 600 kv-a at 230 volts and 1200 kv-a. for the higher voltages. They consist of the required number of individually fused single phase capacitor units to be mounted in a welded angle iron frame covered on the sides with expanded metal screens, on the bottom with perforated sheet steel and on the top, rear and front with solid sheet steel. These frames have three shelves, each to take a double row of capacitor units.

Discharge coils, connectors, bus bars and a circuit-breaker are included with a standard equipment. Equipments of 2300 volts and up are supplied with an oil circuit-breaker to be mounted in a compartment conforming with the capacitor frame in all dimensions to make the best appearance. Enclosed AB and CL breakers are supplied with low voltage equipments to be mounted on the front panels.

Installation of Large Indoor Low Voltage Group Type Equipments

The equipments may be shipped assembled except for the capacitor units and fuses or the housings may be shipped disassembled.

The disassembled housing is shipped as follows:

(a) Front Plate.
(b) Bus Bar Compartment. Fig. 22.
(c) One or more Capacitor Frames. Fig. 23.
(d) One Set or (2) Side Screens for Each Housing. Fig. 21.

After uncrating all the parts, remove the rear plate from the bus bar compartment, then bolt the front plate to

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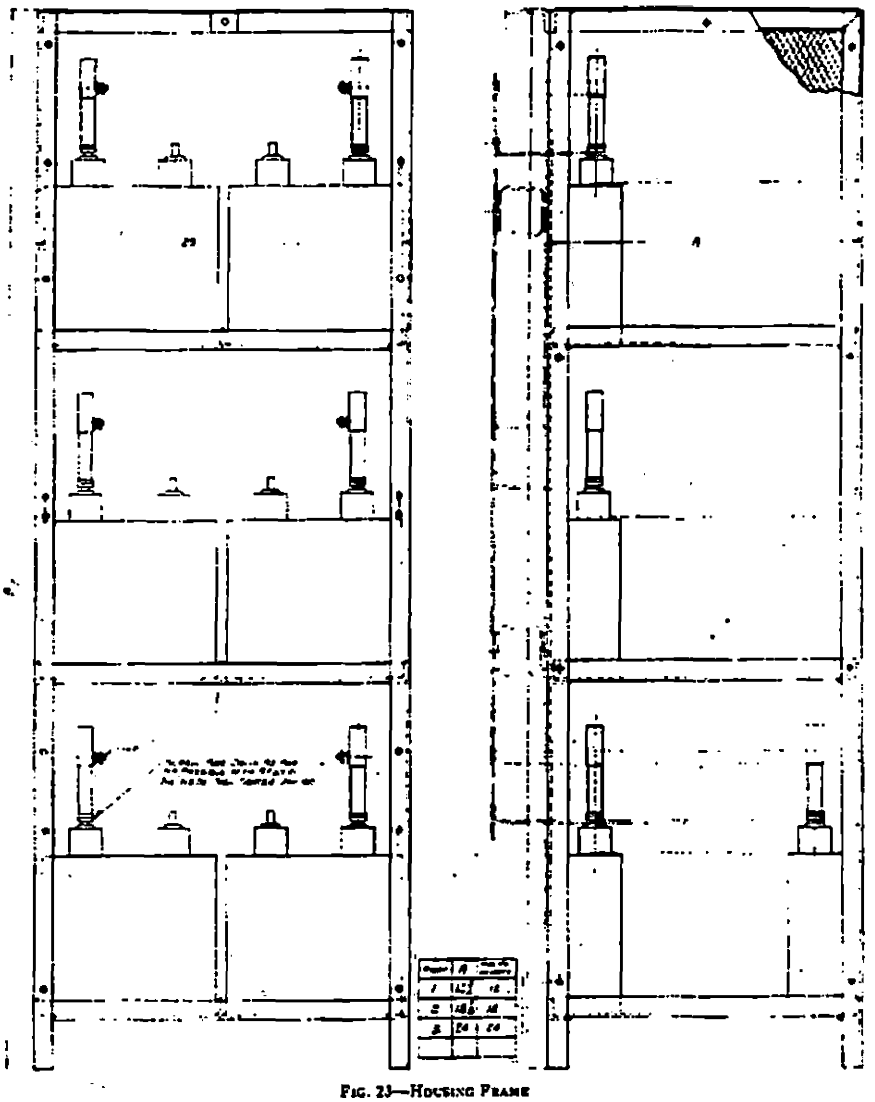


FIG. 23—HOUSING FRAME

the front of the compartment and mount the discharge transformers on the floor (of the bus bar compartment) and connect their leads to the bus bars as shown in the wiring diagram. Bolt one frame in place next to the bus bar compartment. If more than one frame is required bolt them to the rear, the larger frames being assembled first and the smaller ones last. A 600 kv-a. installation using 10 kv-a. units, requires a total of three housing frames. The rear plate removed from the bus bar compartment is now bolted to the rear of the last frame. The type AB or CL breakers are to be mounted in place on the front panel and connected to the bus bars. For the CL breakers set the I.T.L. attachment to the minimum trip position so that the settings will correspond to between 130 and 150 per cent of the normal capacitor phase current.

Installations of Large Indoor Group Type Equipments

2300 Volts and Above

A disassembled housing is shipped as follows

(a) Front Plate, Fig. 24.
(b) Bushing Plate, Fig. 24.
(c) Circuit-Breaker Housing with Bus Bars and Rear Plate, Fig. 24.
(d) One or more Capacitor Frames, Fig. 23.

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(e) One set or (2) Side Screens for each Housing, Fig. 21.

This housing is assembled similar to the low voltage equipment except that a circuit-breaker housing with bus bars is used in place of the bus bar compartment. The oil circuit-breaker and current transformers are mounted in this breaker housing and are connected to the bus bars and line. The trip coils should be set for 100% or the 5 ampere setting on the dashpot which should correspond to between 130 and 150 per cent of the normal capacitor phase current.

Assembly of Special Indoor Capacitor—The special indoor capacitor is similar to the standard indoor except that the circuit-breaker housing is omitted and the circuit-breaker is mounted on its pipe or panel frame in front or wherever convenient and connected to the capacitor leads from the bushing plate to the line. The front plate supplied is different than that for the standard indoor equipment and is bolted on the front of the bus bar compartment.

Ammeters for Standard Indoor Equipments—Where it is desired an ammeter with a type W transfer switch is mounted on the front plate beside the circuit-breaker handle. This is connected to the current transformers used for operating the circuit-breaker. Fig. 1 shows the meter and switch in place. This metering equipment is a special feature and supplied only when ordered.

Large Outdoor Group Type Equipments—The outdoor equipments are the same as the indoor except that the side screens are replaced by side plates of solid steel and the entire assembly is covered with a pitch roof. Ventilating ducts are provided throughout the assembly, thus assuring a good circulation of air about the capacitor units. These equipments are shipped completely assembled except for the capacitor units and fuses. The purchaser is required to install the capacitor units and fuses and properly connect them to the bus bars as shown in wiring diagram.

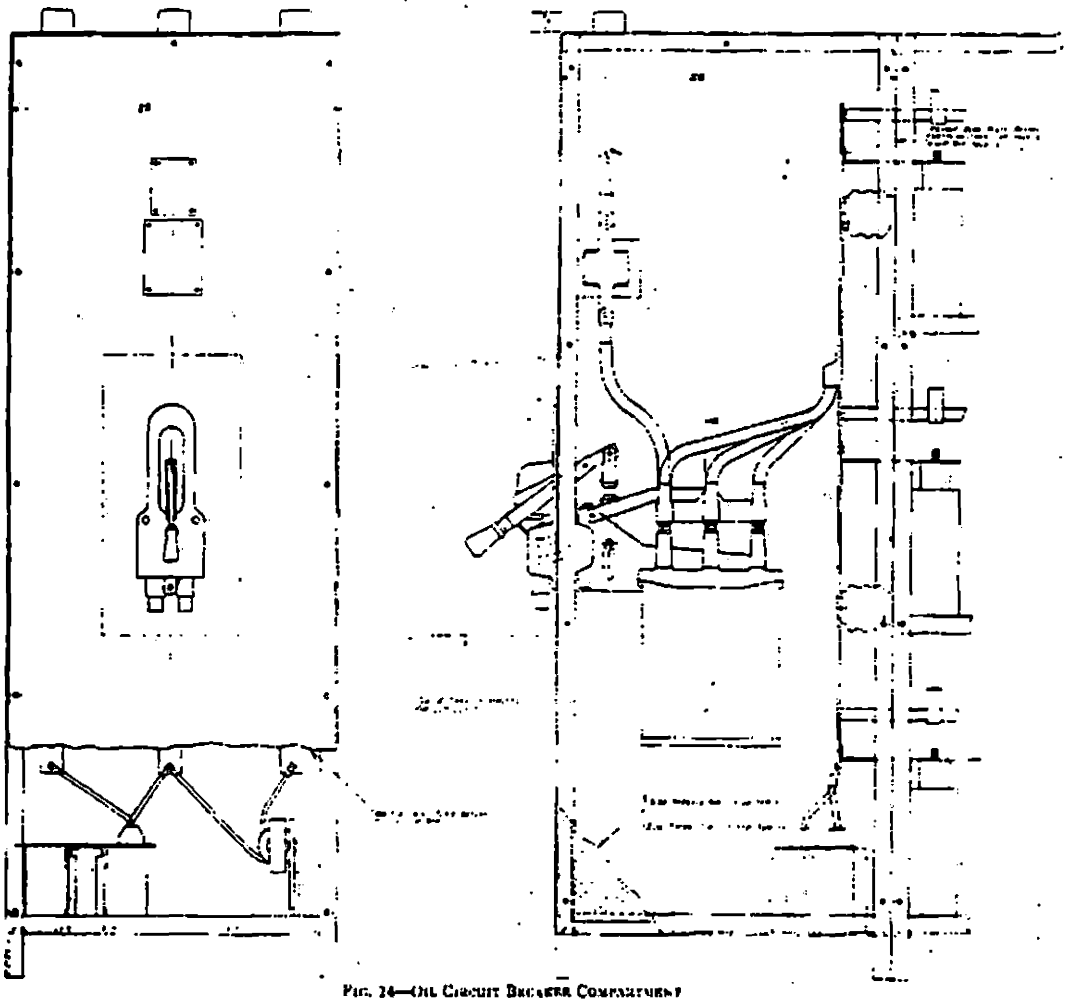


Fig. 24—Oil Circuit Breaker Compartment

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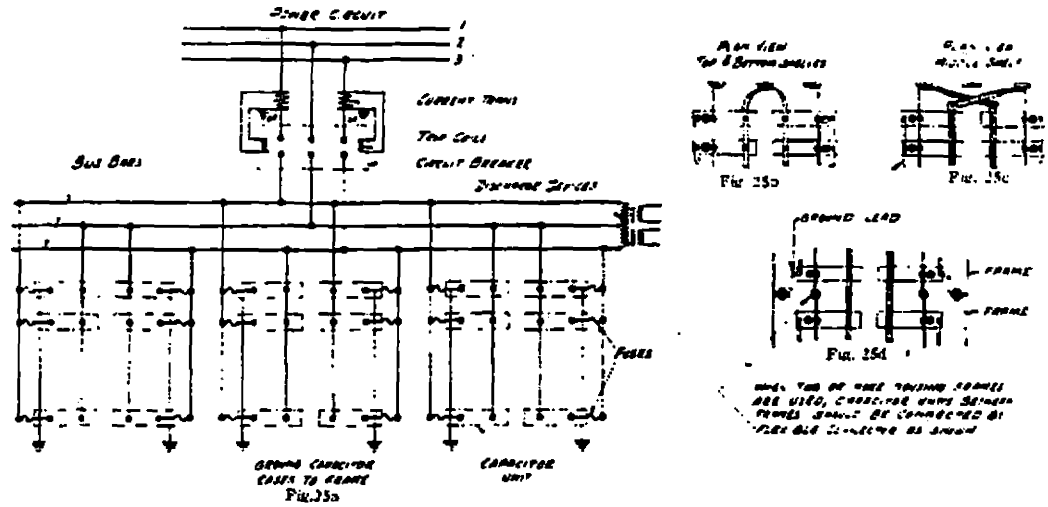


FIG. 25—3 PHASE WIRING DIAGRAM LARGE GROUP TYPE EQUIPMENTS 2300, 4000, 4600 AND 6600 VOLTS

PART III

Pole Type Equipments—A pole type capacitor equipment consists of the required number of individually fused capacitor units mounted in a welded weatherproof housing with hanger irons and lifting eyes. Flexible connectors are provided for connecting the units together and to the outlet terminals. Discharge coils are provided for discharging the residual voltage. The equipments are shipped completely assembled except for the capacitor units and fuses. The purchaser is required to install the capacitor units and fuses and connect them as shown in wiring diagram. Pole type capacitors are connected to the line through fused cutouts mounted on a cross arm above the housing.

APPLICATION

Switching Equipment—Usually group capacitors are applied at the load end of lines where the current is limited. The choice of breaker to use with capacitor is made on the basis of limited short circuit current, as is the case on the majority of industrial applications.

Often capacitors are applied on high capacity circuits, and therefore breakers

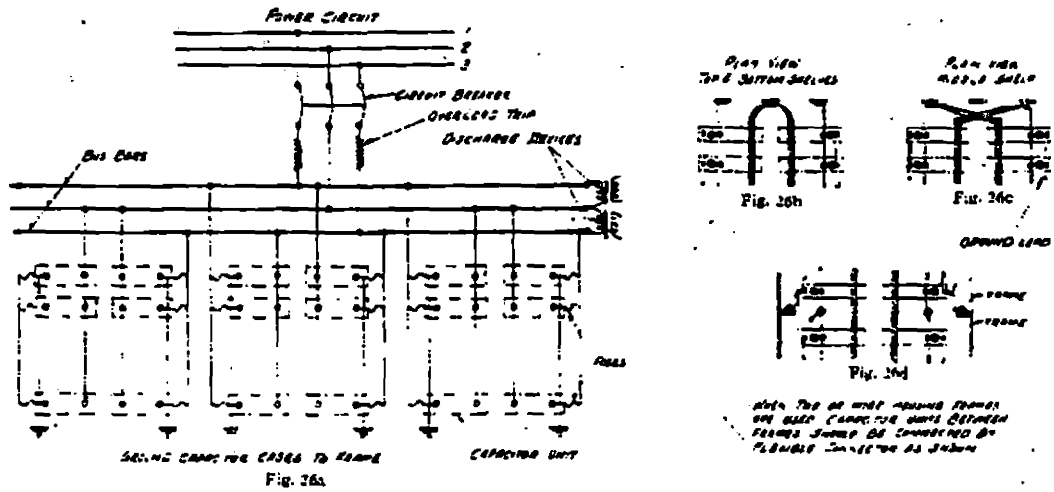


FIG. 26—3 PHASE WIRING DIAGRAM LARGE GROUP TYPE EQUIPMENTS 230, 460 AND 575 VOLTS

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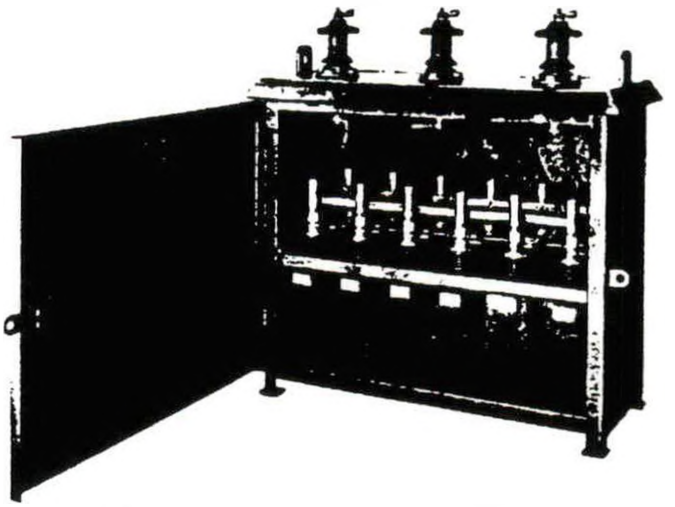


Fig. 27—60 Kv-a., 3 Phase, 2300 Volt, Pole Type FP Capacitor

of suitable interrupting ability must be used.

Line Characteristics—Capacitors are designed for continuous service on voltages 15% over rated voltage and ambient temperatures up to 40°C. The kv-a. rating of the capacitor, however, is based on rated voltage so that with 15 per cent over voltage the kv-a. of the capacitor will be 32 per cent greater.

When transformers are used it would be uneconomical to supply transformer with sufficient kv-a. capacity to handle 15 per cent over voltage on the capacitor, especially when the actual kv-a. of the capacitor even at rated voltage is over normal rating.

When voltage on the 2300 volt capacitor is above 2640, the capacitor is taking more than 33 per cent over its rated kv-a. at 2300 volts. This overvoltage must be corrected for by changing the transformer taps so that the capacitor voltage will always remain below 2640 volts. When no taps are provided a few units should be disconnected.

In rare cases line harmonics may be

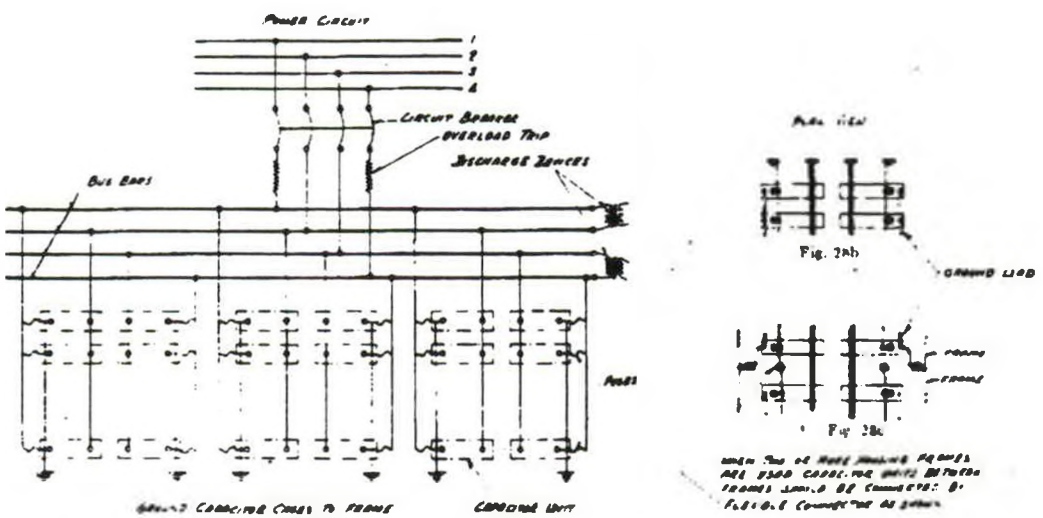


Fig. 28—2 Phase Wiring Diagram Large Group Type Equipments 230, 460, 575 Volts

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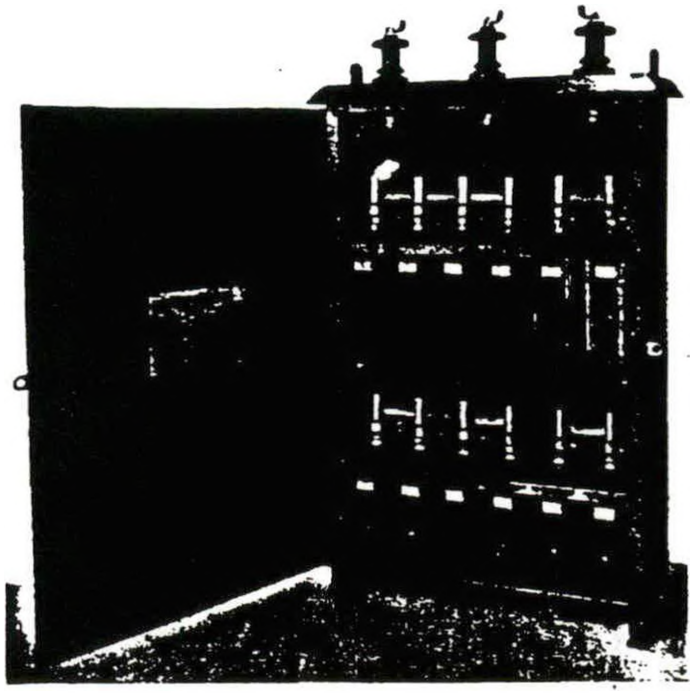


Fig. 29—120 Kv-a., 3 Phase, 4 Wire, 4000 Volt Star Connected Pole Type FP Capacitor

sufficiently marked to cause considerable harmonic current to pass through the capacitor. Take the case of a line carrying 100 amperes at 50 per cent power factor. If we install a capacitor to raise the power factor to 100 per cent we expect the line current to drop to 50. We expect the line loss to be $50^2 \times R$ where R is the resistance of the line. If there had been a harmonic which caused the capacitor to take a harmonic current of 10 amperes the resultant current would be $\sqrt{50^2+10^2}$ or 50.8 amperes instead of 50. This would give a line loss about $1\frac{1}{2}$ per cent higher than expected.

The above effect is generally negligible because line wave form is usually good and because it is only when the capacitors happen to be near the source of bad wave form that the reactance of

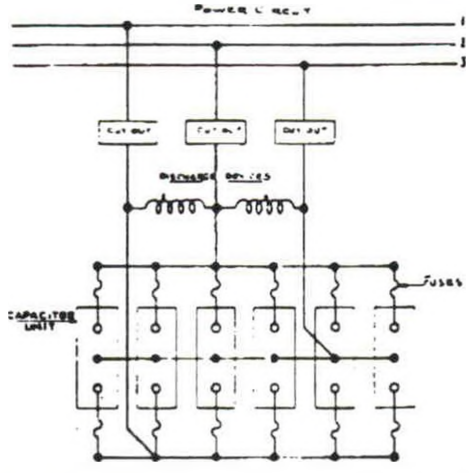


Fig. 30—3 Phase Wiring Diagram for a 60 Kv-a., 2300, 4000, 4600 Volt Pole Type Capacitor

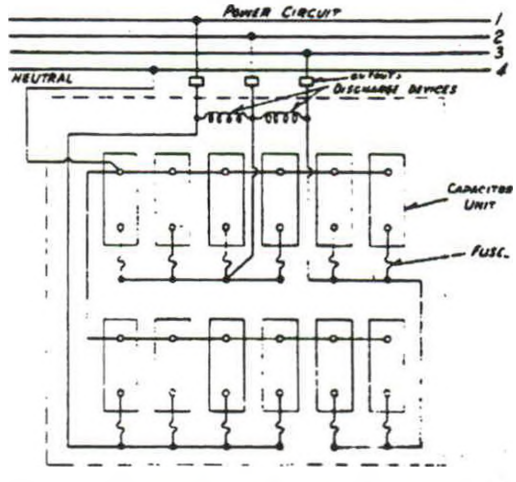


Fig. 31—3 Phase Wiring Diagram for a 120 Kv-a., 4000 Volt Star Connected Pole Type Capacitor

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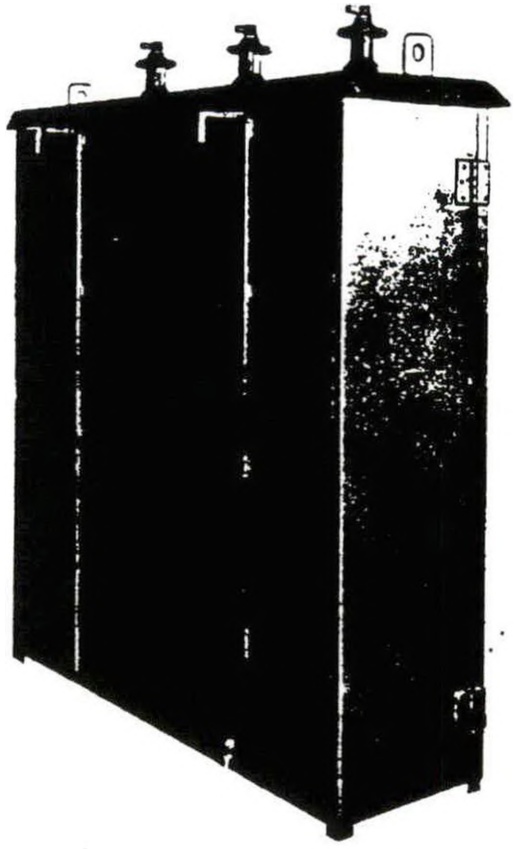


FIG. 32—140 KV-A., 3 PHASE, 4800 VOLT, POLE TYPE PP CAPACITOR SHOWING HANGER IRONS AND LIFTING EYES

the line is low enough for the harmonic frequency to cause serious current.

If the measured effective current exceeds the calculated current based on the actual voltage and *microfarad capacity by more than 15% an investigation should be made. If the conditions are troublesome the remedy is to use a series reactor or a wave trap. The reactor or wave trap must be selected to suit each case.

Variation in corrective kv-a. is obtained by disconnecting capacitor units. As many units as desired may be removed by removing one connection on each phase. On a three-phase outfit, units should be taken off in groups of three and on a two-phase outfit in groups of two, in order to keep the phases balanced.

Where it is desirable to make finer adjustments in the kv-a. corrective capacity of an installation, it may be done by means of an induction regulator, whereby the voltage may be varied on the complete equipment, getting any portion of the total kv-a. rating.

The cost of such regulation or the size of the regulator, of course, depends on the per cent regulation desired. The kv-a. of the capacitor varies with the square of the voltage impressed upon it.

Technical Data

(a) Microfarad. The unit of capacity of a capacitor, corresponding to millihenry for an inductance. There are one million microfarads in a farad.

(b) Capacitors Kv-a.—

VA or Volt Amperes = voltage x current.

$$\text{Kv-a.} = \frac{\text{VA.}}{1000}$$

$$\text{Kv-a} = \frac{E \cdot 2\pi fc \times 10^6}{1000} \quad \text{or} \quad \frac{E \cdot 2\pi fc}{10^3 \times 10^3}$$

I (amps.) = E2πfc.

E = voltage on capacitor

f = frequency in cycles.

c = microfarads.

2π = 6.28

(c) Kv-a. rating of capacitor.

5 kv-a., 230 volts, 60 cycles = 250 microfarads.

10 kv-a., 460 volts, 60 cycles = 125 microfarads.

10 kv-a., 2300 volts, 60 cycles = 5 microfarads.

*NOTE—The actual microfarad capacity of each capacitor unit may be obtained from the factory by sending in the test number of each capacitor unit.

NPC00007957

770596

MEMORANDUM

(Use Ink)

NPC00007958

770597

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

WESTINGHOUSE SALES OFFICES

ABILENE, KAN., 100 N. Cedar St.
AKRON, OHIO, 11 S. Main St.
ALBANY, N. Y., 100 Broadway
ALLENTOWN, PA., Maple & Law Sts.
APPLETON, WIS., 91 Bellaire Court
*ATLANTA, GA., 426 Marietta St. N. W.
BAKERSFIELD, CALIF., 1224 19th Emedio St.
BALTIMORE, MD., 118 E. Lombard St.
BEAUMONT, TEX., La Salle Hotel
BIRMINGHAM, ALA., 2030 Second Ave.
BLUEFIELD, W. VA., 208 Bluefield Ave.
*BOSTON, MASS., 10 High St.
BRIDGEPORT, CONN., Bruce Ave. and Seymour St.
*BUFFALO, N. Y., 910 Ellicott Square
†BURLINGTON, IOWA, P. O. Box 197
†BURLINGTON, VT., 208 Park Ave.
*BUTTE, MONT., 58 E. Broadway
CANTON, OHIO, 130 Tuscarawas St., West
*CHARLOTTE, N. C., 216 E. Sixth St.
CHATTANOOGA, TENN., 536 Market St.
CHICAGO, ILL., 50 N. Wacker Drive
*CINCINNATI, OHIO, 207 W. Third St.
*CLEVELAND, OHIO, 1216 W. 69th St.
*COLUMBUS, OHIO, 209 S. Third St.
*DALLAS, TEX., 300 Browder St.
DAVENPORT, IOWA, 208 E. Second St.
DAYTON, OHIO, 38 N. Main St.
*DENVER, COLO., 910 Fifteenth St.
*DETROIT, MICH., 5757 Trumbull Ave.
DULUTH, MINN., 10 East Superior Street
ELMIRA, N. Y., 348 E. Water St.
*EL PASO, TEXAS, 103 N. Oregon St.
*EMERYVILLE, CALIF., 5811 Peladeau St.
†ERIE, PA., 102 W. 6th St.
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FAIRMONT, W. VA., 602 Cleveland Ave.
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FORT WORTH, TEX., 501 Jones St.
GARY, IND., 719 Arthur St.
GRAND RAPIDS, MICH., 197 Monroe Ave. N.W.
GREENVILLE, S. C., 122 West Earle St.
HAMMOND, IND., 401 Wentham St.
*HOUSTON, TEX., 608 Fannin St.
*HUNTINGTON, W. VA., 209 Ninth St.
INDIANAPOLIS, IND., 530 Madison Ave.
ISHPEMING, MICH., 433 High St.
JACKSON, MICH., 212 W. Michigan Ave.
JOHNSTOWN, PA., 47 Messenger St.
*KANSAS CITY, MO., 2124 Wyandotte St.
*KNOXVILLE, TENN., 602 Gay St.
LITTLE ROCK, ARK., 1123 West Twenty-fourth St.
*LOS ANGELES, CALIF., 420 S. San Pedro St.
LOUISVILLE, KY., 332 W. Broadway
MADISON, WIS., 508 Edgewood Ave.
MEMPHIS, TENN., 110 Madison Ave.
MIAMI, FLA., P. O. Box 1098
MILWAUKEE, WIS., 346 N. Broadway
*MINNEAPOLIS, MINN., 2301 Kennedy St. N.E.
MONROE, LA., 1010 N. Fourth St.
NASHVILLE, TENN., 210 N. Second Ave.
*NEWARK, N. J., Haynes Ave. and Lincoln Highway
NEW HAVEN, CONN., 246 Cedar St.
*NEW ORLEANS, LA., 333 St. Charles St.
NEW YORK, N. Y., 30 Rockefeller Plaza
NIAGARA FALLS, N. Y., 305 Falls St.
OKLAHOMA CITY, OKLA., 10 E. California St.
OMAHA, NEB., 409 S. Seventeenth St.
PEORIA, ILL., 104 E. State St.
*PHILADELPHIA, PA., 1001 Walnut St.
PHOENIX, ARIZ., 11 W. Jefferson St.
PITTSBURG, KAN., P. O. Box 11
*PITTSBURGH, PA., 435 Seventh Ave.
†PORTLAND, ME., P. O. Box 1795
*PORTLAND, ORE., 308 Southwest Sixth Ave.
PROVIDENCE, R. I., 103 Harris Ave.
RALEIGH, N. C., 801 N. Person St.
RICHMOND, VA., 101 S. Fifth St.
ROCHESTER, N. Y., 410 Atlantic Ave.
ROCKFORD, ILL., 130 S. Second St.
SACRAMENTO, CALIF., 1127 Ninth St.
*SALT LAKE CITY, UTAH, 10 W. First South St.
†SAN ANTONIO, TEX., 313 East Houston St.
SAN FRANCISCO, CALIF., 1 Montgomery St.
*SEATTLE, WASH., 1003 Stewart St.
SIOUX CITY, IOWA, 8311 George St.
*SOUTH BEND, IND., 216 E. Wayne St.
SPOKANE, WASH., 159 S. Monroe St.
SPRINGFIELD, ILL., 110 S. Sixth St.
SPRINGFIELD, MASS., 303 Liberty St.
*ST. LOUIS, MO., 411 N. Seventh St.
*SYRACUSE, N. Y., 400 N. Geddes St.
TACOMA, WASH., 1021 "A" Street
TAMPA, FLA., 417 Ellamae Ave.
TOLEDO, OHIO, 208 Summit St.
†TULSA, OKLA., 120 E. Brady St.
*UTICA, N. Y., 111 N. Genesee St.
WASHINGTON, D.C., 1625 New York Ave. N.W.
WATERLOO, IOWA, 328 Jefferson St.
WICHITA, KAN., 400 South Emporia St.
WILKES-BARRE, PA., 307 N. Pennsylvania Ave.
WORCESTER, MASS., 32 Southbridge St.
YORK, PA., 142 S. George St.
†YOUNGSTOWN, OHIO, 33 E. Boardman St.
The HAWAIIAN ELECTRIC CO., Ltd., Honolulu, T. H.—Agents

*Warehouses located in these cities.

WESTINGHOUSE AGENT-JOBBERS

ABILENE, KAN., Union Electric Co.
AKRON, OHIO, The Monch Elec. Supply Co.
ALBANY, N. Y., Westinghouse Elec. Sup. Co., Inc.
ALLENTOWN, PA., Westinghouse Elec. Sup. Co.
ATLANTA, GA., Westinghouse Elec. Sup. Co.
AUGUSTA, ME., Wermore Savage Elec. Supply Co.
BALTIMORE, MD., Westinghouse Electric Supply Co.
BANGOR, ME., Wermore Savage Elec. Sup. Co.
BINGHAMTON, N. Y., Westinghouse Electric Supply Co., Inc.
BIRMINGHAM, ALA., Moore-Handley Hdwe. Co.
BLUEFIELD, W. VA., Superior Sterling Co.
BOSTON, MASS., Wermore-Savage Elec. Sup. Co.
BUFFALO, N. Y., McCarthy Bros. & Ford
BURLINGTON, VT., Wermore Savage Elec. Sup. Co.
BUTTE, MONT., Westinghouse Elec. Sup. Co.
CANTON, OHIO, The Monch Elec. Supply Co.
CHARLOTTE, N. C., Westinghouse Elec. Sup. Co.
CHATTANOOGA, TENN., Mills & Lupton Sup. Co.
CHICAGO, ILL., Hyland Elec. Supply Co.
CHICAGO, ILL., Westinghouse Elec. Sup. Co., Inc.
CINCINNATI, O., The Johnson Elec. Sup. Co.
CLEVELAND, O., Westinghouse Elec. Sup. Co.
COLUMBIA, S. C., Westinghouse Elec. Sup. Co.
COLUMBUS, O., The Hughes-Peters Elec. Corp.
COLUMBUS, O., Pixley Elec. Supply Co.
DALLAS, TEX., Westinghouse Elec. Sup. Co.
DENVER, COLO., The Mine & Smelter Sup. Co.
DES MOINES, IA., Westinghouse Elec. Sup. Co., Inc.
DETROIT, MICH., Westinghouse Elec. Sup. Co.
DULUTH, MINN., Westinghouse Electric Supply Co., Inc.
EL PASO, TEX., The Mine & Smelter Sup. Co.
EL PASO, TEX., Zork Hardware Co.
ERIE, PA., Star Electrical Co.
EVANSVILLE, IND., Westinghouse Elec. Sup. Co.
FLINT, MICH., Westinghouse Elec. Sup. Co.
FORT WORTH, TEX., Westinghouse Elec. Sup. Co.
GRAND RAPIDS, MICH., Westinghouse Electric Supply Co.
GREENVILLE, S. C., Westinghouse Elec. Sup. Co.
HOUSTON, TEX., Westinghouse Elec. Sup. Co.
HUNTINGTON, W. VA., Sunk-Miller Sup. Co.
INDIANAPOLIS, IND., Westinghouse Elec. Sup. Co.
JACKSONVILLE, FLA., Westinghouse Elec. Sup. Co.
KANSAS CITY, MO., Columbian Electrical Co.
*KNOXVILLE, TENN., Westinghouse Elec. Sup. Co.
LOS ANGELES, CALIF., Westinghouse Electric Supply Co.
LOUISVILLE, KY., Tafel Electric Co.
MADISON, WIS., Westinghouse Elec. Sup. Co., Inc.
MEMPHIS, TENN., Westinghouse Elec. Sup. Co.
MILWAUKEE, WIS., Westinghouse Electric Supply Co., Inc.
MINNEAPOLIS, MINN., Westinghouse Electric Supply Co., Inc.
MONROE, LA., Monroe Hardware Co.
NASHVILLE, TENN., Tafel Electric Co.
NEWARK, N. J., Westinghouse Elec. Sup. Co., Inc.
NEW HAVEN, CONN., Westinghouse Elec. Sup. Co.
NEW ORLEANS, LA., Electrical Supply Co.
NEW YORK, N. Y., Times Appliance Co., Inc.
NEW YORK, N. Y., Westinghouse Elec. Sup. Co., Inc.
OAKLAND, CALIF., Westinghouse Electric Supply Co.
OKLAHOMA CITY, OKLA., Westinghouse Electric Supply Co.
OMAHA, NEB., Westinghouse Elec. Sup. Co., Inc.
PEORIA, ILL., Westinghouse Elec. Sup. Co., Inc.
PHILADELPHIA, PA., Westinghouse Electric Supply Co.
PHOENIX, ARIZ., Westinghouse Electric Supply Co.
PITTSBURGH, PA., Iron City Electric Co.
PORTLAND, ORE., Westinghouse Elec. Supply Co.
PROVIDENCE, R. I., Wermore-Savage Elec. Sup. Co.
RALEIGH, N. C., Westinghouse Electric Supply Co.
READING, PA., Westinghouse Elec. Sup. Co.
RICHMOND, VA., Westinghouse Elec. Sup. Co.
ROCHESTER, N. Y., Westinghouse Elec. Sup. Co., Inc.
SALT LAKE CITY, UTAH, Westinghouse Electric Supply Co.
SAN ANTONIO, TEX., Westinghouse Elec. Sup. Co.
SAN FRANCISCO, CALIF., Westinghouse Electric Supply Co.
SCRANTON, PA., Penn. Elec'l. Engineering Co.
SEATTLE, WASH., Westinghouse Elec. Supply Co.
SIOUX CITY, IA., Westinghouse Elec. Sup. Co., Inc.
SPOKANE, WASH., Westinghouse Elec. Sup. Co.
SPRINGFIELD, MASS., Wermore-Savage Elec. Supply Co.
ST. LOUIS, MO., Westinghouse Elec. Sup. Co.
ST. PAUL, MINN., Westinghouse Electric Supply Co., Inc.
SYRACUSE, N. Y., Westinghouse Elec. Sup. Co., Inc.
TAMPA, FLA., Westinghouse Electric Supply Co.
TOLEDO, OHIO, Westinghouse Elec. Sup. Co.
TRENTON, N. J., Westinghouse Elec. Sup. Co., Inc.
TULSA, OKLA., Westinghouse Elec. Sup. Co.
UTICA, N. Y., Westinghouse Elec. Sup. Co., Inc.
WASHINGTON, D. C., Westinghouse Electric Supply Co.
WATERLOO, IA., Westinghouse Elec. Sup. Co., Inc.
WICHITA, KAN., Westinghouse Electric Supply Co.
WILMINGTON, DEL., Westinghouse Elec. Sup. Co.
WORCESTER, MASS., Wermore-Savage Elec. Sup. Co.
YORK, PA., Westinghouse Elec. Sup. Co.
YOUNGSTOWN, OHIO, Monch Elec. Supply Co.

WESTINGHOUSE SERVICE SHOPS

APPLETON, WIS., 1020 S. Outagamie St.
ATLANTA, GA., 426 Marietta St., N. W.
BALTIMORE, MD., 501 East Preston St.
BOSTON, MASS., 10 Farnsworth St.
BRIDGEPORT, CONN., Bruce Ave. and Seymour St.
BUFFALO, N. Y., 1123 Seneca St.
CHARLOTTE, N. C., 210 E. Sixth St.
CHICAGO, ILL., 2211 W. Pershing Road
CINCINNATI, OHIO, 207 W. Third St.
CLEVELAND, OHIO, 1216 W. 69th St.
DENVER, COLO., 1044 Walnut St.
DETROIT, MICH., 5757 Trumbull Ave.
FAIRMONT, W. VA., 602 Cleveland Ave.
HOUSTON, TEX., 2311 Commerce St.
HUNTINGTON, W. VA., 209 Ninth St.
INDIANAPOLIS, IND., 531 W. Merrill St.
JOHNSTOWN, PA., 47 Messenger St.
KANSAS CITY, MO., 2124 Wyandotte St.
LOS ANGELES, CALIF., 420 S. San Pedro St.
MILWAUKEE, WIS., 1006 N. Water Street
MINNEAPOLIS, MINN., 2301 Kennedy St., N. E.
NEWARK, N. J., Haynes Ave. and Lincoln Highway
NEW YORK, N. Y., 286 W. Thirty-fourth St.
PHILADELPHIA, PA., 3001 Walnut St.
PITTSBURGH, PA., 345 N. Lang Ave.
PORTLAND, OREGON, 2114 N. Interstate Ave.
PROVIDENCE, R. I., 103 Harris Ave.
ROCHESTER, N. Y., 410 Atlantic Ave.
SALT LAKE CITY, UTAH, 346-A Pierpont Ave.
SAN FRANCISCO, CALIF., 1400 Powell Street, Emeryville, Calif.
SEATTLE, WASH., 1031 East Marginal Way
SPRINGFIELD, MASS., 303 Liberty St.
ST. LOUIS, MO., 717 S. Twelfth St.
UTICA, N. Y., 111 N. Genesee St.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.
WORCESTER, MASS., 32 Southbridge St.

†Change from previous issue.

WESTINGHOUSE ELECTRIC INTERNATIONAL CO.
30 ROCKEFELLER PLAZA, NEW YORK, U. S. A.

CANADIAN WESTINGHOUSE CO., Limited
HAMILTON, ONTARIO

Westinghouse Press—Printed in U. S. A.—S. A. J. Sept.—'34

NPC00007959

770598

Registered Aug. 27. 1935

Trade-Mark 327,517

WED
TINGHOUSE ELE--TRIC CORPORATION
PITTSBURGH 24,

UNITED STATES PATENT OFFICE

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Act of February 20, 1905

Application May 1, 1935, Serial No. 364,461

INERTEEN

STATEMENT

To the Commissioner of Patents:

Westinghouse Electric & Manu[facturing Com]pany, a corporation duly organ[ized under the] laws of the State of Pennsylva[nia and located at] East Pittsburgh, Pennsylvania, [doing busi]ness at 700 Braddock Avenue, E[ast Pittsburgh,] Pennsylvania, has adopted and [used the trade]mark shown in the accompanyi[ng drawing, for] ELECTRICAL CONDENSERS, [namely, 21, Elec]trical apparatus, machines and [supplies, and] presents her with five specime[ns showing the] trade-mark as actually used by [the applicant] upon the goods, and requests tha[t same be] registered in the United States P[atent Office in] accordance with the act of Febr[uary 20, 1905,] as amended.

The trade-mark has been cont[inuously used] and applied to said goods in applic[ant's business] since on or about February 2, 1935.

The trade-mark is applied to the goods by applying thereto metal name plates bearing the trade-mark.

The undersigned hereby appoints O. H. Eschholz, (Registered No. 12,464), whose postal address is Patent Department, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., its attorney with full powers of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the certificate and to transact all business in the Patent Office in connection therewith.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY,
By S. M. KINTNER,
Vice President.

NPC00007960

770599

5-111 Case 18,402

Inerteen® insulating askarel

for transformers • circuit breakers regulators and related equipment

price list 45-82

Inerteen is the registered trademark for Westinghouse askarel. It is a nonflammable and nonexplosive insulating and cooling liquid used in specific designs of transformers, switch compartments and terminal chambers to eliminate the fire hazard characteristic of electrical equipment insulated with hydrocarbon insulating oils. It is now designated as Inerteen 7336-9 and may be purchased as a supply item for the replacement of liquid in Westinghouse equipment originally supplied with Inerteen.

Inerteen 7336-9 is an improved formula which includes a special ingredient known as M-12254-1. This compound acts as a scavenger and minimizes the effect of any hydrogen chloride that may be present due to arcing within the equipment. Hydrogen chloride is a by-product of burning or arcing in Inerteen, and, in the presence of moisture, forms hydrochloric acid which damages the insulation and causes rusting of ferrous materials. The presence of M-12254-1 effectively reduces this action and thus helps to preserve insulation and metal parts.

Inerteen 7336-1 through 7336-7 may be converted to Inerteen 7336-9 by adding compound M-12254-1, as outlined in Engineering Data Letter no. 1337-B.

Inerteen 7336-8 which possesses similar characteristics to Inerteen 7336-9, need not be converted. However, the two can be mixed and Inerteen 7336-9 may be used as a replacement liquid for Inerteen 7336-8 with no change in the basic characteristics of either liquid.

When ordering replacement Inerteen, serial numbers of the transformers must be given.

net prices f.o.b. shipping point

material	quantity	approx shipping weight: lbs	net prices f.o.b. Sharon, Pa.	net prices f.o.b. Sunnyvale, Cal.
Inerteen 7336-8	5 gal. can	70	$ 17.00	$ 20.40
Inerteen 7336-8	55 gal. drum	770	137.50	165.00
compound M-12254-1	½ pt bottle	½	2.25	.....
compound M-12254-1	1 pt bottle	1	3.50	.....
compound M-12254-1	1 qt bottle	2	5.00	.....
compound M-12254-1	1 gal bottle	8	20.00	.....

note 1: Prices include non-returnable containers.

note 2: Prices for less than 55 gallons, shipped in a single drum, should be pro-rated accordingly.

reconditioning of Inerteen

Due to the presence of moisture or other foreign material, it may become necessary, to recondition Inerteen. This may be done either in the field by means of an askarel filter or reconditioned at the Sharon plant laboratory.

Before returning Inerteen to the Sharon plant laboratory for reconditioning, a test sample should be forwarded for determining the advisability of reconditioning, since there are cases where this operation is not economical. Upon receipt of samples, tests will be made and the customer informed of the advisability of reconditioning the Inerteen.

In general, oil-contaminated or heavily-arced Inerteen cannot economically reconditioned. Therefore, no allowance will made on the purchase of new Inerteen.

prices for reconditioning Inerteen:

(a) odd lots returned to Sharon plant laboratory in drums (net per gallon) $1

(b) in transformers returned to Sharon plant for repair (net per gallon) .....

Inerteen testing service

Complete facilities are available for testing customer's Inerte Inerteen sample containers are available and samples should taken in accordance with ASTM D117.

1. By separate general order, obtain Inerteen sampling set (st no. 1608 629) from Sharon Order Service Dept. (Compon Parts).

   note: Do not include testing service on this general order.

   Sampling set (style no. 1608 629 consists of two (2) 16-ou empty bottles packaged in a single carton with compl instructions and ordering blanks (Form 10038) for specifyi tests to be made.

2. Prepare samples and packages for shipment to Sharon Pl Laboratory in accordance with instructions in the sampling s

   The white and canary copies of Form 10038 are to be mail to nearest Westinghouse sales office by customer. Pi copy to be enclosed in green envelope attached to t sampling set and forwarded to Sharon Plant Laborat with the sample set.

   Green copy to be retained by customer.

   note: Westinghouse sales office to issue a new general order for test service.

3. Tests will be made in accordance with ASTM D117, as spe fied, and a report of tests forwarded by the Sharon Orc Service Dept.

description	net pri
1. carton of two (2) empty bottles (style no. 1608 629)	$ 1.
2. dielectric strength test, per sample	5.
3. physical and chemical examination	25.
3(a) acid and base numbers	
(b) color	
3(c) interfacial tension	
(d) pour point	
(e) specific gravity	
(f) viscosity	
4. power factor test—60 cycles at 25 C	3.
5. complete Inerteen tests—2 to 4 inclusive	30.
6. power factor curve—25 C to 100 C	75.

NPC00007961

Send samples to:

Westinghouse Electric Corporation
469 Sharpsville Ave.
Sharon, Pennsylvania

Attention: Sharon Plant Laboratory

1 Tests most commonly used and recommended for general purposes. To set price $30.00.

note: Separate tests 3(a) to 3(f)—$5.00 each per sample.

PATENT DEPARTMENT
RECEIVED
SEP 14 1956
FILE CLERK

August 4, 1955
supersedes price list 44-800 dated July 9, 1952
mailed to: E-156 Pt.; D66-1C, C30-1Y

prices effective August 4, 1955; subject to change without noth

for standard terms and conditio of sale, refer to selling policy 45-0

770600

Inerteen characteristics (7336-9)

general: Inerteen 7336-9 is a nonflammable liquid used in specific designs of transformers where the fire hazard of insulating oil is to be eliminated. It is a mixture of chlorinated diphenyl-trichlorbenzene and a small amount of scavenging compound M-12254-1.

acidity: less than 0.010 milligrams of sodium hydroxide per gram (Method of test for Neutralization Number of Petroleum Products by Color Indicator Titration: D-663, A.S.T.M.)

free chlorides: ..... less than 0.10 ppm

chemical stability: no generation of free chlorides under normal operating conditions

condition: ..... clear

specific gravity: at 15.5C/15.5C (60F/60F) not less than 1.560 (Westphal balance or hydrometer)

viscosity: (Saybolt Universal Viscometer at 37.8C (100F) ..54 sec.

color: (maximum) ..... 150 A.P.H.

pour point: (Method of Test for Cloud and Pour Points: D-97, A.S.T.M.) ..... (minus 25.6F) minus 32C max.

dielectric strength: (minimum) 25C (77F) at point of shipment.. ..... 35 kv
(minimum) 25C (77F) at point of receipt ..... 30 kv
(Method of Testing Insulating Oils: D-117, A.S.T.M.)

electrical resistivity: (minimum) 100 x 10^6 ohms / cm 3 (100C (212F) at 500 volts dc)

dielectric constant: at 1000 cy. 25C (77F) ..... 4.0 to 4.3
at 1000 cy. 100C (212F) ..... 3.5 to 3.8

refractive index: at 25C (77F) ..... 1.6137 to 1.6157

weight per gallon: 25C (77F) ..... 13.08 lbs.

further information

askarel test sets:
- prices: price list 45-820
- description: descriptive bulletin 45-850

askarel filtering equipment
- prices: price list 45-821
- description: descriptive bulletin 45-851

liquid dielectrics
- application: technical data 45-860

askarel for electrical apparatus
- instruction book 44-860-1

NPC00007962

Westinghouse Electric Corporation
transformer division: Sharon plant • Sharon, Pa.
printed in U.S.A.

PDS 54201CM Rev A DATE April 1969

SUBJECT INERTEEN (WITH SCAVENGER)

CAUTION: DO NOT BREATHE VAPOR. AVOID PROLONGED OR REPEATED CONTACT WITH SKIN. USE WITH ADEQUATE VENTILATION. AVOID SKIN CONTACT. See MSDS I-1

SUPPLIERS -

Monsanto Chemical Co, 800 N Lindbergh Blvd, St Louis, Mo 63166

ORDER FROM SUPPLIER AS -

Inerteen, PDS Spec 54201CM Rev A

CHARACTERISTICS - 54201CM (User SH) Clear, nonflammable liquid insulating material consisting of chlorinated diphenyl and 0.18 to 0.22 percent phenoxypropene oxide (scavenger).

Properties / Tests per ASTM D-924	
Free Chlorides, ppm, max	0.10
Water Content, ppm, max	35
Neutralization, mg KOH/gram Inerteen, max	0.01
Refractive Index, 25°C (77°F)	1.622 - 1.626
Color, APHA, max	100
Distillation Range:	
10% Distillation Temp, max (by wt)	332°C (617°F)
90% Distillation Temp, max (by wt)	360°C (680°F)
Pour point, max	-14°C (7°F)
Specific Gravity 15/15°C (60/60°F)	1.381 - 1.392
Viscosity, SSU at 37.8°C (100°F), max	92 - 92
Dielectric Strength, 0.1 gap, KV, min	30
Resistivity, ohms/cm³ at 100°C (212°F), min. (at 500 V DC after 2 minutes charging)	50.0 X 10¹⁰

Bright aluminum does not show evidence (visually) of corrosion when heated 6 hours in Inerteen at 200 - 210°C (392 - 410°F).

APPLICATION - Transformer insulation.

SPECIFY AS - (54201CM) INERTEEN stating number

Printed in U.S.A. © Corp Std R&D (Fed. CODE IDENT NO. 79500)

NPC00007963

770602

FDS 54201KA Rev D Feb 20, 1970

CP

INHERTEKS

CAUTION: DO NOT BREATHE VAPOR. PROVIDE ADEQUATE VENTILATION. AVOID CONTACT WITH THE SKIN. SEE SFDS I-1.

SUPPLIERS -

Monsanto Chemical Co, Organic Chemicals Div, 800 N Lindbergh Blvd St Louis, Mo 63166

ORDER FROM SUPPLIER AS - Inerteen, F D Spec 54201KA Rev D

CHARACTERISTICS - (Users: MAF, SN) Nonflammable, transformer insulating liquid for use in transformers designed to eliminate fire hazards. Material is mixture of chlorinated diphenyl and trichlorobenzene with 0.20 per cent phenoxypropene oxide added.

Color, APHA, max	50
Dielectric Strength, 0.1" gap, KV, min	30
Neutralization No., mg KOH/gram, max	0.014
Refractive Index, 25 C (77 F)	1.6153 - 1.6173
Viscosity, SSU, 37.8 C (100 F), max	60 ± 2
PF, per cent, at 60 Hertz, rm temp, max	1.0
at 100 C (212 F) max	5.0

APPLICATION - Transformer insulating liquid

SPECIFY AS - INERTEEN, stating number.

NPC00007964

770603

September 16, 1971

Mr. P. C. Benignus
Monsanto Chemical Company
Industrial Fluids Sales
800 North Lindberg Boulevard
St. Louis, Missouri 63166

Dear Mr. Benignus:

Subject: Tentative P D Spec 54201KJ Rev B

I am sending you herewith two copies of the subject tentative P D Spec which covers Inerteen intended for use as a capacitor dielectric impregnant. This specification has been revised based on your comments on the previous tentative P D Spec.

Please submit the specification to your Engineering Department for review and let me know whether or not you can furnish material in conformance with the specified requirements. You should note that if we have not heard from you on this subject by October 28, 1971, we will assume that you have no objection to the specification and that your Company may be listed as an approved supplier without exception.

Please note that if you have any comments on this specification, they should be submitted to this office not to someone else in the organization. To reiterate, unless we hear from you directly we will assume that the specification is considered to be acceptable to Monsanto Chemical Company.

Very truly yours,

R. H. Lloyd, Materials Engineer
Corporate Standards, 501-3766

rm

Enclosures (2)

10-28-71
No response
RHL

NPC00007965

770604

AUG 1971
SPECIFICATION

WESTINGHOUSE PROPRIETARY
Mutilate Before Discarding

Westinghouse Electric Corporation
Corporate Standards - R & D Center

Nov 20, 1971

P D Spec 54201KJ Rev B

(Federal CODE IDENT NO. 79500)

INERTEEN

1. This specification covers nonflammable liquid suitable for use as capacitor dielectric impregnant.

P D Spec Designation	Description
54201KJ	Mixture of 32.5% chlorinated diphenyl containing 21% chlorine, 32.5% chlorinated diphenyl containing 40 - 43% chlorine, and 35% trichlorobenzene.

2. No change shall be made in the quality of successive shipments of material furnished under this specification without first obtaining the approval of the purchaser.

CHEMICAL PROPERTIES AND TESTS

3. COMPOSITION: Per Section 1.

4. FREE CHLORIDES: Shall not exceed 0.10 ppm, determined per ASTM D 901.

5. HYDOLYZABLE CHLORINE: Shall not exceed 3.0 ppm, determined in accordance with Westinghouse MTS 80138.

6. WATER CONTENT: Shall not exceed 35 ppm.

7. NEUTRALIZATION NUMBER: Shall not exceed 0.010 milligrams KOH, determined per ASTM D 974.

8. CORROSION: Bright aluminum foil shall not show evidence of corrosion, either visually or by weight determination, when heated in the Inerteen for a period of 6 hours at 200-220 C (392 - 428 F). After use in this test the Inerteen shall meet the following requirements:

Color, APHA, max	400
Neutralization Number, max	0.014
Free Chlorides, ppm, max	5.0
Clarity	Clear

PHYSICAL PROPERTIES AND TESTS

9. REFRACTIVE INDEX: 1.6025 - 1.6040 at 25 C (77 F)

10. SPECIFIC GRAVITY: 1.325 - 1.340 at 25/15.5 C (77/60 F)

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11. COLOR: Shall not exceed 50 APHA, determined per ASTM D 901.

12. CLARITY: The Inerteen shall be clear and free from any suspended or settled foreign materials.

13. VISCOSITY: 35 - 45 SSU at 37.8 C (100 F)

14. POUR POINT: Shall not exceed - 40 C (-40 F), determined per ASTM D 97.

15. FIRE POINT: Material shall not ignite at temperatures up to its boiling point when tested per ASTM D 92.

16. DISTILLATION RANGE:

Initial Temp, Min	200 C (392 F)
35% (max wt)	270 C (518 F)
90% (max wt)	350 C (662 F)

17. DIELECTRIC STRENGTH: Per ASTM D 877.

At point of shipment, KV/.1" (.254 cm), min	35
At destination, KV/.1" (.254 cm), min	30

18. RESISTIVITY: 100 x 10^9 ohms/cm^3 (min), after 1 minute at 500 volts DC on 0.1" gap at 100 C (212 F).

19. DIELECTRIC CONSTANT: 4.3 to 4.5 determined per ASTM D 150 at 100 C (212 F) and 1 KHz.

20. POWER FACTOR: The power factor of the Inerteen as received shall not be greater than 5% when tested at 60 Hertz and 100 C (212 F) per ASTM D 924. When treated with fuller's earth it shall be reduced to less than 1%.

PACKING AND MARKING

21. PACKING: (21.1) The Inerteen shall be shipped in drums or tank cars, as specified on the purchase order.
(21.2) Drums shall conform to regulations of the U.S. Dept of Transportation.

22. MARKING: (22.1) Drums shall be plainly marked as follows: Purchase Order Number; Inerteen, P D Spec Number and Revision Letter; Net Weight in Lbs; Name of Manufacturer.
(22.2) Each tank car shall have a packing slip bearing the following information: Purchase Order Number; Inerteen, P D Spec Number and Revision Letter; Batch Number; Number of Gallons; Name of Manufacturer.

INSPECTION

23. INSPECTION: The manufacturer shall furnish the Quality Control Dept of the W E Corp, Bloomington, Ind a report of the tests made per Sections 3 to 20 inclusive on each shipment of Inerteen.

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~~N to PDS~~ ~~PDS to N~~ ~~CONFIDENTIAL~~ (NEW) ~~TRADENAME~~

~~N or~~ PDS 5420IKJ Rev B DATE Nov 20, 1971

SUBJECT INERTEEN OR FUMIZ.

CAUTION: WESTINGHOUSE PROPRIETARY - MUTILATE BEFORE DISCARDING
AVOID BREATHING VAPOR OR MIST. USE ONLY WITH ADEQUATE VENTILATION. AVOID SKIN CONTACT. SEE SPDS I-1 (R)

SUPPLIERS - Monsanto Chemical Co, Organic Chemicals Div, 800 N Lindbergh Blvd, St Louis, Mo 63166

ORDER FROM SUPPLIER AS - Inerteen, PD Spec 5420IKJ Rev B

~~Stating "Permanently mark all containers with Westinghouse N number."~~

CHARACTERISTICS - (User: DA) Inerteen suitable for use as capacitor impregnant. Mixture of 32.5% chlorinated diphenyl containing 21% chlorine, 32.5% chlorinated diphenyl containing 40 to 42% chlorine, and 35% trichlorobenzene.

Color, APHA, max	400
Refractive Index at 25°C (77°F)	1.6025 - 1.6040
Specific Gravity at 25/15.5°C (77/60°F)	1.325 - 1.340
Water Content, ppm, max	35
Neutralization Number, mg KOH/gram, max	0.010
Viscosity, SSU, at 37.8°C (100°F)	32 - 45
Pour Point, max	-40°C (-40°F)
Dielectric Strength, KV/0.1" (.254 cm), min	30
Dielectric Constant at 100°C (212°F)	4.3 - 4.5
Power Factor % as received, 60Hz, 100°C, max	5
Power Factor, %, Treated, Less than	1

APPLICATION - Capacitors

SPECIFY AS - Specify by P D Spec & Size Code
Example: INERTEEN 5420IKJ00V

Printed in U.S.A. Ⓦ Corp Std R&D (Fed. CODE IDENT. NO. 79500)

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Westinghouse Electric Corporation

Corporate Standards - R & D Center
WESTINGHOUSE PROPRIETARY - Mutilate Before Discarding ~~Nov 20, 1971~~ Aug 5, 1975

P D Spec 54201KJ Rev ~~B~~ C (Federal CODE IDENT NO. 79500)

INERTEEN → of chlorinated diphenyl and trichlorobenzene

1. This specification covers a nonflammable liquid mixture suitable for use as a dielectric impregnant.

2. The included SI (metric) values are rounded equivalents of the U.S. values, and are for reference only. Where they appear alone

2. No change shall be made in the quality of successive shipments of material furnished under this specification without first obtaining the approval of the purchaser.

CHEMICAL PROPERTIES AND TESTS

3. COMPOSITION: Mixture of 32.5% chlorinated diphenyl containing 21% chlorine 32.5% chlorinated diphenyl containing 40 to 43% chlorine and 35% trichlorobenzene

4. COMPONENT HOMOLOGS: Higher boiling homologs shall not exceed 0.4% by weight

5. FREE CHLORIDES: Shall not exceed 0.10 ppm, determined per ASTM D 901.

6. HYDOLYZABLE CHLORINE: Shall not exceed 3.0 ppm, determined in accordance with Westinghouse MTS 80138.

7. WATER CONTENT: Shall not exceed 35 ppm.

8. NEUTRALIZATION NUMBER: Shall not exceed 0.010 milligrams KOH, determined per ASTM D 974. (to)

9. CORROSION: Bright aluminum foil shall not show evidence of corrosion, either visually or by weight determination, when heated in the Inerteen for a period of 6 hours at 200-220 C (392-428 F). After use in this test the Inerteen shall meet the following requirements: (to)

Color, APHA, max	400
Neutralization Number, max	0.014
Free Chlorides, ppm, max	5.0
Clarity	Clear

PHYSICAL PROPERTIES AND TESTS

10. REFRACTIVE INDEX: 1.6025 (to) 1.6040 at 25 C (77 F)

11. SPECIFIC GRAVITY: 1.320 (to) 1.335 at 25/15.5 C (77/60 F)

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12. COLOR: Shall not exceed 50 APHA, determined per ASTM D 901.

13. CLARITY: The Inerteen shall be clear and free from any suspended or settled foreign materials.

14. VISCOSITY: SSU at 38C(100 F) 33 to 43

15. POUR POINT: Shall not exceed - 40 C (-40 F), determined per ASTM D 97.

16. FIRE POINT: Material shall not ignite at temperatures up to its boiling point when tested per ASTM D 92.

17. DISTILLATION RANGE:

Initial Temp, Min	200 C (392 F)
35% (max wt)	270 C (518 F)
90% (max wt)	350 C (662 F)

kV/.1 inch kV/2.54 mm

18. DIELECTRIC STRENGTH: Per ASTM D 877:

At point of shipment, min	35
At destination, min	30

cubic centimetre

19. RESISTIVITY: 100 x 10^9 ohms/ (min), after 1 minute at 500 volts DC on gap at 100 C (212 F). (2.54mm) 0.1 inch

20. DIELECTRIC CONSTANT: 4.3 to 4.5 determined per ASTM D 150 at 100 C (212 F) and 1 kHz.

21. POWER FACTOR: The power factor of the Inerteen as received shall not be greater than 5% when tested at 60 Hertz and 100 C (212 F) per ASTM D 924. When treated with fuller's earth it shall be reduced to less than 1%.

PACKING AND MARKING

22. PACKING: (22.1) The Inerteen shall be shipped in drums or tank cars, as specified on the purchase order.
(22.2) Drums shall conform to regulations of the U.S. Dept of Transportation.

23. MARKING: (23.1) Drums shall be plainly marked as follows: Purchase Order Number; Inerteen, P D Spec Number and Revision Letter; Net Weight in Lbs; Name of Manufacturer.
(23.2) Each tank car shall have a packing slip bearing the following information: Purchase Order Number; Inerteen, P D Spec Number and Revision Letter; Batch Number; Number of Gallons; Name of Manufacturer.

INSPECTION

24. INSPECTION: The manufacturer shall furnish the Quality Control Dept 21 of the W E Corp, Bloomington, Ind a report of the tests made per Sections 3 to 20 inclusive on each shipment of Inerteen.

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Instructions for Handling Inerteen® Insulating Fluid P.D.S. 54201 CM and Installation and Maintenance of Inerteen Transformers



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

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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 nonflammability 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.

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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

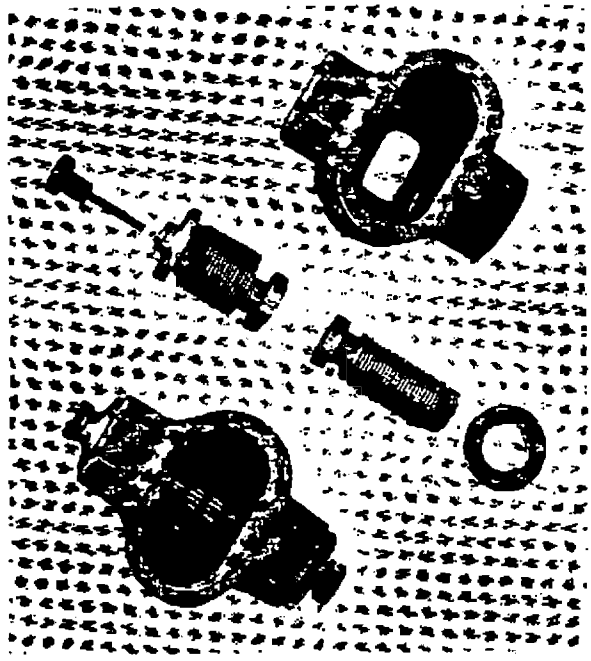


Fig. 1. Fluid Test Cup for Dielectric Test

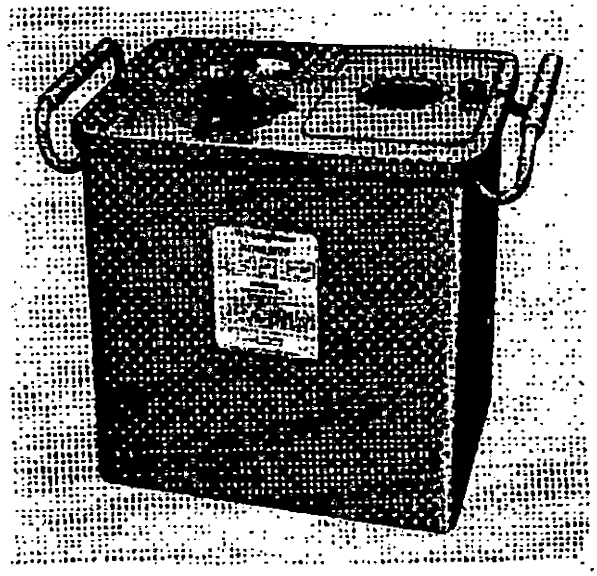


Fig. 2. Portable Oil Testing Set, 1/2 KVA. 35,000 Volts

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.

$$\text{KOH per g. of Inerteen} = \frac{(A\text{-}B\ (N) \times 56.1}{W}$$

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 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 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

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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.

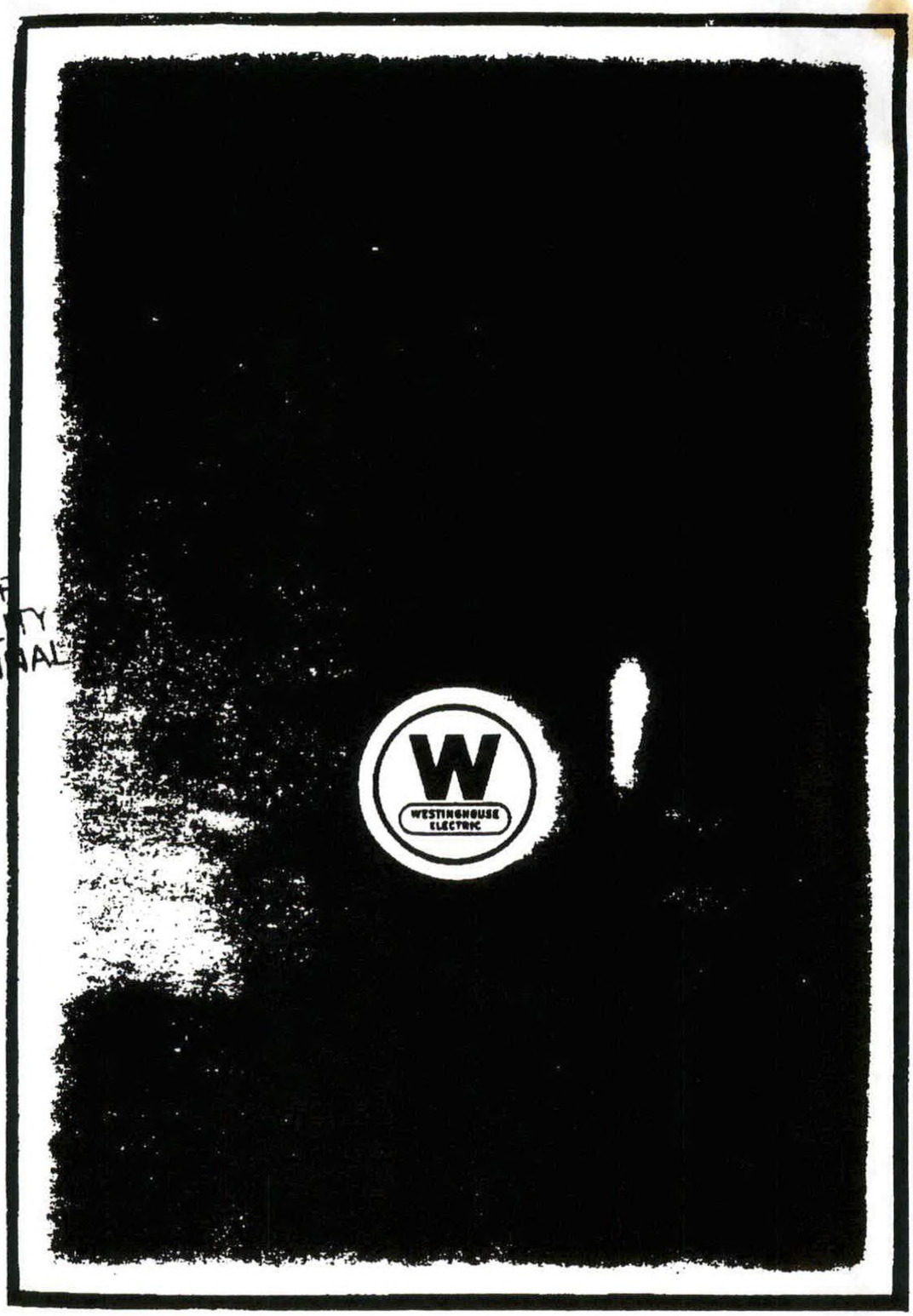
Memorandum



Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

NPC00007986



POOR
QUALITY
ORIGINAL

NPC00007987

UNIVERSAL WEMCO C OIL—Continued

Oil-Testing Service—In order to make sure that the dielectric strength is up to its proper value, insulating oil in any piece of apparatus should be tested at regular intervals.

The EEI recommends that oil samples from all power station and substation apparatus be tested at least once every 3 months, and that samples from distribution transformers be tested at least once a year.

Many users of transformers and large oil circuit breakers do not have the necessary equipment for testing the insulating oil. In order that these users be able to make the periodic tests recommended by the EEI, Westinghouse has established an oil-testing service.

This service has been developed to make it simple for the customer to handle, and to secure a prompt report as to the condition of the oil. This includes the furnishing of containers for, and analysis of, oil samples when returned to Westinghouse.

In addition to dielectric tests, Westinghouse is prepared to make physical and chemical examinations, if desired.

This service consists of examination of the oil by a competent oil chemist. Recommendations will be made as to the suitability of the oil for continued use, whether it will be desirable and economical to clean it, and in a general way, the preferred method of cleaning, if this is found to be desirable. Samples should be approximately 1 quart in quantity. When submitting samples, the type of service required should be plainly indicated.

A nominal charge is made for these services. Prices will be quoted on request to the nearest district office.

For detailed instructions relative to oil-testing service, the reader is referred to Catalog Section 65-100.

Complete information for handling and testing of Wemco C oil is given in Westinghouse Instruction Book, I.B. 5336, copies of which may be obtained from the nearest district office.

INERTEEN

Application

The search for a non-inflammable, non-explosive insulating and cooling medium for use in transformers and switches has resulted in the development of synthetic liquids for such applications. Similar liquids in which other characteristics have been given special attention have been developed for capacitors.

The name Inerteen has been adopted to cover these liquids. Capacitor Inerteen is covered in Catalog Section 49-100. Inerteen as used in transformer applications is described below.

Distinctive Features

Non-inflammable, cannot be made to burn.

Non-explosive, since the gas given off is non-combustible when mixed with air in any proportion.

Dielectric strength is greater than that of oil. Preservation of that strength, however, involves the same general precautions as are exercised with oil. Inerteen should be free of lint, dirt, and moisture.

Viscosity is quite the same as that of transformer oil.

Freezing point is approximately −40°F. Inerteen does not expand at freezing temperature, therefore no mechanical damage to transformer parts results.

Thermal characteristics of Inerteen allow for greater heat conductivity per unit of cooling medium.

Non-oxidizing and non-corrosive at temperatures considerably above those normally obtained in transformers. It will not sludge under any condition.

Operating Characteristics

Solvent action—Inerteen exerts a strong solvent action on most of the ordinary varnishes, gums and paints commonly used in oil-insulated transformers. Therefore, such materials cannot be used in Inerteen-filled apparatus. It is necessary to use 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.

All screwed fittings and gaskets are sealed with Westinghouse sealing compound, rendering the complete apparatus Inerteen and gas tight. All valves are fitted with metal or other Inerteen-resisting seats.

Soldering fluxes ordinarily purchased on the market are particularly harmful to power factor and resistance of the Inerteen, and when used, extreme care must be exercised in their complete removal. For soldering, a solution of resin in alcohol is recommended.

Arcing—The products of arc decomposition are definitely harmful. In case of severe arcing, the Inerteen and the solid insulation of the transformer will be saturated with the products of arc decomposition and must be removed and either replaced or reconditioned.

Shipment—Inerteen transformers are shipped properly filled with Inerteen and ready for installation. Switches or terminal chambers 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.

Care and Operation

Physical Discomfort—Inerteen has an irritating effect upon the skin; more so to some persons than others. Especially the eyes, nose and lips are affected when coming in contact with Inerteen and safety precautions must be observed when handling it.

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.

Purifying Inerteen—Inerteen may be dehydrated and filtered by means of a specially designed Westinghouse reconditioner using "activated clay" as the filtering medium. (See page 474.)

CHARACTERISTICS OF INERTEEN

Color	Straw-Yellow
Odor	Slightly Aromatic
Viscosity at 100°F. (Saybolt)	50 Seconds
Flash Point	None
Fire Point	None
Boiling Point	446°F.
Freezing Point	−40°F.
Specific Gravity at 60°F.	1.535
Coefficient of Expansion per °C.	.00078
Specific Heat (Cal./cc)	.40
Dielectric Constant	4.42
Dielectric Strength	35 to 40 Kv.

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SAFE PRACTICES AND PROCEDURES:

PCB's (POLYCHLORINATED BIPHENYLS)

PRECAUTIONS

1. The low evaporation rate of PCB's at normal temperatures does not present it as an inhalation hazard. If there is a high concentration of PCB vapor in the air created by an elevated temperature of liquid or within confined spaces, respirators should be worn. The recommended protection is an M.S.A. respirator (COMFO II) with combination cartridges type GMC-H/or a Scott Air Pack.

   For effective protection, respirators must fit the face and head snugly. Respirators should not be loosened or removed in work situations where use is required. If you can smell PCB's while wearing a respirator, the respirator is not working correctly; go immediately to fresh air. If you experience difficulty breathing while wearing a respirator, notify your supervisor.

2. Where work procedures may cause splashes to the face, splash-proof goggles must be worn. Contact lenses should not be worn when working with this chemical.

3. Where there is a possibility that work procedures may require frequent contact with hands, PVC gloves should be worn. Avoid gloves that may absorb the liquid or allow it to pass through. If your skin becomes contaminated with PCB's, immediately wash using soap or mild detergent to remove.

4. Do not eat or smoke in areas where PCB's are handled.

5. Promptly remove any non-impervious clothing that becomes contaminated with PCB's. This clothing must not be reworn until the liquid is thoroughly removed.

6. PCB's are essentially nonflammable and non-explosive, but they do fall into the combustible liquid category. When the liquid contacts a flame, welding arcs, or extremely hot metal surfaces, it may decompose to form highly irritating hydrogen chloride gas, highly toxic carbon monoxide, and some carbon dioxide.

EMERGENCY FIRST-AID PROCEDURES

Swallowing -If PCB's have been inadvertently swallowed, get medical attention immediately. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of the throat with his finger,

or by giving him large amounts (one pint or more) of warm salt water (two tablespoons of salt per pint of water). Do not make an unconscious person vomit.

Breathing -If you or any other person breathes in large amounts of PCB's, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Eye Exposure -If PCB's get into your eyes, wash your eyes immediately with large amounts of water for at least 15 minutes. Get medical attention immediately.

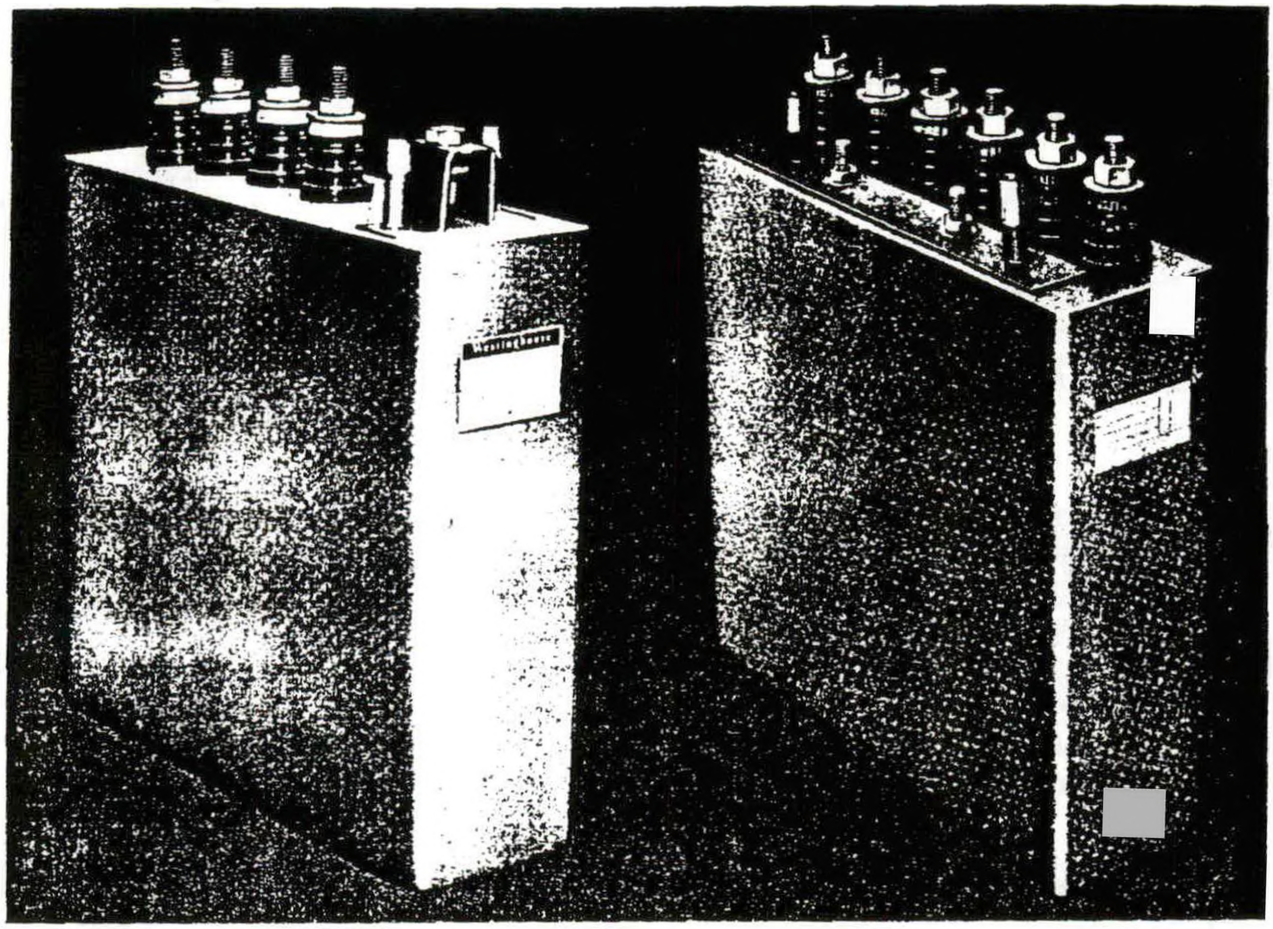
Skin Exposure -If PCB's get on your skin, immediately wash the contaminated skin using soap or mild detergent and water. If it soaks through your clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

Westinghouse

High Frequency Capacitors

Type FPW, Water Cooled

For Induction Heating Equipment
960 – 9600 Hertz, Up to 450 Kvar
200 – 1250 Volts



Design Features

Compact, Lightweight: Efficient design of capacitor components and cooling system results in optimum use of materials, weight and volume thereby being held to a minimum.

High Current Rating Per Unit Volume: Multiple bonding of foil electrode to cooling coil provides maximum heat transfer with minimum temperature rise.

Permanent Characteristics: The combination of Inertex™ paper with Inerteen® impregnant produces a capacitor having characteristics of stability with low loss and high dielectric constant especially suited to high frequency applications.

Hermetically Sealed: Provides a capacitor with stable characteristics assuring long, maintenance-free operation. Although vertical mounting is preferred, the units may be mounted in any position.

Application

Westinghouse type FPW high frequency water-cooled capacitors have been designed to improve the inherently low power factor associated with induction heating apparatus on melting furnaces, billet heating, forging and heat treating applications.

Based on load requirements, high frequency capacitors are usually installed in multiple unit banks with a means of switching provided to adjust capacitance and tune the circuit for efficient operation under varying load conditions.

Mounting and Operation

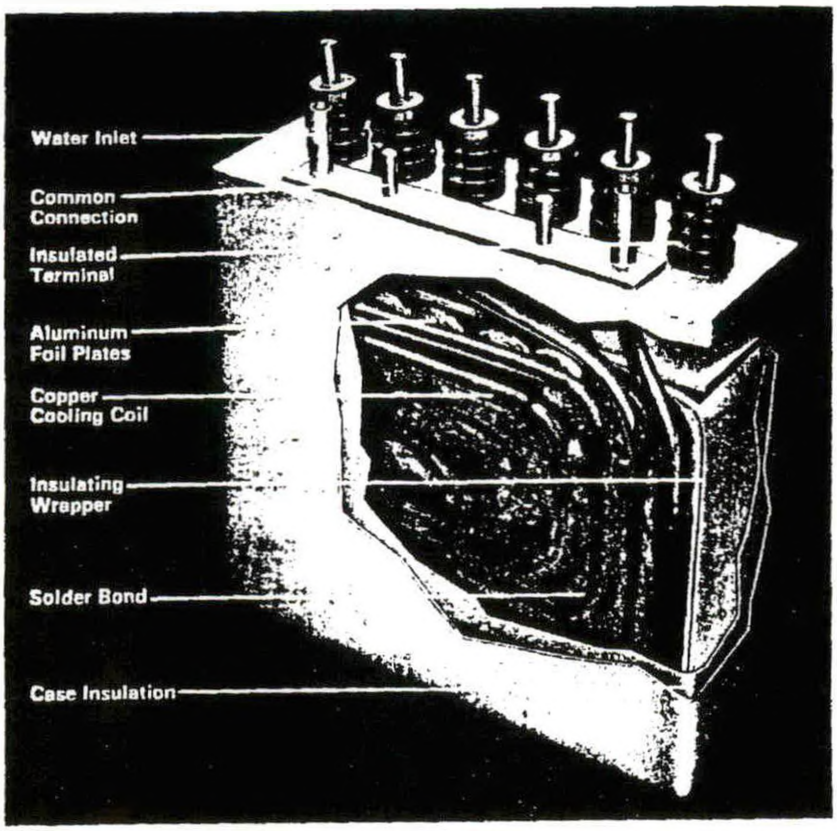
The capacitor units may be mounted with terminals upright, or on edge with the terminals horizontal. The units have one pole grounded to the case and may be operated with the case and cooling-coil either insulated or grounded depending on the circuit.

December, 1970
Supersedes DB. 38-256, pages 1-4, dated October, 1966
E.D.C/2001/DB

NPC00007991

Westinghouse

Construction



Type FPW capacitors are wound with aluminum foil plates separated by layers of thin Inertex paper. The extended foil construction of opposite polarity are staggered so the edges project from opposite sides of the capacitor section. The projecting edges are then bonded together using a solder alloy and a special bonding technique. The heavy braided copper leads are soldered to the bond. The foil edges of the opposite side of each section are also soldered directly to a tubular copper water-cooling coil which, in turn, extends through the cover assembly and serves as the common connection for the capacitor assemblies.

After the capacitor is assembled in its case, it is thoroughly vacuum dried. It is then filled with Westinghouse Inerteen, a synthetic, non-inflammable liquid dielectric having superior qualities at high frequency. In addition, it has stable electrical characteristics over a broad temperature range (−40°C to +46°C) low losses and is chemically inert. The capacitor is then hermetically sealed. All welded, non-magnetic case and covers are used to assure minimum heat generation when operating at high frequencies. Porcelain terminal bushings are sealed to capacitor enclosure by silicon rubber sleeves confined under pressure. This provides a seal with sufficient strength and flexibility to prevent damage to porcelain or seal that might result from excessive mechanical strains on the bus or connections. Cooling coils are permanently bonded to the enclosure and complete the hermetic seal.

One pole of all sections is common to the cooling coil and case. The other pole is brought out through one or more insulated terminals. Multiple terminals are used to provide desired kilovac steps, and also when high current capacity is necessary.

The voltage rating of a capacitor section for high frequencies must be limited to avoid damaging corona discharges at the foil edges. Since one pole of the section must be bonded to the cooling coil for good heat transfer, the practical voltage ratings of water-cooled units is restricted to 1250 volts and under.

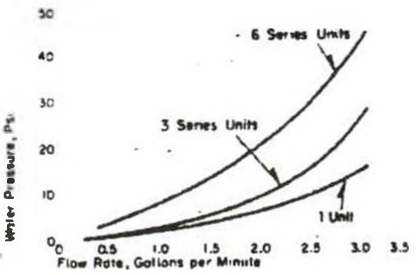
Cooling System

An adequate flow of clean water must be supplied to the capacitors. The coils of several units may be connected in series if the inlet water is cool, and the available pressure is high enough.

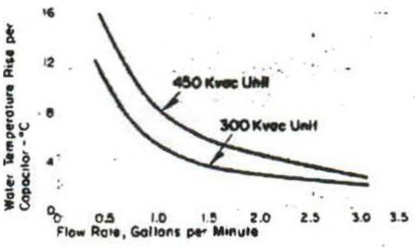
The cooling coil is a continuous copper tube terminated as shown on the outline drawings. It has no sharp turns that might become clogged. The cooling coil is designed in a double spiral, to assure uniform heat dissipation over the entire internal capacitor assembly. A recommended minimum flow rate of 0.5 gal/min. should be maintained and the outlet water temperature should not exceed 45°C (113°F). To prevent erosion of the tubing the flow rate should not exceed 4 gal/min.

A large size tubing is used so that two or more units may be connected in series if water of suitable temperature and pressure is available.

The curves below show the pressure required for various flow rates using 12 inches of ½ inch I.D. hose between each capacitor unit for the water connections. The bottom curves show the water temperature rise per capacitor for various flow rates and can be used for determining the required inlet water temperature.



Pressure required for Flow Rates using 12 inches of ½ inch I.D. Hose per Capacitor for Water Connections.



Water Temperature Rise per Capacitor Unit operated at rated KVAC in an ambient of 25°C.

NPC00007992

770631

High Frequency Capacitors

Type FPW, Water Cooled

For Induction Heating Equipment
960 – 9600 Hertz, Up to 450 Kvar
200 – 1250 Volts

Ratings

Type FPW high frequency, water-cooled capacitors are rated maximum continuous working current, maximum continuous working voltage, maximum kvac. The operating conditions may be varied over a wide range as long as none of these limits are exceeded. The values, given on the nameplate, are based on an outlet water temperature of 45°C. If at any time the outlet temperature is above 45°C, the voltage must be reduced 1½% for each degree above 45.

Rating limitations are voltage stress, temperature rise, and current per terminal.

The voltage rating is rms and applies for an impressed voltage having substantially a sine wave shape. If the voltage wave is distorted, its peak value must not exceed $\sqrt{2}$ times the capacitor voltage rating.

Capacitors may be operated at less than rated voltage or frequency. In some cases it may be permissible to operate at more than the rated frequency if the voltage is reduced. This involves design considerations and advice should be obtained from Westinghouse for specific cases.

If the capacitor is to be operated at some voltage or frequency below the rated value,

$$Kvac = \frac{CE^2 2\pi f}{10^9}$$

where Kvac = actual burden in kva,
E = working voltage,
C = rated capacity,
f = working frequency.

Thus, if a 61 mfd capacitor is operated at 400 volts instead of 625 volts,

$$Kvac = \frac{61 \times 400^2 \times 2 \times 3.14 \times 2000}{10^9} = 123$$

Reduced Voltage:

$$Kvac = Rated\ Kvac \left(\frac{Applied\ Volts}{Rated\ Volts} \right)^2$$

Reduced Frequency:

$$Kvac = Rated\ Kvac \left(\frac{Applied\ Frequency}{Rated\ Frequency} \right)$$

Frequency Hertz	Voltage		Kvac	Total Mfd	Mfd Per Terminal from Common to Terminal						Style Number	Approx. Net Wt. Lbs.	Fig. Ref. (See Dimensions Page 4
					Terminal Number								
	Common to Terminal (Volts)	Terminal 1 to 2 (Volts)			1	2	3	4	5	6			
960	400	....	200	204	5	10	21	42	63	63	367C750A50	58	6
	450	900	160	131	65.5	65.5	(32.75 mfd terminal 1 to 2)				367C750A28	50	2
	800	....	300	78	2	4	8	16	24	24	367C750A49	58	6
	900	....	215	44	22	22	....	....	....	....	367C750A27	50	2
	1000	....	215	35.7	13.4	22.3	....	....	....	....	367C750A41	50	1
	1000	....	215	35.7	13.4	22.3	....	....	....	....	367C750A48	50	2
1000	400	....	210	210	52.5	52.5	52.5	52.5	....	....	367C750A44	54	4
	600	....	300	108	18.6	18.6	18.6	18.6	....	....	367C750A51	54	4
	1200	....	300	32.0	2.0	4.0	6.0	10.0	10.0	....	367C750A97	58	5
	1250	....	160	15	7.5	7.5	....	....	....	....	367C750A37	50	2
	1250	....	245	25	9.4	15.6	....	....	....	....	367C750A47	50	2
2000	625	....	300	61	6	16	37	....	....	....	367C750A04	52	3
	625	....	300	61	37	16	8	....	....	....	367C750A13	52	3
	625	1250	300	61.2	30.6	30.6	(15.3 mfd terminal 1 to 2)				367C750A01	52	2
	800	....	300	37.6	9.4	9.4	9.4	9.4	....	....	367C750A10	54	4
	1250	....	300	15.3	10.2	5.1	....	....	....	....	367C750A38	52	2
3000	275	....	300	210	52.5	52.5	52.5	52.5	....	....	367C750A29	54	4
	400	....	300	100	25	25	25	25	....	....	367C750A17	54	4
	400	....	300	100.5	6.7	13.4	26.8	53.6	....	....	367C750A43	54	4
	400	....	300	99.8	31.5	31.5	21	10.3	5.3	....	367C750A20	57	5
	400	....	300	99.9	2.7	2.7	10.5	21	31.5	31.5	367C750A32	58	6
	400	....	450	150.0	4.0	4.0	15.8	31.5	47.3	47.3	367C750A82	58	6
	625	....	300	41	26	10	5	....	....	....	367C750A06	52	3
	625	....	300	41	21.6	11	5.6	2.8	....	....	367C750A39	54	4A
	625	1250	300	40.8	20.4	20.4	(10.2 mfd terminal 1 to 2)				367C750A02	50	2
	800	....	300	24.92	8.23	8.23	8.23	8.23	....	....	367C750A16	54	4
	800	....	300	24.9	1.3	2.6	5.2	7.9	7.9	....	367C750A19	57	5
	800	....	450	37.3	2.0	3.9	7.8	11.8	11.8	....	367C750A89	54	5
	1000	....	300	15.65	1.95	3.9	3.9	5.9	....	....	367C750A08	54	4
	....	1250	75	2.5	2.5	....	(terminal 1 to 2)				367C750A24	50	2
	....	1250	150	5	5	....	(terminal 1 to 2)				367C750A25	50	2
	....	1250	220	7.5	7.5	....	(terminal 1 to 2)				367C750A26	50	2
	1250	....	300	10.2	1.45	2.9	5.85	....	....	....	367C750A46	52	3
	1250	....	150	5	2.5	1.25	1.25	....	....	....	367C750A03	54	3
	1250	....	300	10.2	1.45	2.9	5.85	....	....	....	367C750A40	52	3A
3600	200	....	180	200	50	50	50	50	....	....	367C750A36	54	4
	400	....	300	84	21	21	21	21	....	....	367C750A35	54	4
	400	....	80	16.8	2.8	2.8	2.8	2.8	2.8	2.8	367C750A34	58	6
	400	....	300	82.8	13.8	13.8	13.8	13.8	13.8	13.8	367C750A33	58	6
4200	400	....	300	72.0	4.8	9.6	19.2	38.4	....	....	367C750A42	54	4
8500	200	....	230	96	24	24	24	24	....	....	367C750A30	54	4
	220	....	230	80	2	4	8	16	25	25	367C750A21	58	6
	400	....	230	24	6	6	6	6	....	....	367C750A18	54	4
	440	....	300	25.94	0.64	1.3	2.7	5.3	8	8	367C750A22	58	6
	440	....	450	39.0	1.0	2.0	4.0	8.0	12.0	12.0	367C750A72	58	6
	800	....	300	7.76	0.78	0.78	1.6	2.3	2.3	....	367C750A31	57	5
	800	....	300	7.8	1.95	1.95	1.95	1.95	....	....	367C750A23	54	4
	800	....	450	11.8	1.2	1.2	2.4	3.6	3.6	....	367C750A81	54	5

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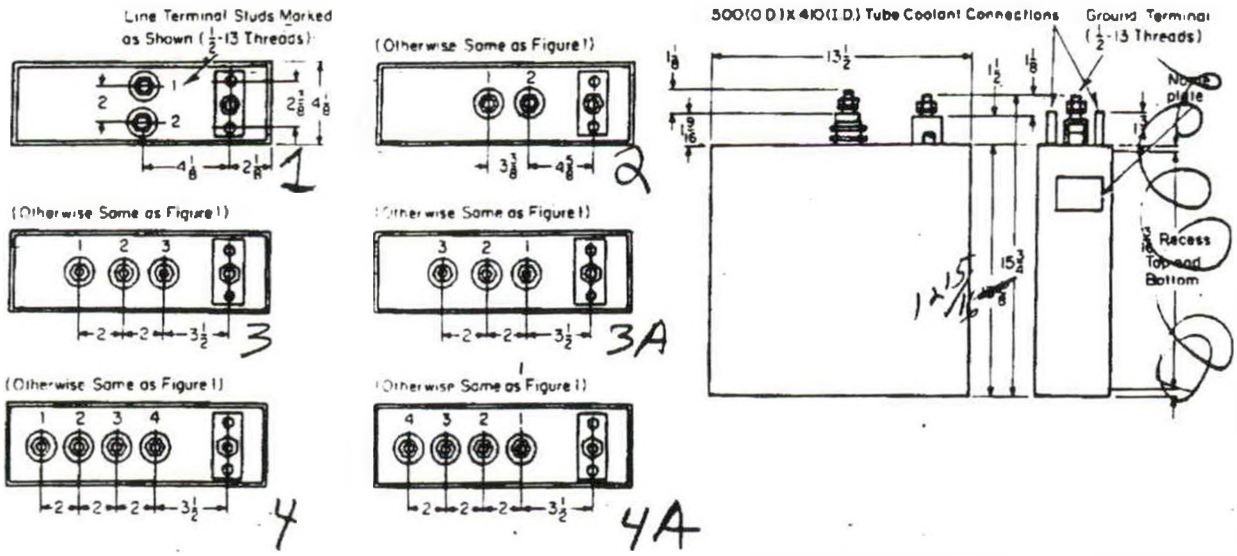
High Frequency Capacitors

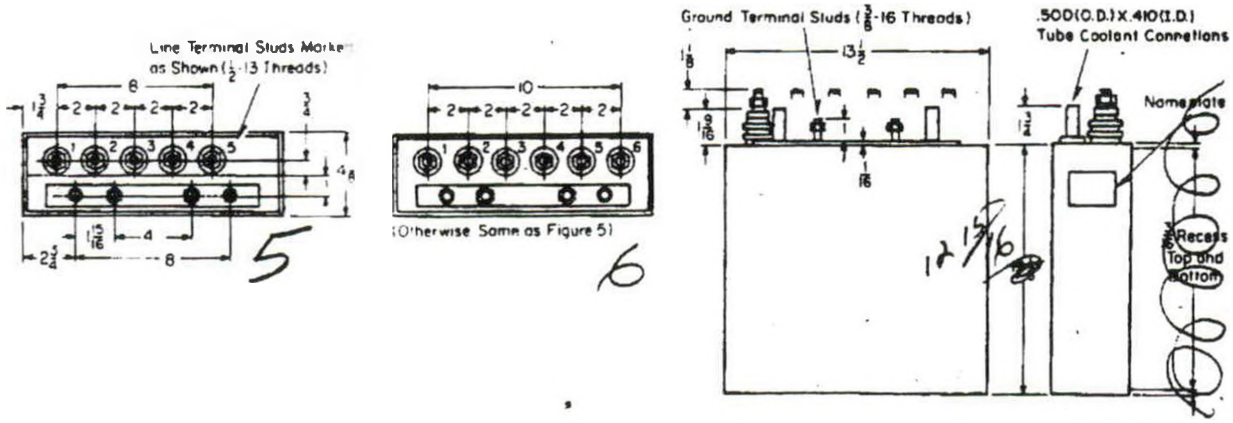
Type FPW, Water Cooled

For Induction Heating Equipment
960 – 9600 Hertz, Up to 450 Kvar
200 – 1250 Volts

Dimensions in Inches

(Approx.) For cross reference to capacitor style numbers, see last column in table on page 3.





Further Information

Pricos: PL 39-210
PL 39-350

NPC00007994

Westinghouse Electric Corporation
Distribution Apparatus Division, Bloomington, Ind. 47401

Printed in USA

770633

ENVIRONMENTAL RELATIONSHIPS OF PCB COMPOUNDS

by

B. A. Kerns, Manager
Environmental Control
Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

As you have already heard today, there are 209 possible homologs of PCBs. The mixtures of PCBs used by the electrical distribution equipment industry for the past forty-five years include Aroclor 1260, 1254, 1242 and 1016. Presently Westinghouse uses only Aroclor 1016 for capacitors and Aroclor 1242 for transformers. The basic differences in these materials is in the degree of chlorination. For example:

1. Aroclor 1254 contains 54 percent by weight chlorine and is primarily 77 percent five chlorine atoms and higher.

2. Aroclor 1242 has 42 percent chlorine and is only 9 percent five chlorine atoms and higher.

3. Aroclor 1016 contains 41 percent chlorine and is only one percent five chlorine atoms and higher.

For the polychlorinated-biphenyl materials, the level of chlorination appears to be the most significant factor in their relative biodegradability. The rate of biodegradability decreases as the number of chlorine atoms per biphenyl molecule increases. Chromatograms (which

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770634

I'll explain in a minute) representing samples after exposure to activated sludge (as used for example in the City of Bloomington sewage treatment plant) show significant alterations in the Aroclor 1016 distribution but little for Aroclor 1254.

Passage of PCBs through activated sludge has shown that 33 percent of Aroclor 1016 degrades per forty-eight-hour cycle with a semi-continuous treatment method. This compares favorably, since 25 percent of Aroclor 1242 degrades in forty-eight hours, and 15 percent of Aroclor 1254 degrades in forty-eight hours. Results of additional tests with Aroclor 1016 showed that treatment for fourteen days reduces the various mixtures in 1016 from 17 to more than 98 percent. More on this later.

These tests have led to the conclusion that Aroclor 1016 is sufficiently biodegradable to remain in controlled usage.

Most analytical data for PCBs utilize chromotography. This is a device to analyze a micro-sample of the material which is injected into a column or coil of tubing under controlled conditions of temperature, injection rate and volume. The heated column selectively releases each isomer. The release is recorded on a chart. Slide 1, 2 and 3 show typical charts or chromotograms for Aroclor 1016, 1242 and 1254. The horizontal axis indicates time while the vertical axis represents the amount present. The total amount of PCBs present is determined by integrating or measuring the area under the curves. You will note that while Aroclor 1016 and 1242 exhibit similar retention times, Aroclor 1254 shows a much greater retention time due to its higher chlorination and higher molecular weight. Slide No. 4 shows the small differences between 1016 and 1242. Note additional peaks from time 70 on 1242 also showing some higher chlorination and higher molecular weight.

These data on degradation plus the complexity experienced developing analytical tools to correctly identify and quantify the mixtures of PCBs used within our own plants led us to conclude that many of the agencies supervising PCB analyses are arriving at erroneous results.

For example, analytical data provided to Westinghouse by agencies in Indiana show amounts of Aroclor 1016 in waters and in fish which could not possibly be there from degradation. In addition, the analyses for PCBs in fish used the whole fish. More commonly, however, only the edible portions are analyzed, allowing a correction factor of about four. In other words, the amount of PCBs in the whole fish should be divided by four to arrive at the concentration in the edible portion.

It seems incongruous that PCB standards are being imposed using as background information an analytical technique which was nonexistent five years ago and is presently, at best, questionable. An analytical technique which stretches technology to the limit and shows error ranges up to plus or minus 50 percent. How can reasonable replies to these important questions be answered, using inaccurate and/or non-existent data.

In November, 1975, the EPA held a conference on PCBs in Chicago. At this meeting, many papers were presented on research studies, under EPA supervision and support, to determine the effect of PCBs on fish and animals. It was unfortunate that practically all experiments, at that time, were conducted using Aroclor 1254. This material has not been used in Westinghouse transformers since 1968, because of its

nonbiodegradability and its possible detrimental effects on the environment. Importantly, Aroclor 1254 has never been used in the Bloomington plant. While a few screening studies were carried out by EPA on Aroclor 1242, no studies on the use of Aroclor 1016 had been planned at that time.

In addition, most of the data reported at this meeting indicated that massive doses of PCBs (not even available for the last two or three years -- 1248, etc.) given to rats and monkeys had detrimental effects. However, little work was carried out using concentrations as found in the environment. Another critical factor, often overlooked, is that residual PCB levels in the fat tissues of animals do decrease rapidly, following the cessation of exposure to PCBs (See slide No. 6).

Fish found to contain the highest levels of PCBs were the bottom dwelling scavengers such as catfish, carp and eel. The game fish showed much lower levels. Factually, in surveys carried out between 1973 and 1975 in Lake Michigan, the number of fish found to contain PCBs decreased. Moreover, we are unaware of any study to measure PCB content in fish after cooking. Cooking should remove fat and fat containing PCBs from edible fish.

Presently EPA has agreed to carry out studies on the effects of Aroclors 1016 and 1242. These data should be available within 12 to 18 months. We feel that these studies will show a dramatically reduced environmental effect from these lower homologs -- effects that allow a timely and orderly conversion to other dielectric fluids that will not cause severe penalties in safety and energy use.

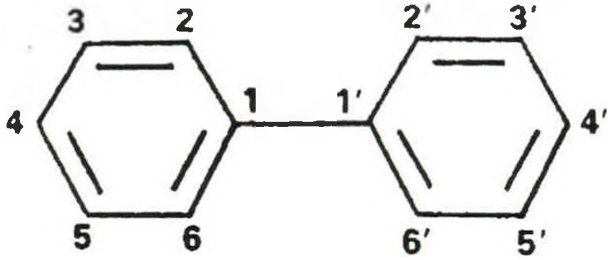
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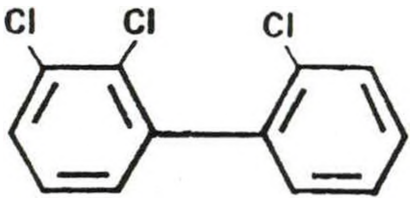
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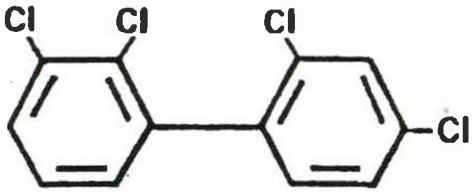
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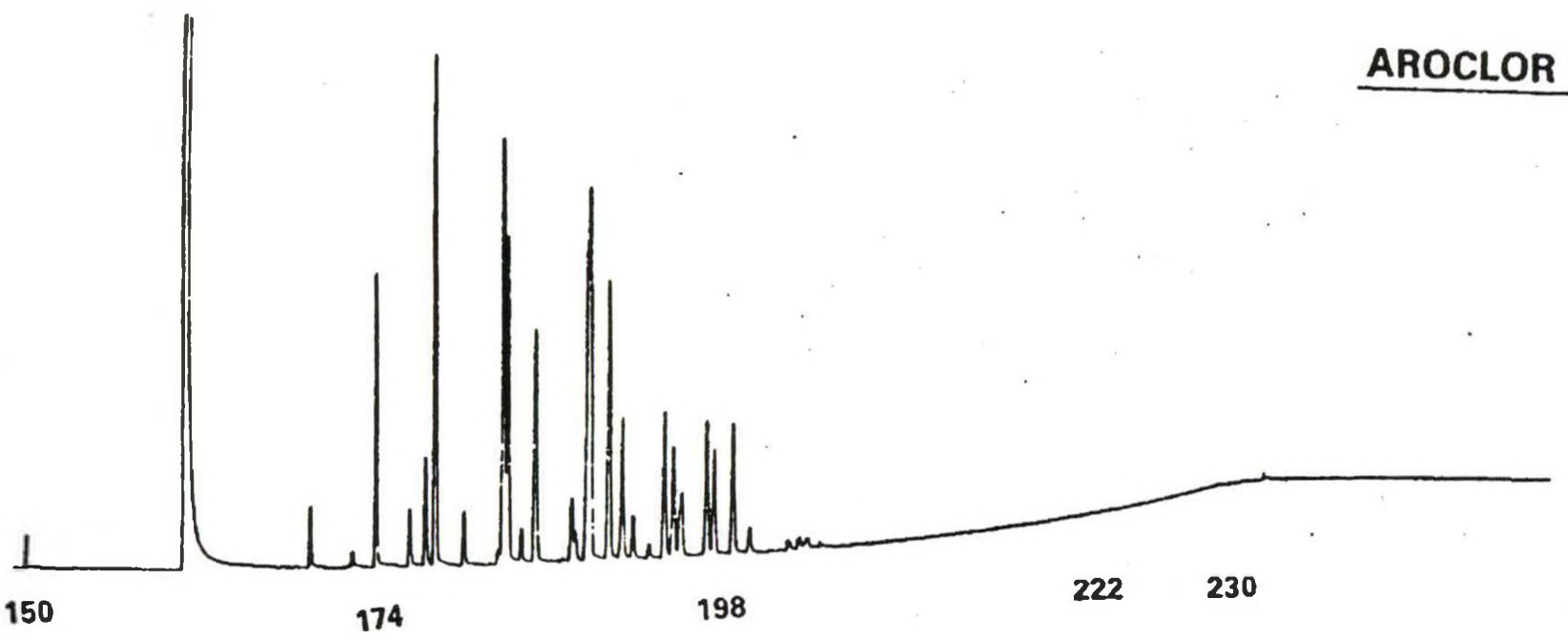
BIPHENYL



2,2',3-TRICHLOROBIPHENYL



2,2',3,4'-TETRACHLOROBIPHENYL



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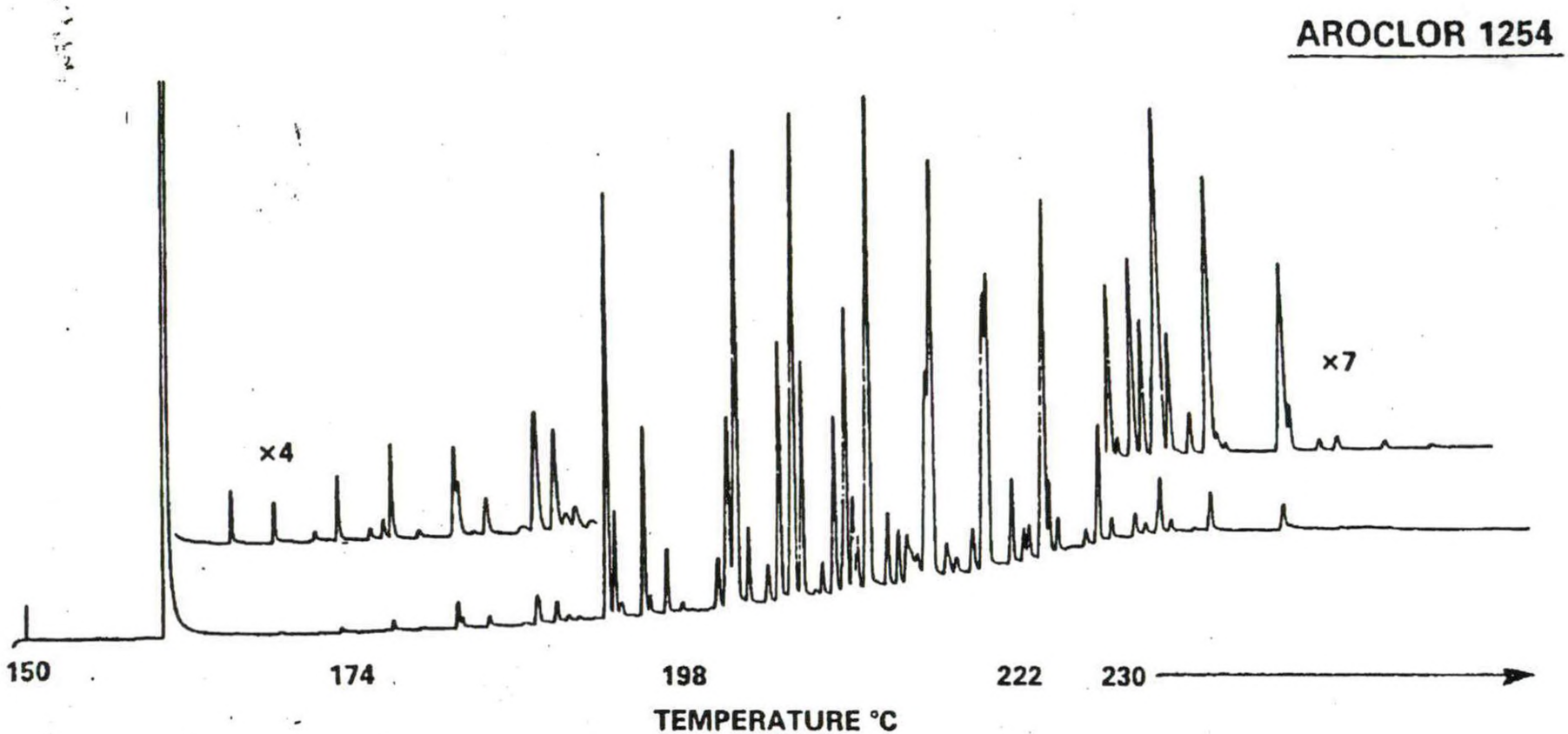
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AROCLOR 1242

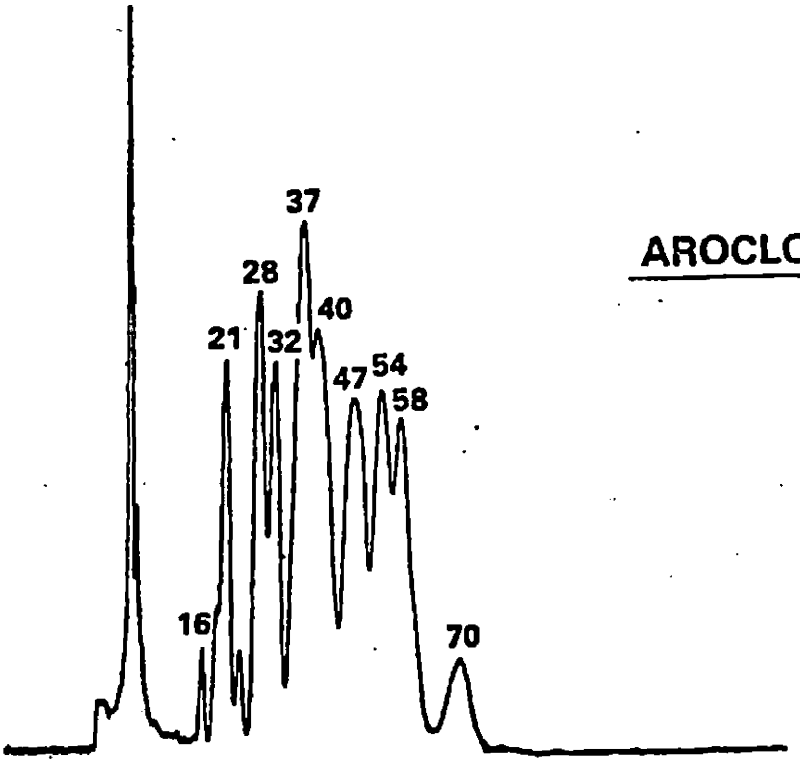


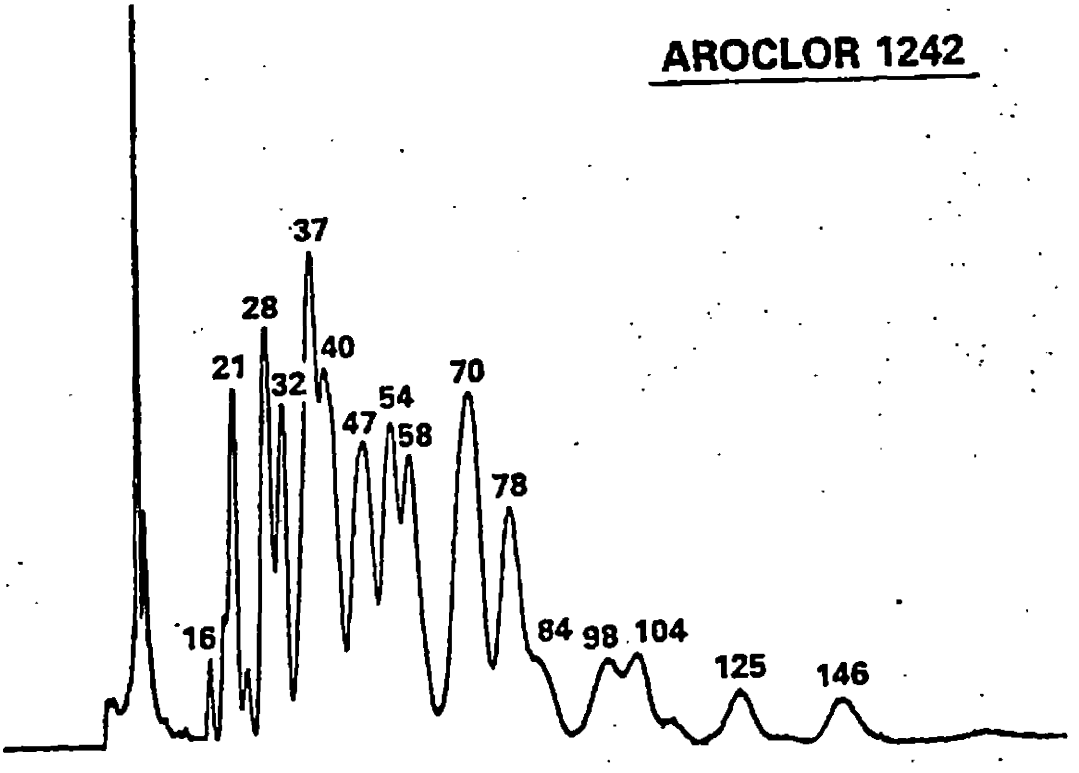
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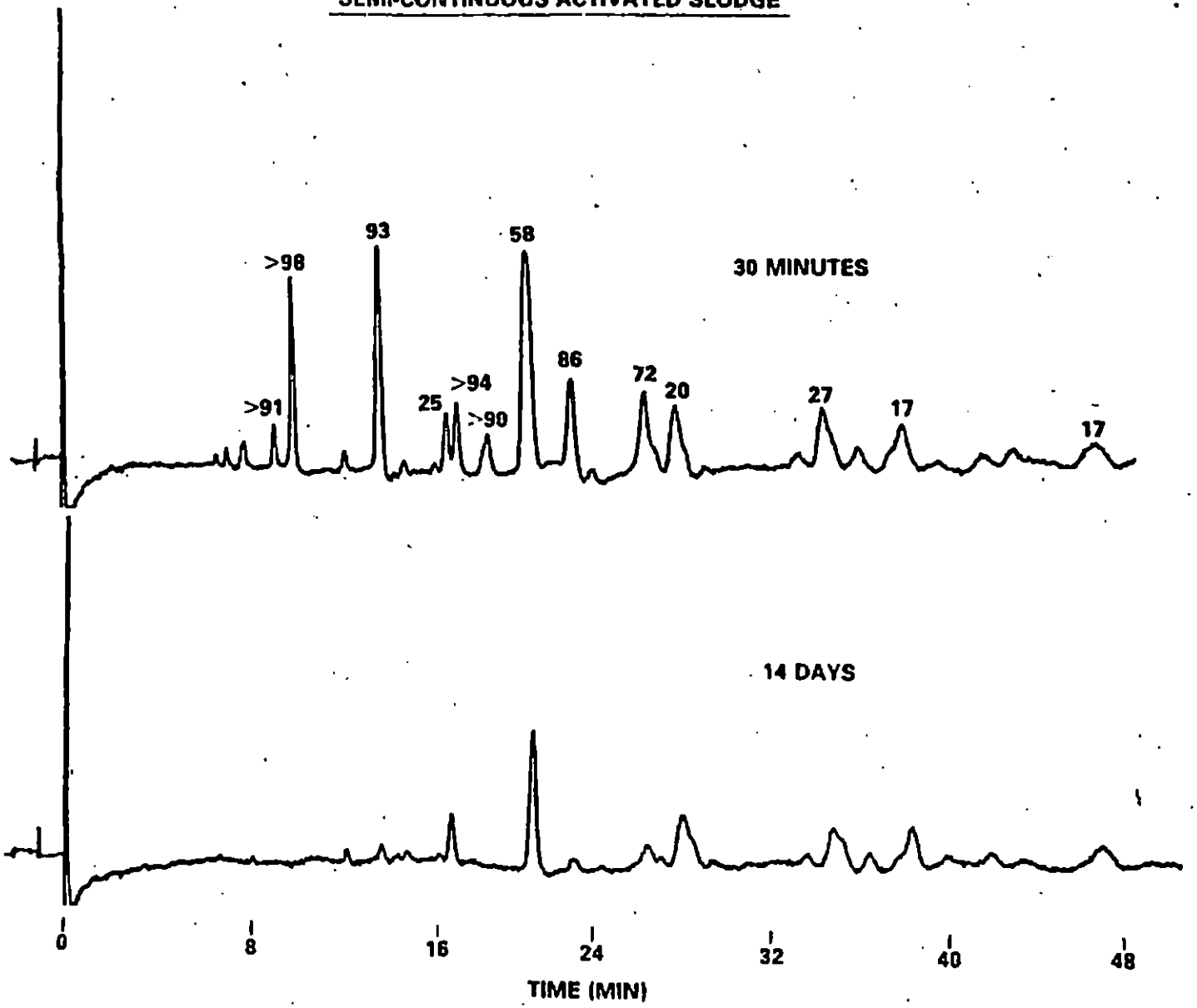


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AROCLOR 1016 BIODEGRADATION

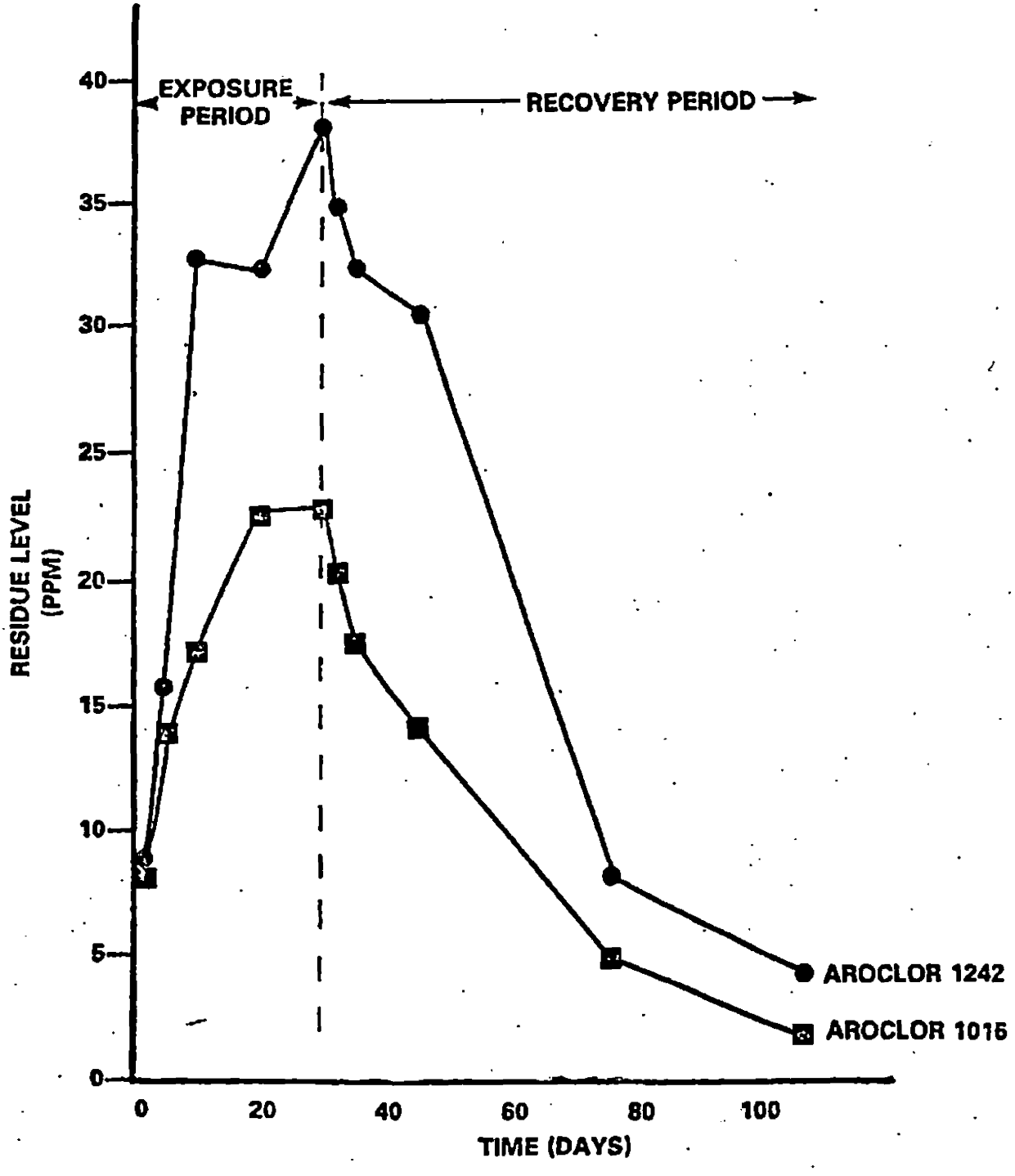
SEMI-CONTINUOUS ACTIVATED SLUDGE



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770643

FAT TISSUE RESIDUE LEVEL VS. TIME

25 PPM FEED LEVEL FOR RATS



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770644

DIPHENYL POISONING IN FRUIT PAPER PRODUCTION

A NEW HEALTH HAZARD

Ilona Hakkinen, et al

Archives of Environmental Health

Vol. 26, February 1973

A CRITICAL REVIEW

H. W. GERARDE, M.D., PH.D.
FAIRLEIGH DICKINSON UNIVERSITY
TEANECK CAMPUS
MARCH 16, 1973

NPC00008006

770645

This paper describes the working conditions in a paper mill in Finland and presents the clinical findings in workers employed from five to sixteen years in the production of diphenyl impregnated paper. In a study of 33 workers, 9 cases, one fatal, are reported in detail. Employees in this plant were exposed to high concentrations of diphenyl vapor and dust. In addition, they had intensive, prolonged skin contact with a warm mineral oil solution of diphenyl. The concentration of diphenyl vapor and dust ranged from a low of 0.6 mg/M^3 near a rolling machine to a high of 128 mg/M^3 behind the impregnating roller of a paper machine. The TLV* for diphenyl is 1 mg/M^3. It is difficult to quantitate the skin exposure to a warm solution of diphenyl in mineral oil. However, from the description of the working conditions it appears that the exposure by skin contact could have exceeded that by inhalation. It is well-known that mineral oil promotes the percutaneous absorption of lipid-soluble chemicals. In addition, the elevated temperature (90°C) of the mineral oil-diphenyl mixture would reduce the viscosity of the oil and promote the spread on the skin and consequently enhance the rate of percutaneous absorption.

The unhygienic working conditions which led to the death of one worker who added diphenyl to hot mineral oil (oil man) shows a flagrant disregard or ignorance of the basic concepts of occupational medicine. Prolonged and repeated exposure to excessive amounts of any chemical, regardless of toxicity will cause illness and possibly death. The subtitle of this paper " A New

* Threshold Limit Value- Concentration of diphenyl that can be inhaled 8 hrs/day 5 days/wk for an indefinite time by normal healthy workers without any adverse effect on health.

Health Hazard" is therefore misleading and inappropriate. Prior human experience in the manufacture of diphenyl in industry and its use as a fungistatic agent in paper for many years has demonstrated that diphenyl is not a health hazard if the proper precautions are taken to prevent exposure.

The clinical, biochemical, neurophysiological and pathological manifestations of prolonged intensive exposures to diphenyl are to be expected. The workers in this plant complained of the strong odor and of irritation of the throat and eyes. Other symptoms included headache, giddiness, nausea, indigestion, numbness, aching of the limbs and general fatigue. It is surprising that under these working conditions seven of the 33 workers were asymptomatic.

Ten of the workers had elevated SGOT and SGPT levels in the blood serum. Animal experiments conducted by Deichmann and co-workers* revealed that diphenyl has the capability of causing liver injury following prolonged exposure to concentrations ranging from 5 to 40 mg/M^3.

Physiological studies of the nervous system revealed abnormalities in the electroencephalogram, the electromyogram and the maximal conduction velocity in peripheral nerves of some of the workers. These neurophysiological manifestations of diphenyl intoxication have not been reported in animals exposed to diphenyl because neurophysiological studies were not conducted. It is not unexpected to find these abnormalities following severe prolonged exposure to diphenyl since peripheral neuropathy following gross exposure to hexane has been reported in Japan and in the United States.

* Deichmann, W.B., et al: Observations on the effects of diphenyl, o- and p-aminodiphenyl, o- and p-nitrodiphenyl and dihydrocyoctachlorodiphenyl upon experimental animals. A J Ind Hyg Toxicol Vol. 29:1-13, 1947

* This what concerns me, I find it hard to believe that animal test on diphenyl that nervous system wasn't studied. 2/16/76

The histopathological findings in the liver of the workers exposed to diphenyl confirm the hepatotoxicity reported in the animal studies. The oil-man who died from exposure to diphenyl had additional pathological changes involving the kidney and other organs.

Some of the workers in this plant were exposed for sixteen years to concentrations higher than the levels used by Deichmann et al in some of their animal experiments which lasted for a few months. The extent and degree of injury from exposure to any chemical depends on the dose. The exposures to diphenyl in this plant were of such a magnitude in proportion to the TLV that some of the workers were subjected to acute exposures for sixteen years. It would have been most informative to have data on the concentration of diphenyl or its metabolites in body fluids and tissues in the worker who died and in the blood and urine of the other employees.

The authors stated that the producer of diphenyl is responsible for the "nonchalant" handling of diphenyl in the paper mill. To support this statement they cite the following from the manufacturer's technical bulletin:

"Laboratory and practical investigations have shown that diphenyl is completely harmless in quantities several times greater than that to which workers are exposed in the manufacture or use of diphenyl impregnated paper."

The statement in the technical bulletin is based on working conditions prevailing in plants manufacturing diphenyl impregnated paper where the proper precautions are taken to minimize exposure to dust and vapor and by skin contact. If the concentration found in the air in these plants is well below the TLV and no skin contact occurs, workers can be exposed to several times this concentration without adverse health effects.

It is incomprehensible that the management of a plant in an enlightened country such as Finland would permit men to work under such deplorable conditions for so many years. This shows complete disregard of industrial hygiene, safety and occupational health practices and procedures.

H. W. Gerarde, M.D., Ph.D.

HWG/cms

INERTEEN

(Capacitor M-54201CF thru CH and Transformer PDS 54201CM)

GENERAL

Capacitor Inerteen, PDS 54201CF thru CH, is trichlorodiphenyl. Prior to January 1, 1965, transformer Inerteen PDS 7336-9 (54201CC) was a mixture of 60 percent hexachlorodiphenyl and 40 percent trichlorobenzene. From January 1, 1965 to January 1, 1968, transformer Inerteen PDS 54201KA consisted of a mixture of 70 percent pentachlorodiphenyl and 30 percent trichlorobenzene. On January 1, 1968, transformer Inerteen was changed to PDS 54201CM. It now consists of trichlorodiphenyl to which 0.2 percent glycidyl phenyl ether is added as a scavenger.

CONTAINERS AND STORAGE

Inerteen may be received in tank cars, drums, or cans. Containers, when received, should bear the Name, Westinghouse Material Number, and a brief statement of precautions to be followed during usage. In the Receiving Department, attach yellow Ⓦ Precautionary Label 35817 to all containers of Inerteen. This label is available from the Ⓦ Trafford Printing Division. Place this label on containers where it is always visible to the user. For drums, the label should be placed on the dispensing end and in such a position that it can be easily read by the person removing the Inerteen from the drum. Storage tanks and other containers of Inerteen for use in the shop should also bear the Name, Ⓦ Material Number, and Ⓦ Precautionary Label 35817.

Store Inerteen in an approved storage space, preferably indoors, which is cool, dry, and well ventilated. Precautions should be taken to prevent moisture from entering drums; therefore, as soon as drums of Inerteen are received, the bung should be examined and tightened if it is loose. To dispense Inerteen from drums, use molasses gate valve, Ⓦ M-72085GP. Bulk quantities of Inerteen are transferred from storage tanks by using equipment designed for that purpose.

PROPERTIES

FIRE -- Non-flammable.

EXPLOSION -- Non-explosive.

DECOMPOSITION -- When Inerteen or its vapors contact flames, welding arcs, or extremely hot metal surfaces, it will decompose to form highly irritating hydrogen chloride gas, highly toxic carbon monoxide, and also some carbon dioxide.

WHEN IN DOUBT CONSULT THE
SAFETY DEPARTMENT OR HEADQUARTERS INDUSTRIAL HYGIENE

WESTINGHOUSE ELECTRIC CORPORATION, INDUSTRIAL HYGIENE LABORATORY, EAST PITTSBURGH, PA.

NPC00008011

770650

INERTEEN (CONTINUED)

BREATHING -- Inerteen vapor is moderately toxic, however, the possibility of a health hazard existing at normal room temperature is unlikely since its evaporation rate is very low. The health hazard will increase if the material is heated, sprayed, or in any way atomized into the breathing zone of a worker. The odor of Inerteen can be noticed at concentrations below the Maximum Acceptable Vapor Concentration. For the Maximum Acceptable Concentrations of vapor from capacitor or transformer Inerteen, refer to SPDS M-20. Concentrations of Inerteen vapor which exceed the Maximum Acceptable Concentrations may cause irritation of the eyes, nose, throat, and upper respiratory tract. Much higher concentrations could cause detrimental internal reactions after prolonged exposures.

SWALLOWING -- Inerteen is moderately toxic if taken internally. Swallowing of several ounces could cause irritation of the digestive tract and internal reactions.

SKIN IRRITATIONS -- Although the Inerteens are only moderate skin irritants when contact is for a short duration, there is a possibility that it can be slowly absorbed through the skin. Repeated contact over prolonged periods may result in a severe dermatitis which may persist for many months after removal from exposure. Inerteen and its vapors are also irritating to the eyes.

WASTE CONTROL AND DISPOSAL

The handling of all waste must be very carefully controlled so that Inerteen or its decomposition products DO NOT ENTER the environment. UNDER NO CIRCUMSTANCES SHALL WASTE INERTEEN BE POURED INTO SEWER SYSTEMS, STREAMS, DUMPED ON THE GROUND, OR BURNED.

All systems for handling or holding liquid Inerteen must be designed and maintained to assure that leaks or spills will not occur. If they do occur, the Inerteen MUST BE COMPLETELY RECOVERED AND PLACED IN LEAK-PROOF METAL CONTAINERS (55 gallon drums). In areas where spills or leaks could occur, the floor should have a smooth surface and be properly curbed to contain any spilled Inerteen. In some instances, drip pans, catch basins, dikes, etc., are appropriate. These containers must be properly drained into the metal container used for collecting waste Inerteen for disposal.

ALL WASTE INERTEEN or material contaminated with Inerteen shall be placed in leak-proof open head drums with suitable closures (55 gallon drums) for later shipment to the proper disposal service agency.

The owner of scrap INERTEEN MUST ASSUME THE COST of the shipping container, cost of transportation to the disposal service organization, and a disposal fee usually based upon a per gallon or per pound charge.

All drums must be properly labeled for shipment to the proper disposal service organization, including the type of waste material in the container and the proper address.

At the present time, Headquarters Industrial Hygiene is recommending the following organizations for disposal services for Inerteen. These

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INERTEEN (CONTINUED)

companies MUST BE CONTACTED before waste material is shipped to them. Following is a list of these companies, their shipping addresses, and the type of material they can handle:

1. Chem-trol Pollution Services, Inc.
   Balmer Road
   Model City, New York 14107
   PHONE: 716-754-8231

   Chem-Trol is capable of handling:

   1. Liquid Inerteen or Inerteen mixed with oil or solvent.
   2. Inerteen soaked compounds, rags, cartons, Fuller's earth, absorbents, wire coatings, etc.
   3. Transformer tanks, cores, capacitors, drums, etc.

2. Monsanto Company
   Incineration Department (831)
   W. G. Krummrich Plant
   Sauget, Illinois 62206
   PHONE: 618-271-5835

   Monsanto will accept:

   1. Contaminated liquid Inerteen or Inerteen mixed with oil or solvents. Monsanto will NOT accept water contaminated Inerteen.

PERSONAL PROTECTIVE EQUIPMENT

WHEN IT IS NECESSARY, UNDER EMERGENCY CONDITIONS, TO ENTER A SPACE CONTAINING A HIGH CONCENTRATION OF INERTEEN VAPOR, A HOSE MASK WITH BLOWER, (E) M-76524AL, or BREATHING EQUIPMENT WITH A SELF-CONTAINED AIR SUPPLY, (E) M-76524CJ,CL, SHOULD BE USED.

GAS MASK, (E) M-76524AP, AIR-LINE RESPIRATOR, (E) M-76524BF,BG, or HOSE MASK WITHOUT BLOWER, (E) M-76524AM, MAY BE USED if there is no danger of oxygen deficiency, that is, where the breathing atmosphere contains at least 19% oxygen and not more than 2% Inerteen vapor. Air-line respirators should be provided with at least 4 cubic feet per minute of uncontaminated fresh air. To provide this minimum air requirement, follow the manufacturer's recommendation for air pressure, air flow controls, and length of hose to be used. When using a hose mask, place the hose opening in an area where air is not contaminated. When the odor of Inerteen is detected while wearing respiratory equipment, the wearer should immediately go into fresh air.

When there is a possibility of the atmosphere in the work area containing a concentration of Inerteen vapor, a fume slightly above the Maximum Acceptable Concentration (MAC), the Standard Chemical Cartridge Respirator, (E) M-76524BL, equipped with cartridge, (E) M-76524BM, or respirator, (E) M-76524BQ, equipped with cartridge, (E) M-76524BR, if properly fitted to the face, will provide satisfactory protection for concentrations up to about 10 times the Maximum Acceptable Concentration. For higher concentrations, emergency respiratory protection equipment shall be used. Respirator cartridges should be replaced according to a pre-determined schedule or at any time the odor of Inerteen becomes noticeable under the respirator.

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INERTEEN (CONTINUED)

All gas masks, respirators, and replacement parts should have the Bureau of Mines approval, which is indicated by a label on larger parts or BM# _____ (approval number) on smaller parts.

Refer to Safe Practice Procedure Sheet #12 for information concerning the use and care of respiratory protective equipment.

Neoprene coated aprons, Ⓔ M-76503AD, and neoprene coated gloves, Ⓔ M-76502CD, may be used where necessary to protect the skin. Hand cream, Ⓔ M-53535LM, may be of some value where the use of gloves is not practical. Waterless hand cream, Ⓔ M-53512KH, is very useful for removing Inerteen from the skin. To protect the eyes, wear safety spectacle, Ⓔ M-76522EA-EC, or goggles, Ⓔ M-76522CJ, depending on the type of protection needed.

PRECAUTIONS

All systems for handling Inerteen must be very carefully controlled. Where Inerteen is heated, these operations must be ventilated; and in addition, the ventilation system must be equipped with the proper scrubber to prevent Inerteen or its decomposition products from entering the environment. (Contact Headquarters Industrial Hygiene for design, etc.).

Breathing vapor or fumes from heated Inerteen shall be avoided. The Maximum Acceptable Concentration must not be exceeded under normal working conditions. Where an emergency condition could exist, use the respiratory protective equipment previously recommended under "Personal Protective Equipment".

If skin contact occurs, remove the Inerteen by thoroughly cleaning the skin area with waterless hand cream, Ⓔ M-53512KH, followed by a thorough washing with soap and warm water. Prolonged or repeated skin contact should be avoided. Contaminated clothing should be laundered before wearing again.

Personal cleanliness and the prevention of skin contact are the most important precautions to be observed.

Any person who develops a skin irritation or respiratory tract irritation apparently due to Inerteen or its vapors should be placed under the supervision of the plant Medical Department.

Proper preplacement and periodic physical examinations should be made by the Medical Department on workers when the odor of Inerteen is repeatedly or containuously noticeable in the work area.

Spills of Inerteen should be removed immediately. Absorb liquid Inerteen with absorbent compound, Ⓔ M-53401EA-EB, and dispose of per instructions under WASTE CONTROL AND DISPOSAL on page 2. Employes performing this work should wear adequate protective equipment.

FIRST AID

Any person who has had an appreciable exposure to Inerteen either by breathing an excessive concentration of vapor, fume, or decomposition products, or by swallowing, or where the material has been spilled over large areas

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INERTEEN (CONTINUED)

of the body, should be placed under the supervision of the plant physician. In cases of swallowing, vomiting should be induced immediately by carefully inserting a finger in the person's throat.

If overcome from breathing high concentrations of Inerteen vapor, the person should be quickly removed from the vapor exposure to the nearest area of uncontaminated air and artificial respiration started at once if breathing stops. A physician should be called immediately. Do not give stimulants. If Inerteen should contact the eyes, they should be irrigated immediately with large quantities of running water from an approved eye wash fountain for fifteen minutes and then the person should report to the Medical Department for observation and treatment, if necessary.

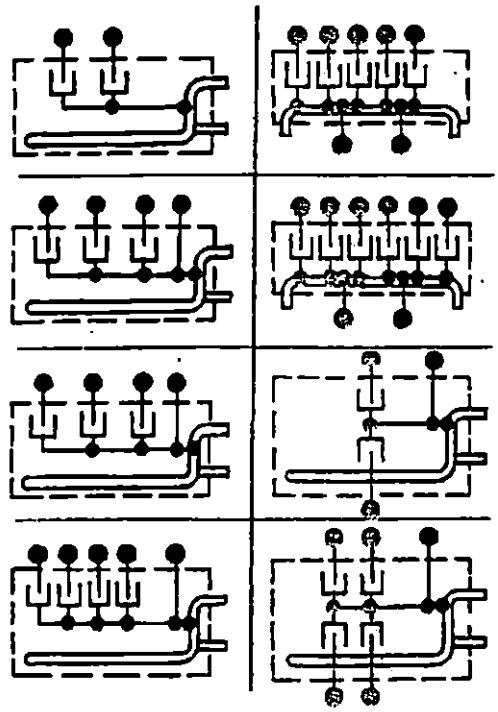
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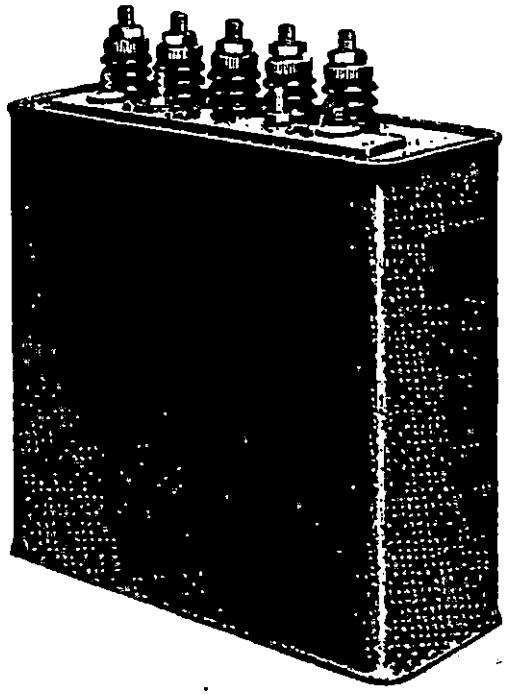
high frequency capacitors • type FPW

for induction heating equipment

500 to 12,000 cycles • up to 300 kvar • 200 to 1250 volts

descriptive bulletin 49-460 page 1





applications

Westinghouse type FPW high frequency water-cooled capacitors have been designed to improve the inherently low power factor associated with induction heating apparatus on melting furnaces, billet heating, forging and heat treating applications.

Based on load requirements, high frequency capacitors are usually installed in multiple unit banks with a means of switching provided to adjust capacitance and tune the circuit for efficient operation under varying load conditions.

advantages

compact, lightweight: Efficient design and use of material reduces weight and volume to a minimum.

high current rating per unit volume: Multiple bonding of foil electrode to cooling coil provides maximum heat transfer with minimum temperature rise.

permanent characteristics: The combination of Inertex paper with Inerteen® impregnant produces a capacitor having characteristics of stability with low loss and high dielectric constant especially suited to high frequency applications.

hermetically sealed: Provides a capacitor, that is, resistant to damage and assures long, maintenance-free operation.

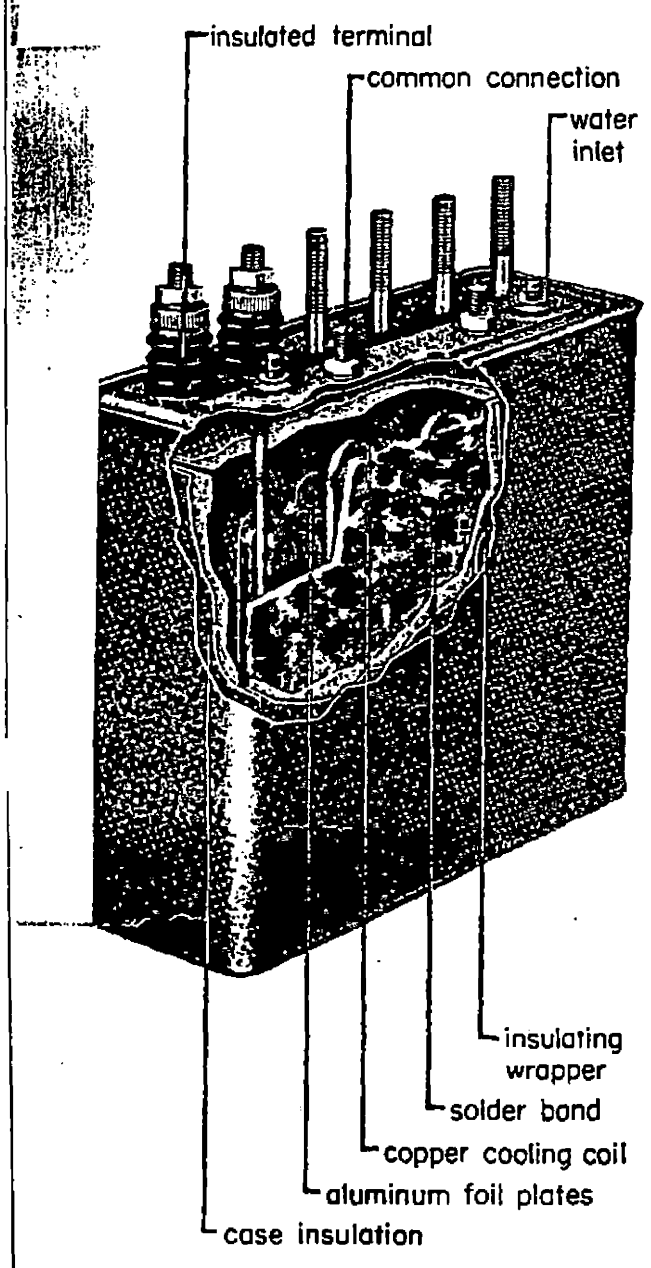
November, 1953
supersedes catalog section 49-275 dated March, 1940
mailed to: E43-SM; D66-5H; C31-8C

FPW 49-460

NPC00008016

770655

construction



Type FPW capacitors are wound with aluminum foil plates separated by layers of thin Inertex paper. The foils of opposite polarity are staggered so the edges project from opposite sides of the capacitor section. The projecting edges are then bonded together using a solder alloy and a special bonding technique. The heavy braided copper leads are soldered to the bond. The foil edges of one side of each section are also soldered directly to a tubular copper water-cooling coil.

After the capacitor is assembled in its case, it is thoroughly vacuum dried. It is then filled with Westinghouse Inerteen, a synthetic, non-inflammable liquid dielectric having superior qualities at high frequency. In addition, it has stable electrical characteristics, low losses and is chemically inert. The capacitor is then hermetically sealed. All welded enclosures of heavy gauge steel with non-magnetic covers are used where frequency and current permits. Complete non-magnetic enclosures are used on higher frequencies. Porcelain terminal bushings are sealed to capacitor enclosure by silicon rubber sleeves confined under pressure. This provides a seal with sufficient strength and flexibility to prevent damage to porcelain or seal that might result from excessive mechanical strains on the bus or connections. Cooling coils are permanently bonded to the enclosure and complete the hermetic seal.

For low voltage ratings, one pole of all sections is common to the cooling coil and case. The other pole is brought out through one or more insulated terminals. Multiple terminals are used to provide kilovar steps, and also when high current capacity is necessary.

For higher voltages, two sections are connected in series with the cooling coil bonded to the common connection. In this case both poles of the capacitor are brought out through insulated terminals, with the cooling coil and case tied to the mid-point of the capacitor. The mid-point may be provided with a current carrying connection and the capacitor given a dual voltage rating.

The voltage rating of a section for these high frequencies must be limited to avoid damaging corona discharges at the foil edges. Since one pole of the section must be bonded to the cooling coil for good heat transfer, the practical voltage ratings of water-cooled units is restricted to 1250 volts and under.

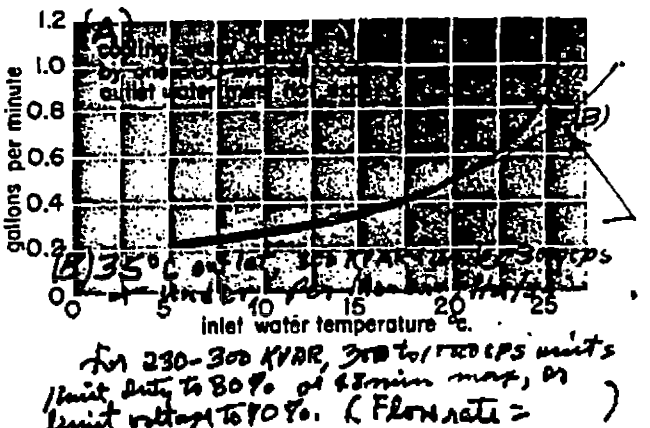
mounting

The capacitor units may be mounted with terminals upright, or on edge with the terminals horizontal. Low voltage units having one pole grounded to the case may be operated with the case and cooling-coil either insulated or grounded depending on the circuit. High voltage units (with midpoint connected to the cooling-coil and case) must be insulated from ground, and cooling coil connections made with insulating rubber hose. The case and cooling-coil of such units must also be insulated from each other unless they are switched as a group.

An adequate flow of clean water must be supplied to the capacitors. The coils of several units may be connected in series if the inlet water is cool, and the available pressure is high enough. A flow of one gpm requires 20 psi per unit. If the water temperature exceeds 30°C. the kilovars must be reduced 1½ per cent per degree above 30°C. by reducing either voltage or frequency.

Individual units or sections of a unit may be connected through switches or contactors to permit adjustment of the kilovars as the load changes. The lower kilovar ratings are useful for fine adjustment.

Installation of capacitors should be made in a clean and dry location, and the porcelain bushings cleaned periodically to prevent flashover due to accumulated dirt. Water connections should be located so that condensation does not drip on the bushings or cases. Bus bar runs close to the capacitor cases are to be avoided because they may cause eddy currents and localized heating in the capacitors.



ratings

Type FPW capacitors have a *maximum rating* in kilovars, voltage and frequency. Microfarad values are stamped on the nameplate for convenience. The rating limitations are voltage stress, temperature rise, and current per terminal.

The voltage rating is rms and applies for an impressed voltage having substantially a sine wave shape. If the voltage wave is distorted, its peak value must not exceed $\sqrt{2}$ times the capacitor voltage rating.

Capacitors may be operated at less than rated voltage or frequency. In some cases it may be permissible to operate at more than the rated frequency if the voltage is reduced. This involves design considerations and advice should be obtained from Westinghouse for specific cases.

If the capacitors are operated at reduced voltage or frequency, the kilovars may be computed from the following relations:

reduced voltage:

$$\text{kvar} = \text{rated kvar} \left(\frac{\text{applied volts}}{\text{rated volts}}\right)^2$$

reduced frequency:

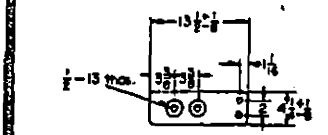
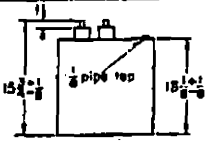
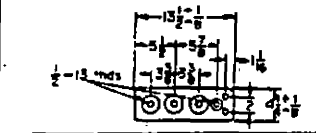
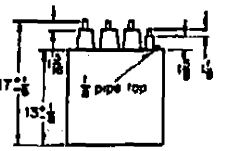
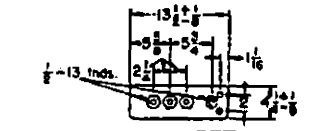
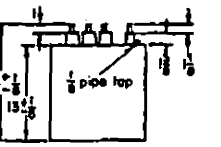
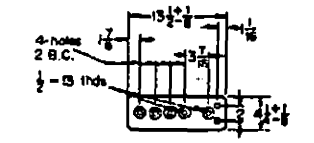
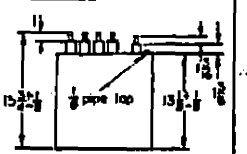
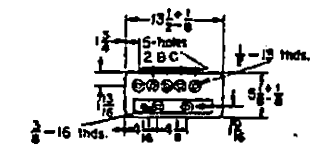
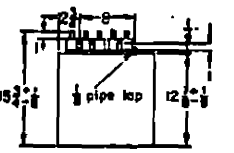
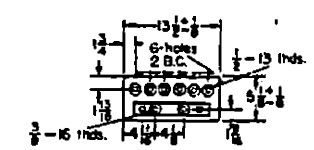
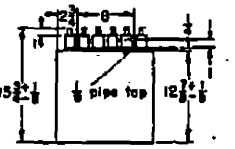
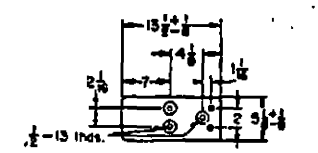
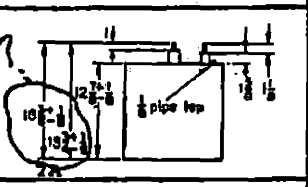
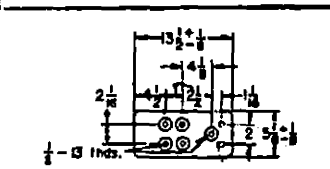
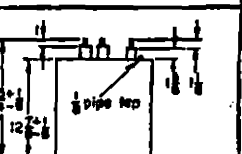
$$\text{kvar} = \text{rated kvar} \left(\frac{\text{applied frequency}}{\text{rated frequency}}\right)$$

fundamental formula:

$$\text{kvar} = \frac{6.28 \times \text{Mfd.} \times \text{volts}^2 \times \text{cycles per second}}{1{,}000{,}000{,}000}$$

freq. (cps)	maximum rms voltage	total kvar	total amps	total Mfd	microfarad taps to common terminal 1	2	3	4	5	6	style number	catalog number	approx. net wt. lbs.	dimen. & diag. ref. fig. no.
960	450/900	160	356	131	65.5	65.5					1616 488	FPW-77	62	7
960	900	215	239	44	22	22					1616 487		62	7A
2000	625	300	480	61	37	16	8				1418 692	FPW-52	68	*3
2000	1250	300	240	15.3							1404 853	FPW-53	67	*1
3000	275	300	1090	210	82.5	82.5	82.5	82.5			1616 499	FPW-86	66	8
3000	400	300	750	100	25	25	25	25			1616 477	FPW-87	54	4
3000	400	300	750	100	31.3	31.3	21	10.5	2.7	2.7	1616 596	FPW-96	69	6
3000	400	300	750	100	31.5	31.5	21	10.3	5.3		1616 480	FPW-67	67	9
3000	625	300	480	41	26	10	5				1418 693	FPW-54	68	*3
3000	800	300	375	25	6.23	6.23	6.23	6.23			1616 478	FPW-88	54	*6
3000	800	300	375	25	7.9	7.9	8.2	2.6	1.3		1616 479	FPW-68	67	5
3000	1250	75	60	2.5							1616 484	FPW-70	62	*1
3000	1250	150	120	5.0							1616 483	FPW-69	62	*1
3000	1250	150	120	5.0	2.5	1.25	1.25				1418 691	FPW-72	60	*2
3000	1250	220	176	7.5							1616 486	FPW-58	52	*1
3000	1250	300	240	10.2							1404 854	FPW-55	57	*1
3600	200	180	900	200	50	50	50	50			1616 500		54	*4
3600	400	60	150	16.8	2.8	2.8	2.8	2.8	2.8	2.8	1616 598		68	6
3600	400	300	750	84	13.8	13.8	13.8	13.8	13.8	13.8	1616 597		68	97
3600	400	300	750	84	21	21	21	21			1616 599		54	*4
9600	200	230	1150	96	24	24	24	24			1616 490	FPW-91	60	8
9600	220	230	1150	80	25	25	15	8	4	2	1616 491	FPW-83	69	6
9600	400	230	575	24	8	8	8	8			1616 478	FPW-89	54	*6
9600	440	300	682	26	8	8	5.3	2.7	1.3	.64	1616 482	FPW-84	68	8
9600	800	300	375	7.8	1.95	1.95	1.95	1.95			1616 483	FPW-90	54	*4
9600	800	300	375	7.8	2.3	2.3	1.6	.78	.78		1616 595	FPW-94	67	5

dimensions

internal connections	dimensions		BOX COVER
Terminal plate + copper cover; or Iron box with SS cover; figure 1 — cooling coil			
Iron box with SS cover; figure 2 — 3 2 1 C; cooling coil			
Iron with SS cover; figure 3 — 3 2 1 C; cooling coil			
Terminal plate with copper cover; or Brass box with copper cover; figure 4 — 4 3 2 1 C; cooling coil			
Terminal plate with copper cover; or Brass box with copper cover; figure 5 — 5 4 3 2 1; C C; cooling coil			
Terminal plate with copper cover; or Brass box with copper cover; figure 6 — 6 5 4 3 2 1; C C; cooling coil			
Terminal plate with copper cover; figure 7, 7A — 2 C; cooling coil			
or Terminal plate + copper cover; Brass box with copper cover; figure 8 — 4 2 C; 3 1; cooling coil			

further information

price list 49-460

Westinghouse Electric Corporation
Distribution Apparatus Department: East Pittsburgh Plant • East Pittsburgh, Pa.
printed in U.S.A.

NPC00008019

770658

Instructions for Type S Inerteen Insulated Distribution Transformers



Westinghouse Electric Corporation

Distribution Transformer Division, Sharon, Pa.

I. B. 46-060-110A, Effective September, 1965. Supersedes I. B. 46-060-110, May, 1963

NPC00008020

770659

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INTRODUCTION AND DESCRIPTION

This Instruction Book has been prepared to provide the purchaser with information to properly install, operate and maintain Standard Inerteen Insulated Distribution Transformer.

The following table gives the voltage and Kva ranges of Inerteen Transformers for which the instructions specifically apply.

Phase	High Voltage	High Voltage Bushings	KVA Range
Single	0 to 5000 MAX	Wall Mounted	5 to 500 Incl.
Single	5001 to 15000 MAX	Cover Mounted	5 to 500 Incl.
Three	0 to 8660 MAX	Wall Mounted	15 to 500 Incl.
Three	8661 to 15000 MAX	Cover Mounted	15 to 500 Incl.

Ratings 5 to 30 KVA incl. will not have a relief device.

Ratings 37-1/2 to 500 KVA will be furnished with a glass diaphragm type relief device.

INSTRUCTIONS

SHIPMENT OF TRANSFORMERS IN INERTEEN

TRANSFORMERS shipped in Inerteen are usually in their own tanks and are filled to the proper operating level. Sometimes other requirements make it desirable to ship them in special tanks filled with Inerteen to cover the transformer assembly; when this must be done the purchaser will be consulted prior to shipment to be sure that facilities are available for the transfer from shipping to operating tank.

The general practice is to ship as many detail parts and bushings in place as is safe and as shipping clearances will permit. Bushings or other detail parts when removed are boxed separately and are to be mounted when the transformers are installed.

The transformer core is always braced or tied securely to the tank wall to take care of shocks received in shipment. If the transformer is removed from the tank for inspection during installation, it is unnecessary to replace the tie plates if there is no possibility of reshipment.

Sometimes special blocking or bracing may be used that interferes with normal operation; it is essential that this bracing be removed before the transformers are placed in service. Where special bracing must be removed, the outline drawing will contain notes of instructions regarding it. The outline drawing should always be checked for such instructions.

Radiator type coolers are always removed and crated before shipment; the radiator flanges on the tank wall are sealed with blind flanges to prevent the accidental loss of liquid from the tank. Valves are built into the radiator flanges making it unnecessary to drain the Inerteen when radiators are installed; sufficient additional Inerteen to fill the removed radiators is shipped in sealed drums.

When switch or terminal chambers are furnished that must be opened for installation purposes, the Inerteen for them is usually shipped in separate sealed containers to avoid frequent handling and possible contamination by moisture or dirt.

Core Form Transformers. In most cases core form transformers can be shipped in their own tanks in an upright position.

Occasionally, it is necessary for large transformers to have a horizontal joint in the tank so that the top section can be removed for shipment. Either the regular cover or a special shipping cover is bolted on top of the lower tank section. If the cover is special, it may be an inverted box-like structure which makes room for terminal boards, etc., that extend up beyond the top of the lower tank section and is usually filled with liquid to a point above the joint in the tank. Care must be taken to lower the level of the Inerteen below the joint before removing this cover.

Shell Form Transformers. Shell form transformers are usually made with form-fit tanks; transformers may be shipped in the upright position or lying down in a horizontal position. The bracing for units in form-fit tanks is usually arranged so that it need not be removed. In exceptional cases, particularly when the transformer is shipped horizontally, it may be necessary to use additional internal bracing. In these cases the outline drawing will contain notes calling attention to the necessity for removing any special bracing.

Occasionally, shell form transformers are placed in rectangular tanks. Large size units may require sectionalized tanks with special covers to meet height limitations for shipment. If a hat-shaped cover is used, care must be taken to lower the level of the Inerteen below the joint before removing the cover. The outline drawing will indicate when special covers are used in shipment.

UNPACKING

When a transformer is shipped complete and in its own tank with Inerteen, unpacking is a simple matter. It is ready to be set in place when the crating or bracing is removed.

Before unpacking, the transformers should be carefully examined to ascertain whether it has been

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damaged in shipment and whether all parts are in place and in good condition. In cases where damage is self-evident or parts are obviously missing, a claim should be filed at once with the carrier, and the Westinghouse Electric Corporation should be promptly notified.

Should the transformer be shipped with Inerteen in a special tank, the shipping tank should not be opened until the transformer tank is in place ready to receive the transformer. In order to avoid condensation, the shipping tank should not be opened until the temperature of the transformer is the same or higher than the surrounding air temperature. The greatest care should be taken to avoid getting moisture in the transformer while transferring it from the shipping tank to its own tank.

All bushings and accessories when shipped separately should be protected against moisture until they are installed. During the installation of these parts, care should be exercised to protect the transformer against the possibility of the entry of moisture. As an extra precaution against moisture having entered during shipment or installation, the dielectric strength of the Inerteen should be tested before the transformer is put in service. The dielectric strength of the Inerteen when tested in a standard test cup should not be less than 22 KV. Tests lower than this are indicative of contamination or moisture and the proper corrective steps must be taken as described in the instruction leaflet "Inerteen Insulating Fluid".

HANDLING

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.

Where a transformer cannot be handled by a crane, it may be skidded or moved on rollers, but in doing so, care must be taken that it is not tipped over. Bases are constructed to permit movement on rollers in any direction. Transformers with a round base are easily tipped and should preferably be bolted to a temporary wooden frame or base before moving.

When lifting a core and coil assembly, it may be necessary to use a spreader to prevent the sling ropes or chains from pressing against the terminal board or insulation and damaging them.

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INSTRUCTIONS

TYPE "SL" INERTEEN TRANSFORMERS

INERTEEN TRANSFORMERS are primarily intended for those applications where the hazards due to location dictate the use of a nonflammable insulating liquid that when decomposed evolves only non-explosive gaseous mixtures.

When purchaser's specification does not conflict, these transformers are designed in accordance with A.S.A., N.E.M.A., and A.I.E.E. standards for distribution and power classifications.

DESCRIPTION

The core and coil assembly is encased in a sealed tank provided with the necessary bushings for incoming and outgoing leads. A sealed-tank construction is one which seals the interior of the tank from the atmosphere and which will withstand the pressure resulting from the operation of the transformer within the limits prescribed by "American Standard Guide for Operation of Transformers, Regulators, and Reactors." Bent tubes, tubular coolers, and radiators are employed when it is necessary to add auxiliary cooling surfaces to the tank. Bushings may be wall or cover mounted, depending on voltage class and Kva rating; solderless adapters for cable leads or spade connectors for bolted bus bar connections to the bushings are furnished.

Standard accessories and fittings are supplied and located in line with N.E.M.A. recommendations and Westinghouse practices; their location and the physical dimensions of the transformer are shown on the outline drawing. Electrical connections and winding sketches, including all auxiliary transformer windings, are shown on the instruction plate drawing.

Identification. A stainless steel instruction plate mounted on each transformer gives the serial number, complete design identification, and operating characteristics. For a permanent record, it is suggested that all data from this plate be duplicated and retained in a convenient location.

Safety for Personnel. The general safety precautions prescribed for nonflammable liquid immersed transformers by the National Electric Code and purchaser's safety regulations should be exercised when this apparatus is installed and operated.

Inerteen has an irritating effect upon the skin of most people; precautionary measures are discussed in the leaflet "Inerteen Insulating Fluid."

METHODS OF SHIPMENT

Generally, the transformers are shipped with Inerteen in the tanks and all bushings and accessories in place. When the assembled height of a complete unit exceeds shipping limitations, the bushings are removed and packed separately; their tank openings are covered with blind flanges. Instructions for installing bushings will be found in the applicable instruction leaflets.

Under special conditions other methods of shipment may be required. The method used in a particular case depends upon the size of the transformer, type of case, transportation facilities from factory to destination, and convenience in handling during unloading. The purchaser should refer to the instruction leaflet on "Shipment" for detailed information.

SPARE PARTS

Component parts for Inerteen transformers are described and maintenance instructions are given in the leaflets that make up this book.

Spare parts are not ordinarily furnished with a transformer. If it is desired to carry a stock of spare parts they may be secured from the factory. When writing with reference to any transformer, the full instruction plate reading should always be given, especially the serial number. A complete description of the parts required including a rough sketch is desirable.

SERVICE DEPARTMENT

Westinghouse maintains Engineering and Service Departments in many locations throughout the country. Questions regarding installation, operation, or maintenance that are not covered in this instruction book should be taken up with the nearest Engineering and Service Department or Westinghouse Office.

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INSTRUCTIONS

INSTALLATION OF INERTEEN TRANSFORMERS

LOCATION

Accessibility, ventilation, and ease of inspection should be considered carefully in locating transformers. Another consideration often overlooked is noise; transformers should not be located on structural members that may transmit or near surfaces that may reflect and amplify the characteristic transformer hum. When it is impossible to locate otherwise and the noise may be a source of annoyance, transformers can be mounted on vibration dampeners. Wall, partitions, and ceilings can be covered with sound absorbing materials.

Inerteen transformers larger than 25 kva are equipped with a pressure relief device. If the device is mounted on the side of a tank or chamber, the transformer should be located so that the exhaust does not face an aisle or passageway. Where practicable for indoor installations or required by code, the relief device should be piped to the outside atmosphere.

Self-Cooled Transformers. Self-cooled transformers depend entirely upon the surrounding air for carrying away their heat. For this reason care must be taken to provide adequate ventilating facilities.

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.

Water-Cooled Transformers. Water-cooled transformers depend almost entirely upon the flow of water through the cooling coils for carrying away heat so that the temperature of the surrounding air has little effect upon that of the transformer. For this reason ventilation is only of minor importance and other considerations should be used in locating water-cooled units.

FOUNDATIONS

Indoor transformers require no special foundation other than a level floor of sufficient strength to support the weight of the transformers.

Outdoor units should never be placed with their bases resting directly upon the ground due to the corrosive action of soil acids. For permanent installations a raised concrete or wooden platform is preferred, but for temporary installations a thick bed of cinders or crushed stone should be first laid down instead of setting the transformers directly on the soil.

Transformers should be located with the thermometers and liquid gauges to the front so that abnormal conditions can be noted readily by an attendant. The water flow gauges on water-cooled units should be easily observed in order that a failure of the water supply may be quickly detected.

SETTING UP

An outline drawing is furnished showing the relative location of all fittings and this should be followed in setting up. The drawing will also list special features requiring attention during installation.

Caution: Care must be taken in handling and installing transformers, particularly those wound for high voltage. A blow upon any part of the winding; stray pieces of wire or solder, tools, nuts, or foreign matter of any kind dropped into the transformer may cause

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a breakdown or burnout. As moisture is an enemy of insulation, a transformer should not be allowed to stand so that it can absorb moisture from the air or from any other source; indoor units should be protected against the accidental entry of dripping water or rain from open windows, etc.

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 22 kv or less the Inerteen should be filtered. See instruction book, "Inerteen Insulating Fluid." If the dielectric strength is very low or if there is any other evidence of moisture, it may be necessary to dry the transformer. Instructions for drying are given in the leaflet, "Determination of Dryness—Method of Drying Out, Inerteen Transformers". Under certain temperature conditions, Inerteen may condense in drops on the underside of the cover parts; these drops should not be mistaken for water.

If the transformer is not shipped in the case, the inside of the case should be inspected for any traps of moisture and thoroughly cleaned with dry cloths or waste; the exterior should be inspected for loose or missing parts and tightening where necessary. Before placing the core and coil assembly in the case, make an inspection to see that it is clean and all bolts and nuts are tight. Valve stem packing nuts should be inspected for tightness before the transformer is placed in operation. While placing it in the case, handle carefully and be sure that it is correctly centered; a light lowered into the case will facilitate this inspection.

When going into the case of a shell type transformer with the core and coils in place, the tops of the insulating washers offer tempting places on which to stand. It is unsafe to stand on these washers, but a clean dry board may be laid across their tops for this purpose.

CENTERING

All transformers are provided with means of centering the core and coil assembly in the case. Different methods of centering are:

1. A metal or wooden frame work.
2. Pieces of structural iron attached to the bottom of transformer.
3. Lugs or pins welded to bottom of case.

PIPING CONNECTIONS AND EXPANSION JOINTS

Where the transformer is to be connected to an external system of piping for electrical, Inerteen, or water connections, provision must be made for the expansion and contraction to prevent throwing excessive stresses on the pipe connections which are welded into the tank and to protect valves, bushings, and other fittings against strain.

Care should be taken to see that the threads of all pipe fittings are not damaged. All threads should be thoroughly cleaned to remove dirt, grease, etc. After cleaning, apply cement M# 7386-1 that is furnished with the transformer to the threads of each fitting and immediately screw the fittings together tightly.

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.

TOUCH-UP PAINT

Inerteen transformers are finished with a special paint which is resistant to the solvent action of Inerteen. A sufficient quantity of this paint is usually furnished with each transformer, except the smaller distribution units, to "touch-up" surfaces that may become marred in shipment or during the process of installation.

FILLING WITH INERTEEN

Complete instructions for handling, storing, testing, and purifying Inerteen are given in the instruction book "Inerteen Insulating Fluid" and it should be consulted before filling any transformer

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

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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. Transformers with round wire coils should always be filled with Inerteen under a full vacuum because of the higher voltage stress across coil groups. If the tank strength is not given on the instruction plate, it should be requested from the Westinghouse Electric Corporation, Sharon, Penna.

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 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 several hours after the Inerteen has been put into the case. This time is necessary to allow the air bubbles to escape.

Filling Switch and Terminal Chambers. Transformers are frequently equipped with Inerteen filled terminal or switch chambers into which cables enter by means of potheads. In cases where it may be necessary to remove the chamber covers to make cable connections to the potheads, the usual practice is to ship the fluid for the chambers in separate sealed containers.

When an Inerteen conditioner is available for use in filling chambers with Inerteen, it is recommended that the liquid be strained through three layers of tightly woven clean white cloth and poured into the chambers through a clean receptacle containing from one to three dry activated clay tubes broken into small pieces. This will materially reduce the possibility of contaminating the Inerteen with dirt and moisture.

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 pres-

sures 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 these shown are properly made, for a wrong connection may cause severe damage. **Important: Terminal board, no-load tap changer, or other connections must never be made or changed when the transformer is energized.** Any lead or connector not in use should be insulated from all other leads and connectors and from ground.

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, show 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.

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INSTRUCTIONS

DETERMINATION OF DRYNESS AND METHODS OF DRYING OUT INERTEEN TRANSFORMERS

All transformers are dry when they leave the factory, but since they may absorb more or less moisture during shipment and storage, they should not be put into service until it has been determined that the Inerteen and insulation is dry enough for safe operation. The higher the voltage, the more chances there are of trouble from moisture, and the greatest care should be exercised to make sure that any moisture is eliminated.

TESTING FOR DRYNESS

When a transformer has been shipped assembled in its case with the Inerteen, four or five samples of the Inerteen should be drawn from the sampling device and tested. If the average of these tests shows a breakdown value of not less than 22,000 volts in a standard 1/10" gap test cup, the transformer is in a satisfactory condition for service. If the average breakdown value is less than 22,000 volts, the transformer must be dried. After the transformer has been in service for four or five days it is advisable to test the Inerteen again for moisture.

METHOD OF DRYING

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 30 KV or higher.

PRECAUTIONS IN DRYING OUT

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.

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OPERATION • MAINTENANCE

INSTRUCTIONS

OPERATION AND MAINTENANCE OF INERTEEN TRANSFORMERS

OPERATION

Entrapped air is a potential source of trouble in all transformers. In general, therefore, it is desirable to fill transformers with Inerteen under vacuum. This is done for all transformers shipped in Inerteen from the factory.

The filling of a transformer with Inerteen in the field should be done under as much vacuum as the tank is designed to withstand. This information will usually be found on the main instruction plate, but if it is not known, it should be requested from the Westinghouse Electric Corporation, Sharon, Pennsylvania. For instructions on filling with Inerteen under vacuum, see instruction leaflet "Installation of Inerteen Transformers". If the transformer tanks have not been designed for vacuum and it is imperative to get the maximum impulse strength immediately, the transformer should be filled with Inerteen under vacuum by placing it in an auxiliary tank. Transformers with round wire coils should always be filled with Inerteen under vacuum because of the higher stress across coil groups.

In those cases where the transformers are not filled under vacuum, full voltage should not be applied to the windings until inspection reveals that no more gas, in the form of bubbles, is being released from the core and coil assembly.

Inerteen Sampling. There is always a chance that moisture may get into the Inerteen after the transformer is installed so that a sample of Inerteen should be drawn from the top of the tank at least once every three months and tested for dielectric strength. See Instruction Book "Inerteen Insulating Fluid" for methods of testing and information on Westinghouse Inerteen testing service for operators who do not have the facilities for testing.

Temperature Readings. Thermometers should be read as often as good operating practice permits. Temperature limits for any specific condition of loading should be in accordance with ASA *Standards and Guides for Operation* (C-57) for the loading involved.

MAINTENANCE

Inspection. Transformers require less care and attention than almost any other kind of electrical power apparatus. This, however, is not a reason for neglecting them. The conditions under which they operate will determine to some extent the frequency with which they should be inspected. A regular program of inspection should be established and carried out rigidly.

It is desirable that periodic inspections of the Inerteen be made. Samples of Inerteen should be taken from each transformer and tested after a short period (approximately three months) of service. 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 inspection and test and if the Inerteen shows a dielectric strength of less than 22 KV, it should be conditioned. See instruction leaflet "Inerteen Insulating Fluid" for information on conducting test on Inerteen and Westinghouse Inerteen testing service.

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.

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Repainting. It is desirable to repaint the transformer at intervals to maintain the finish in good condition. Local climatic conditions cover such a wide range that definite recommendations as to frequency of repainting are not possible. Repainting by flowing on is preferable because it tends to wash off foreign material and produces a uniform coating. Equipment has been developed for flowcoating, cleaning, and handling transformers and parts in the field. The customer should write to the Company for details.

For details on paint in sufficient quantity for repainting complete transformers, contact the nearest Westinghouse Sales Office.

Caution: Activated clay if exposed to the atmosphere will absorb moisture very rapidly. If there is a perforated steel container of activated clay in the transformer and it is exposed to the atmosphere either by removing the core and coils or by lowering the Inerteen level, it should be thoroughly dried before it is again covered with Inerteen. Instructions for drying activated clay can be found in the Instruction Book "Inerteen Insulating Fluid".

Soldering. For soldering, a solution of resin in alcohol is recommended.

Spare Transformers. A spare transformer should be given the same routine checks as are given to transformers continuously in service. The internal parts should be kept free from the condensation and accumulation of moisture. To obtain the maximum advantage from the spare unit, it should be kept ready for instant service.

REPAIRING

With proper care, modern transformers seldom give trouble, but nevertheless, repairs are occasionally necessary.

Where severe arcing or burning has taken place, the bubbling process, for removing hydrochloric acid which may be formed, should be done as quickly as possible after the disturbance. For information on this process, see instruction book "Inerteen Insulating Fluid".

Other than the bubbling process, no general instructions will be given here for repairs of transformers. The operator may write to the Company, describing the nature of the trouble and the extent and character of the damage, and information and instructions for repair will be promptly and freely given.

In writing with reference to any transformer, always give the full name plate reading, as this furnishes accurate information for identification.

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APPLICATION • INSTALLATION • INSPECTION

INSTRUCTIONS

GASKETS
for Liquid Filled Transformers Tap Changers and Regulators

GASKET APPLICATION			
APPARATUS	GASKET MATERIAL	GASKET CEMENT	% GASKET COMPRESSION
Oil Insulated* Apparatus	Cork Neoprene PDS#7249-11 or 45721AH (1)	#8440-4	43%
	Nitrile PDS#12160-713.1 or 45351EH	None	25%
Inerteen Insulated and Network Transformers	Cortile Nitrile PDS#9930-3 or MC45711AB (1)	#7386-1	50%
"URS" and "URT" Tap Changers and Regulators	Cork Neoprene PDS#7249-11 or 45721AH Flat Gaskets-No Gasket Stops	#8440-4	43%
	Dumbell Nitrile Section #258A460 or 45351EP	None	....

* Except "URS" and "URT" Tap Changers and Regulators.
(1)-Temporary shipping gaskets may be cork—for permanent application PDS#7249-11, 45721AH, 9930-3 or MC45711AB should be used.

GENERAL

The gaskets used on liquid filled transformers, tap changers and regulators are of materials which have proven suitable for that particular apparatus with which they are being used. Experience has shown that the use of the proper material used with the correctly associated apparatus and installed by a standard procedure assures a joint that will be leakproof.

GASKET INSTALLATION

A. Preparing Metal Surfaces. Before applying a gasket to any metal surface care must be taken to assure that the mating surfaces are free of ice, dew condensation, oil, grease, rust or dirt by wiping dry. This can be done by using clean rags or any other method that will assure a dry surface. Rust should be removed by sanding or wire brushing. Thin uniform films of primer paint or gasket cement need not be removed. If the gasket is cut in the field, cut the gasket to conform to the surfaces to be sealed. Gasket thickness and percent compression must be in accordance with recommended practice. If the gasket is not a one-piece gasket, scarf the ends of the gasket so that the length of the overlap will be equal to four times the thickness of the gasket material. The mitering should be done with a fine toothed saw and a miter box to assure a clean uniform cut and to obtain full gasket thickness at the lap joint. A hand-type gasket cutter for keystone shaped interlocked joints is available for field work. These interlocked joints must be matched-cut by forming the joint properly and cutting both layers at the same time. Gasket cutting tool (up to 3 inches), style number 328B614G01. When ordering precut gaskets, give the complete nameplate reading of the transformer including serial number. Specify exact description of the gaskets required and give their location.

B. Application of Permanent Gaskets when temperatures are above freezing. It is recommended that both sides of the gasket be cemented to the gasket surfaces. Apply cement as follows:

#8440-4 Cement

1. Apply cement to both gasket and joint surfaces and let dry at least ten minutes but not more than 60 minutes.
2. Assemble gasket and press firmly into place.
3. Coat other side as per (1).
4. Assemble joint.

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Application of Permanent Gaskets when temperatures are below freezing. To keep the gasket from getting too hard and to keep the cement fluid, the gasket and cement should be kept at a minimum temperature of 35°F up to the time of actual application of cement and compression of gaskets. This will mean that the cement and gasket will usually have to be kept warmer than this in freezing weather. It will not be necessary to coat the gasket groove with #8440-4 cement providing the gasket is assembled with the mating parts before the cement is completely set-up. By following these instructions you can be sure that the gasket will not be too hard to compress properly and the cement will adhere to the metal surfaces assuring an oil-tight seal.

#7386-1 Cement

1. Apply cement to both gasket and joint surfaces and let dry until "tacky".
2. Assemble gasket and press firmly into place.
3. Coat other side as per (1).
4. Assemble joint.

C. Inspection Opening Gaskets. Gaskets for inspection openings may be sealed on one side only to permit the removal of the inspection cover without destroying the gasket. It is recommended that the gasket be sealed to the stationary member of large openings and to the cover of small openings and load tap changer oil compartment doors. The gasket is sealed to one member by applying a uniform coating of gasket cement (for cork-neoprene use PDS#8440-4 S#1608171A; for "Cortite" or cork use PDS#7386-1 S#1150419) to one side of the gasket and to the surface to which the gasket is cemented. It is suggested that the surface of the gasket not cemented be coated with silicone lubricant M-5861-4 S#228A253H01, to prevent the vulcanizing of the gasket material to the steel plate. This will permit the removal of the cover without destroying the gasket.

For cemented surface follow cementing instructions above.

Prior to replacing a cover of an inspection opening, the gasket should be examined to make certain that it has not been damaged and that it has sufficient thickness to reseal the joint.

MANHOLE COVER AND BUSHING FLANGE GASKETS

Gaskets for manhole covers should be sealed to the main cover boss opening to permit the removal of the manhole cover without destroying the gasket.

Bushing flange gaskets are sealed in permanently when the bushings are installed. Follow procedure for application of permanent gaskets.

NOTE: It is very important that all openings in the transformer tank and tap changer be tightly closed before putting a unit into operation. This is necessary whether the unit is for indoor or outdoor operation. For all liquid filled tap changers and regulators; the bushing flanges, main cover, manhole covers, etc. must be oil and gas tight.

LEAKAGE TESTS

Liquid filled transformers should be tested for pressure tightness prior to putting in service. The permissible internal pressure that may be used can be determined from the nameplate on the transformer. Internal test pressures of ten pounds per square inch may be used to check the tightness of gasketed joints for transformers whose nameplates indicate that the transformer may be filled under complete vacuum. All other transformers should be tested with an internal pressure of five pounds per square inch.

The following precautions should be observed when making the pressure test:

1. Inertaire transformers;—Close the valves or disconnect the piping and plug the entrances into the tank before testing.
2. Open air breathers, dehydrating breathers, and breathing regulators: Close openings to this equipment before testing.
3. Mechanical relief device:—The relief device must be replaced by a steel plate when the test pressure is likely to exceed the tripping pressure of the relief device. For additional instructions, refer to the instruction leaflet for relief device.
4. Relief diaphragm:—A relief diaphragm must be replaced by a steel diaphragm when the test pressure is likely to exceed the rupturing pressure of the relief diaphragm. For additional instructions, refer to the instruction leaflet for relief diaphragm.

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
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Instructions for INERTEEN® Insulating Fluid P.D.S. 54201 KA



Westinghouse Electric Corporation
Power Transformer Division, Sharon, Pa.

I.B. 45-063-99 Effective July, 1965, Supersedes I.B. 44-860-1, February, 1952

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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.

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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 personnel are working with Inerteen. Continued exposure may cause eruptions on certain individuals due to the absorption of Inerteen through the pores

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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.

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.

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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

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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 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 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 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)
   100×10^9 ohms/cm³ (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

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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 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.

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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.

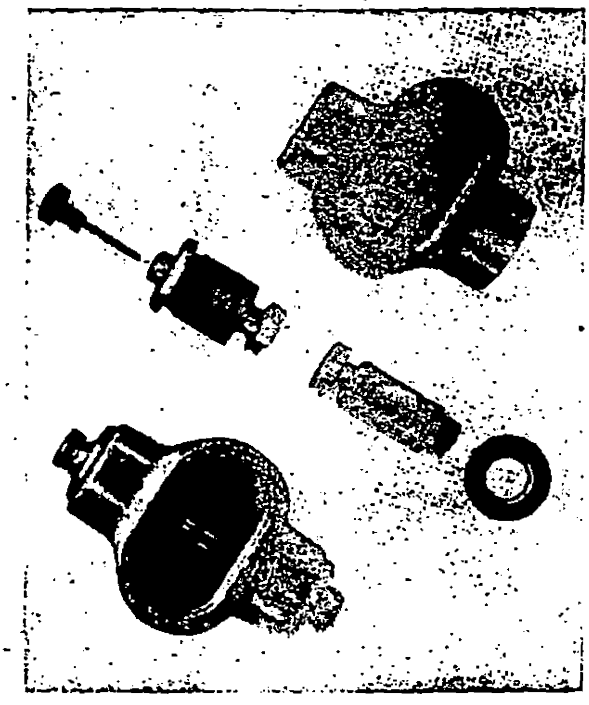


FIG. 1. Fluid Test Cup for Dielectric Test

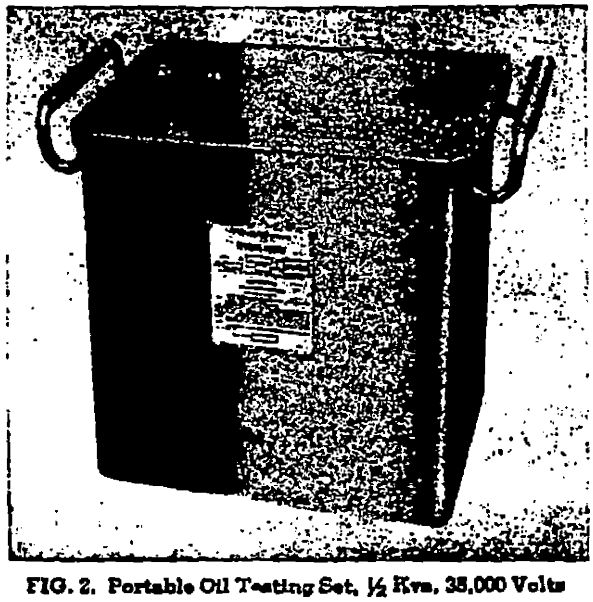


FIG. 2. Portable Oil Testing Set, ½ Kva. 35,000 Volts

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 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).

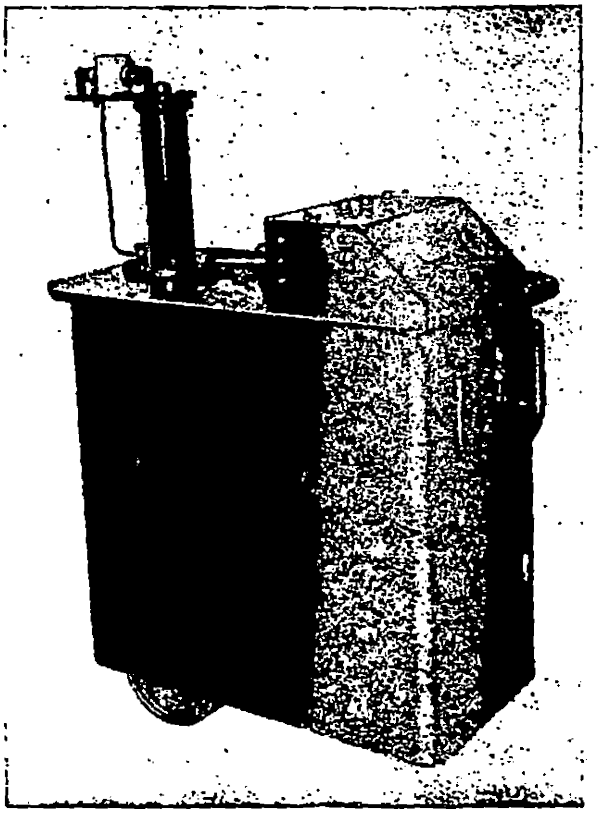


FIG. 3. Portable Trunk Type Insulating Liquid and Insulating Testing Set, 5 Kva, 30,000/60,000 Volts

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.

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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.

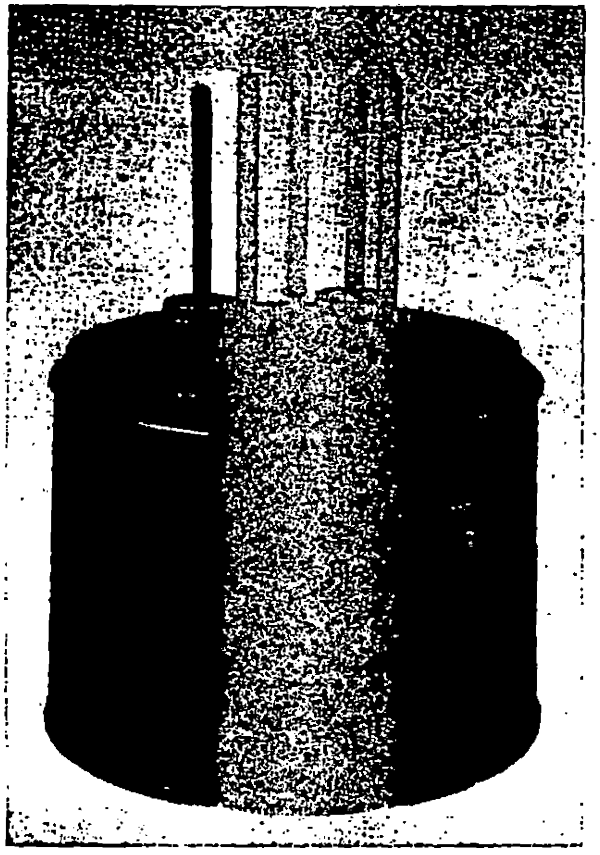


FIG. 4. Apparatus for Pour Test

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-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 $= \frac{(A\text{-}B\ (N) \times 56.1}{W}$

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

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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.

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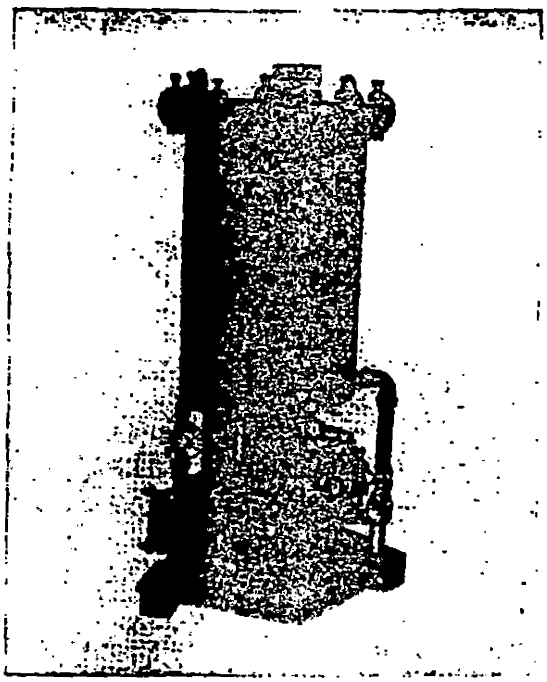


FIG. 5. Three Gallon-per-Minute Conditioner

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

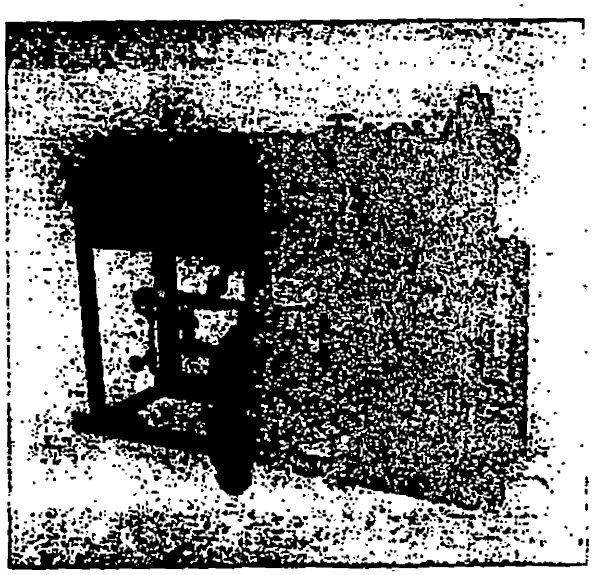


FIG. 6. Seven Gallon-per-Minute Conditioner

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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

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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

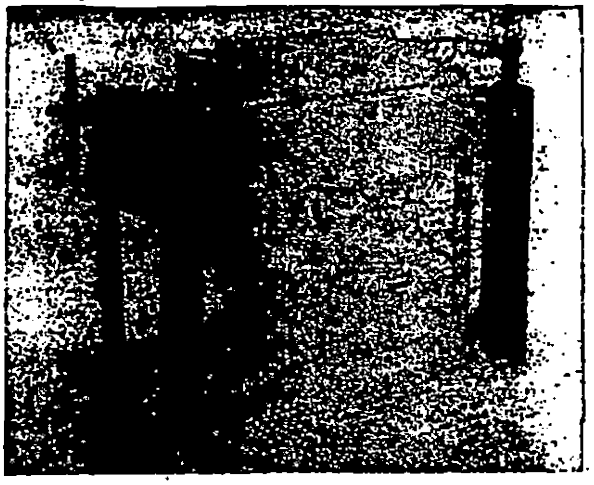


FIG. 7. B-10 Blotter Filter Press

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

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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.

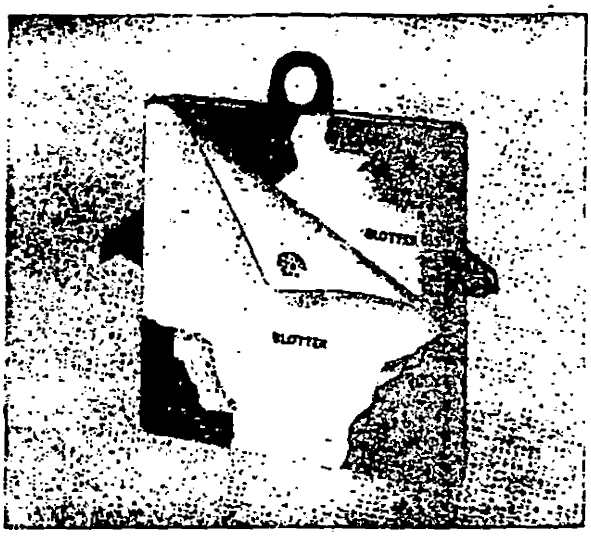


FIG. 8. Blotter Filter Press Frame Showing Blotter Filter Papers in Place

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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Instructions for Standard Outside Finish, Inerteen Transformer Tanks

I.L. 47-069-6

THE STANDARD outside finish for Westinghouse Inerteen transformers consists of three baked-on coats of high grade paint which will resist the solvent action of Inerteen. This system consists of one coat of primer and two coats of finish paint. The color variation between the prime and finish coats insures that the paint is continuous and of sufficient thickness. Each coat is usually flowed on, but can also be applied by dipping, spraying or brushing.

The transformer tanks and accessories being constructed of steel, are susceptible to rusting. Therefore, in order to prevent rusting of exposed steel surfaces give careful attention to the following steps when repainting:

1. All exposed steel surfaces must be thoroughly cleaned and prepared for the application of paint since the proper preparation of the surfaces to be finished is an important factor to securing a satisfactory finish.

Regardless of how good the paint may be, it will fail as a protector if applied over a wet, dirty, rusty, or greasy surface. Rust and scale absorbs and holds moisture. Therefore, to obtain a durable finish, it is essential that no moisture be sealed in by the application of paint. For large areas, a clean dry surface with sufficient roughness for good adhesion of the priming coat can be obtained by shot or sand blasting the exposed surfaces of the transformer tank.

2. The careful application of a quality paint that will resist the solvent action of Inerteen is essential to guarantee a lasting finish.

The two factors that determine the quality of any paint are the pigment and vehicle. The pigment gives the color and body of the paint and the vehicle holds the pigment particles in place and forms a continuous adherent film. Although attention is generally centered upon the selection of the pigment, many tests show that the vehicle of a paint is the first of these two components to disintegrate. Therefore, it is important that a paint of high quality be used to obtain a satisfactory finish.

IMPORTANT. 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 scraper or sandpaper, applying a coat of primer paint and allow it to dry for at least 24 hours, then apply a coat of finish paint.

NOTE. For small marred spots which do not penetrate the paint film to the parent metal, only the finish paint is necessary. Due to the indefinite life of the primer, the finish paint should be applied as soon as possible.

A one-pint container of finish paint is furnished with each order of transformers for use in touching up any places damaged during shipment or installation. Larger quantities of Westinghouse paint can be obtained through the nearest Westinghouse Sales Office. Westinghouse Primer Paint is not packaged in small quantities, but if required, can be purchased in the same manner.

Westinghouse Electric Corporation
Power Transformer Division, Sharon, Pa.

Printed in U.S.A. (T.P.)

Effective January, 1965. Supersedes I.L. 48-650-8, April, 1951

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DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

DIAPHRAGM RELIEF DEVICE

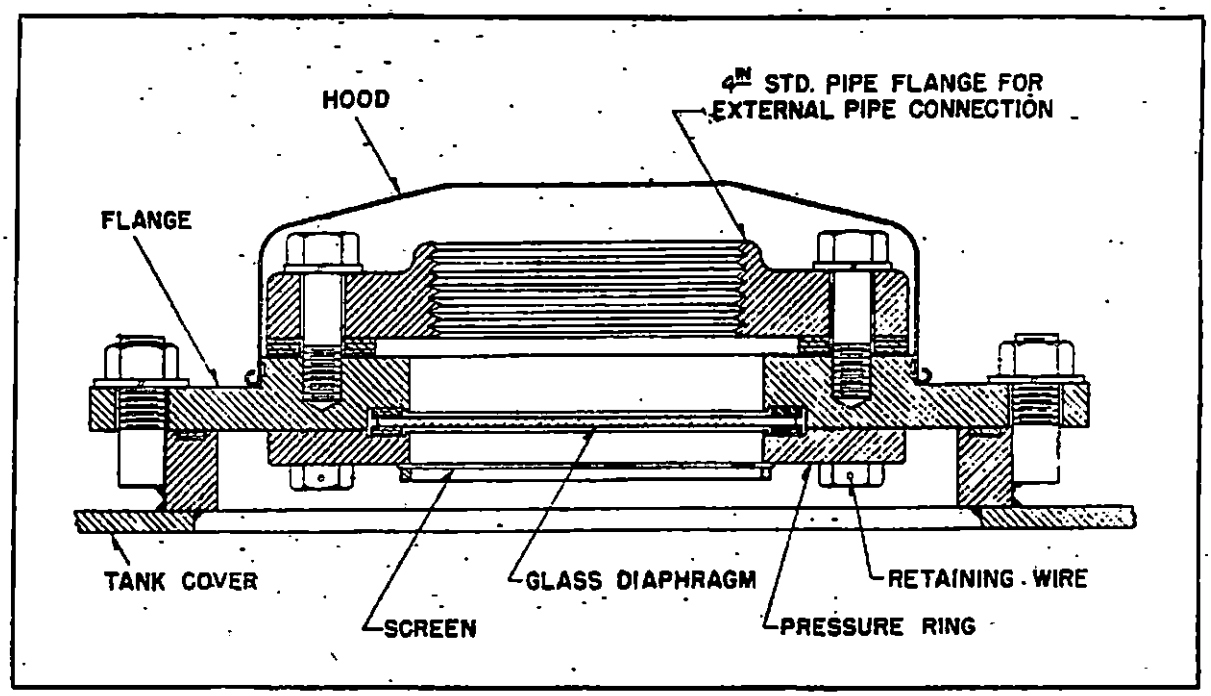


FIG. 1. Type "SL" Transformer Diaphragm Relief Device.

THE DIAPHRAGM RELIEF DEVICE for indoor Inerteen Transformers consists of a sheet of glass mounted in a special manhole cover on top of the transformer case. The diaphragm ruptures at abnormal pressures, which are relieved by the blowing off of a hood which fits tightly over the exhaust opening or exhausting through a vent pipe. Except for replacing a ruptured diaphragm, it is only necessary to inspect the diaphragm occasionally by removing the hood or companion flange. See Fig. 1.

CONSTRUCTION

The relief device is of simple construction. It consists essentially of an annular cast alloy flange, the bottom surface of which is machined to act as a retainer for the upper diaphragm gasket and tapped to take the diaphragm clamping ring studs. The glass diaphragm, each side of which is gasketed, is held securely between the flange and clamping ring. The upper side of the main flange is machined to take a hood which fits snugly over the edge and a companion flange and gasket for vent pipe connection.

The selection of a suitable material for the diaphragm is a matter of some importance. In order to be reliable it must have a uniform rupturing characteristic, under the conditions presented, in relieving abnormal pressures. It must, at the same time, be a material of sufficiently substantial nature to be handled easily without danger of accidental breakage.

Westinghouse glass diaphragms are rugged enough to be readily handled and installed without breakage if instructions are carefully followed. Glass is entirely free from aging, and the glass diaphragms are designed to break at from 12 to 18, and 16 to 22 pounds per square inch.

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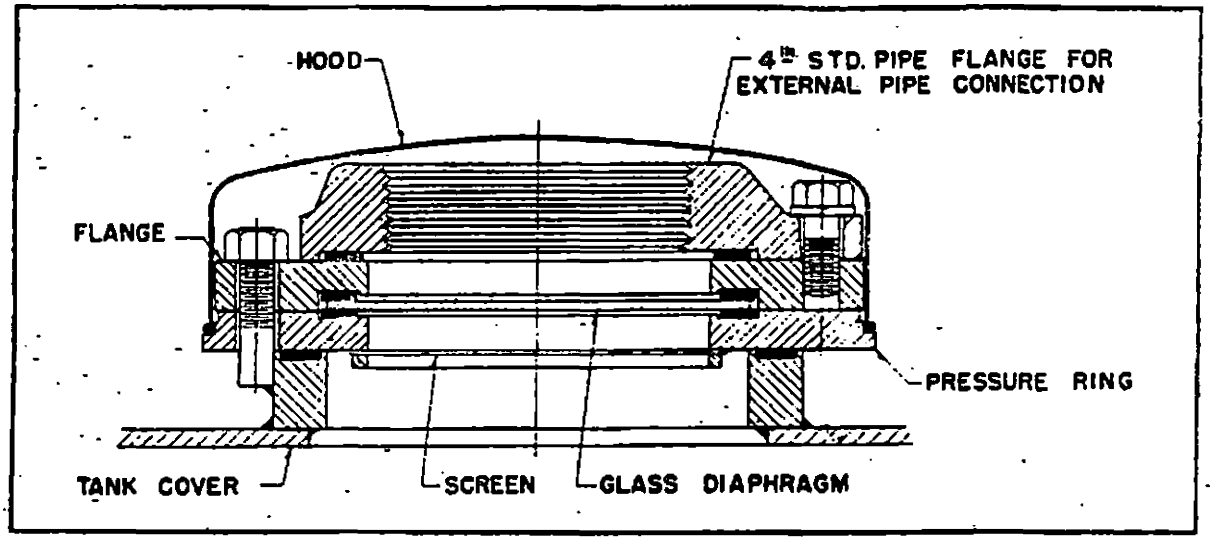


FIG. 2. Type "S" Transformer Diaphragm Relief Device.

INSTALLATION

The relief device is shipped mounted on the transformer cover.

The diaphragm is located under the main relief device flange approximately 1¼" above the level of the transformer cover.

OPERATION

When the pressure in the tank rises above normal, the diaphragm bursts and either the hood is in turn blown off, or the gases are exhausted through a vent pipe when used, thereby relieving the pressure.

When the handhole opening is to be used for entrance into the transformer case, the outer row of bolts is removed and the complete assembly withdrawn, leaving a full-size opening in the cover.

MAINTENANCE

The diaphragm may be inspected by removing the hood or companion flange. If, for any reason, the diaphragm ruptures it should be replaced at once.

In replacing a glass diaphragm, every precaution should be taken to mount it in such a way that it will be centrally located on its gaskets with uniform pressure around its edge. In order to accomplish this, the glass should be placed on the gasket next to the relief device body after the cement has become quite tacky and it should be carefully placed with maximum clearance to studs at all points. The gasket next to the relief device body should be replaced. See Instruction Leaflet I.L. 47-600-11A, "Gaskets", for method of replacing gaskets. Excess cement should be kept off the diaphragms as it will affect their breaking strength. It is not necessary or desirable to use gasket cement on the gasket located between the glass and clamping ring. The studs should be tightened uniformly, turning each screw not more than ⅓ of a turn at a time until the gasket stop is reached. On Type "SL" Relief Device (Fig. 1) thread 24 inches of #14 soft steel wire through the lower ends of the studs and twist ends together. On Type "S" Relief Device, (Fig. 2) this is not necessary, as the flange is held by bolts from the top.

RENEWAL PARTS

Spare diaphragms, gaskets, and cement should be kept on hand. A limited supply is furnished with the transformer. Gaskets should not be kept in stock more than two years. For additional parts, order from the nearest Westinghouse Office or from the Sharon Plant, giving serial number and also the complete transformer information as stamped on the nameplate.

TRANSFORMER	NOMINAL DIAMETER	FLANGE GASKET	DIAPHRAGM	HOOD	ADAPTER GASKET	DIAPHRAGM GASKET
Type SL	9 inches	S#1165 894	S#1165 795	S#1609 323	S#1166 410	S#1165 860
Type S	6 inches	S#1165 411	S#1165 795	S#1609 323	S# 582 455	S#1165 860

WESTINGHOUSE ELECTRIC CORPORATION
SHARON PLANT • TRANSFORMER DIVISION • SHARON, PA.
Printed in U.S.A.

NPC00008053

Earl H. Carroll
612 First Natl. Bldg.
Oklahoma City, Okla. 73102

From : South Boston Division
WIN : 225-7206
Date : January 30, 1976
Subject: Inerteen

To : Power Systems Field Sales
Industrial Field Sales
Construction Field Sales

cc: South Boston Division - Mr. D. P. Keiser

As you are aware, there is a current hue and cry about polychlorinated biphenyls (PCB's). South Boston is affected in that we use Inerteen, an Askarel manufactured by Monsanto, as an insulating liquid. Since there are so many statements being made, we would like to share some facts with you.

1. The EPA has requested that companies voluntarily restrict their use of materials containing PCB's. In a meeting in Chicago (1/22/76) AMTRAK reportedly refused to abandon the use of Askarel.

2. NEMA liaison committees have been set up to guide the EPA.

3. There are over 200 isomers of PCB's. Not all have the same half life, toxicity, or presence in the environment.

4. Inerteen is approximately 91% biodegradable. The Westinghouse number is 54201 CM. The Monsanto designation is Aroclor 1242.

5. There are several fluids currently being considered as possible substitutes for Askarels. Some have been available for several years. None has matched the inflammability of Askarel and none has been accepted by the underwriters or the standards organizations. These fluids are approximately three times as expensive as Inerteen on a per gallon basis.

6. About two years ago South Boston successfully built and tested some units using one of the fluids under consideration by one supplier. There is presently available a system to complement those used for oil and for Inerteen. It can quickly and easily be set up to accept a third fluid.

7. On January 20th, the Monsanto Company announced that they have formulated a plan to eventually phase out Askarel - if necessary. A five year figure was used in their verbal statement. Due to the current state of affairs, this, of course, is an estimate.

The above will supplement what you have read in Business Week dated January 19, 1976 and gathered elsewhere. Attached is a copy of the Westinghouse comments at the December 12th hearing by New York State and a copy of the Monsanto press release. We hope that keeping you informed will better help you achieve your objectives.

DP Keiser

D. P. Keiser
Marketing Manager

se
Enclosures

New York State Hearing -
Polychlorinated Biphenyl Compounds
December 12, 1975

I am Roger E. Wills, Jr. and I am an attorney for Westinghouse Electric Corporation located in Pittsburgh, Pennsylvania. My responsibilities include environmental affairs.

I very much appreciate the opportunity to present these comments at this hearing. The purpose of this hearing, as I understand it, is and I quote "to bring together the most recent data on PCB manufacture, use and disposal; assess how and in what quantities PCB's get into the environment and their possible reclamation; and to determine whether adequate substitutes for this chemical exists."

The statement that I have just quoted concerns me as I feel that there are factors that must be considered before we get to the question of whether present controls are sufficient and whether substitutes for these compounds are needed. Polychlorinated Biphenyls are not just a single chemical, but a chemical designation for a family of chemical compounds containing 209 isomers. This is important for several reasons. Each isomer exhibits different chemical and physical properties and as a result, not all isomers are being found in our environment. Therefore, before legislative alternatives are considered, those isomers of PCB's which are environmental contaminants must be identified and the source of them into our environment must be determined.

The recent National Conference on Polychlorinated Biphenyls provided information on environmental findings and some new insights into possible sources of these compounds. As Dr. Ian C. T. Nisbet summed up the session on Environmental Fate and Occurence, PCB's in dumps or land fills are not a significant source of PCB's; there is adequate evidence that the tetra and lower isomers are degraded; and that those PCB's already in sediments, from whatever the source, that contain the higher homologs will be continually recycled.

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With these points in mind I would like to relate the actions that Westinghouse Electric Corporation has taken since 1968. At this point, I should point out that Westinghouse utilizes the term Inerteen for the mixtures of polychlorinated biphenyls it uses as a dielectric and that the generic term used by the electrical industry is askerel. These terms are not really interchangable with the term polychlorinated biphenyl. While there are, as I stated, 209 isomers of polychlorinated biphenyl, the electrical industry only uses several mixtures of polychlorinated biphenyl isomers as a dielectric. Of these, Westinghouse utilizes primarily only two askerels, Aroclor 1242 for transformers and Aroclor 1016 for capacitors as Inerteen.

Since the early 1970's, when scientific studies indicated polychlorinated biphenyl mixtures presented some hazard in the environment, Westinghouse has expended considerable money and effort to reduce the amount that might escape into the environment. Measures that have been employed are: sealing drains in manufacturing areas where Inerteen is used; utilizing specially designed incineration facilities for the destruction of scrap Inerteen and special scientific land fills for the disposal of Inerteen contaminated material; instructing operating personnel and our customers regarding the need for care, and that special waste disposal is required; and reducing the number of pounds of Inerteen per KVA of transformers and capacitors. Most of these measures were implemented prior to the enactment of the Federal Water Pollution Control Act Amendments of 1972.

Westinghouse recognized, however, that these measures could not prevent the total elimination of Inerteen escaping into the environment. Therefore, concurrent with the above measures, we have conducted extensive evaluation programs designed to utilize those mixtures of polychlorinated biphenyls having low persistence and high biodegradability in the environment. By February, 1968, Westinghouse determined that a mixture of polychlorinated biphenyls, sold by Monsanto as Aroclor 1242, would be satisfactory as Inerteen for transformers. Aroclor 1242 contains about 91% of the lower isomers (containing 4 chlorines or less) that more readily biodegrade in the environment. This material has been used by Westinghouse since that time with the understanding that over 90% of any small amounts that did enter into the environment would have relatively low persistence.

Monsanto subsequently developed a new material from Aroclor 1242 which contained more of the lower chlorinated isomers and marketed this material as Aroclor 1016. By the first quarter of 1972, this material was introduced by Westinghouse into the manufacture of all capacitors. This material contains 99% of the more biodegradable isomers (4 chlorines or less) so that less than 1% of this material that might escape into the environment might be more resistent to biodegradation.

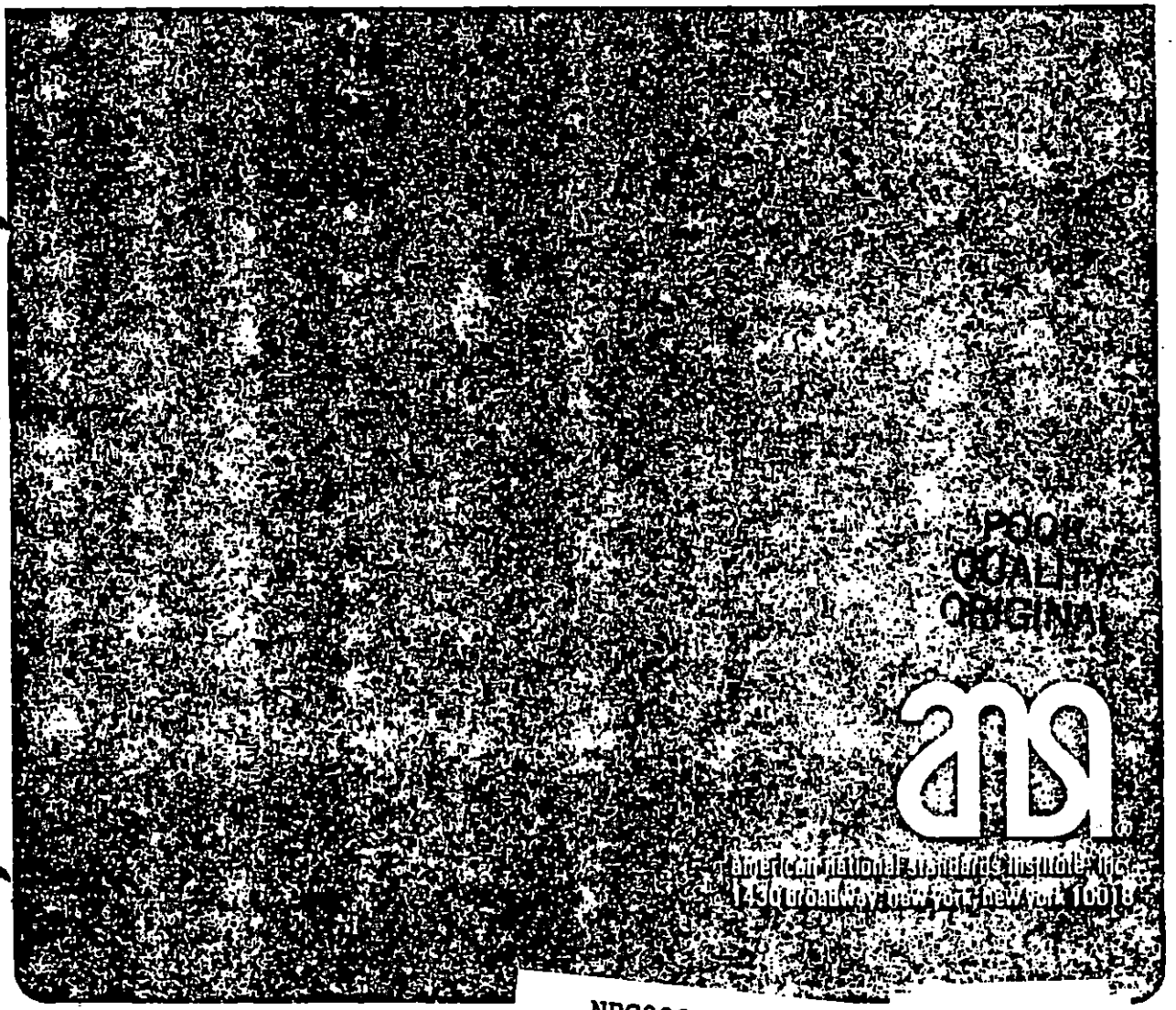
The industry, Monsanto, our own research of the scientific literature and most of the papers presented at the National PCB Conference have indicated that the lower chlorine mixtures of polychlorinated biphenyls are more biodegradable and do not present the same long term toxic environmental problems as those which contain the higher chlorinated isomers. Environmental Protection Agency researchers have found a significant difference between the effects of Aroclor 1242 and Aroclor 1016 on rats and Dr. Robert W. Risebrough stated at the Conference that comments on PCB's should be characterized as to the type of mixture and thus the uses of Aroclor 1016 and 1242 should not be covered by comments and findings related to Aroclors 1254 and 1260.

We believe that the U.S. scientific community should determine the benefits and the environmental impact of the two or three askarels used by the elecrical industry on a scientific basis before conclusions are made in the form of regulations. Industry and Government should not be stampeded into a selection of an alternative fluid which is more potentially dangerous to man and his environment.

ANSI C107.1-1974

American National Standard

guidelines for handling and disposal of capacitor- and transformer-grade askarels containing polychlorinated biphenyls



C107.1-1974

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ANSI
C107.1-1974

American National Standard Guidelines for Handling and Disposal of Capacitor- and Transformer-Grade Askarels Containing Polychlorinated Biphenyls

Secretariat

National Electrical Manufacturers Association

Approved January 9, 1974

American National Standards Institute, Inc

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American National Standard

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Foreword

(This Foreword is not a part of American National Standard Guidelines for Handling and Disposal of Capacitor- and Transformer-Grade Askarels Containing Polychlorinated Biphenyls, C107.1-1974.)

Recognizing that the polychlorinated biphenyls present in askarels were being identified as environmental pollutants and the urgent need for procedures and guides for their safe use and disposal, the Board of Directors of the Power Equipment Division of the National Electrical Manufacturers Association (NEMA) in June 1970 appointed a committee to review the general problem and propose recommendations. In September 1970, the NEMA board approved, as recommended by the committee, the sponsorship of an American National Standards Committee for the use and disposal of askarels in electrical equipment.

American National Standards Committee C107 was established in April 1971. NEMA was designated as the secretariat. An organizational meeting was held on September 14, 1971. Mr W. B. Papageorge, Monsanto Company, was appointed chairman. Committee members included representatives of capacitor and transformer manufacturers, utilities, governmental departments and agencies, and maintenance and disposal service companies. A steering committee and two subcommittees – one to develop guidelines for the capacitor industry, the other for the transformer industry – were established.

The scope and primary objective of the committee was designated as the development of: Procedures and guides for the safe use, maintenance, and disposal of askarel and askarel-soaked materials used in electrical equipment.

Additional objectives proposed were as follows:

(1) To serve as a source for technical information and advice for federal, state, and local authorities and for the information of all others concerned.

(2) To encourage the development of suitable disposal facilities and maintain a list of their capabilities and locations, for the information of all concerned.

(3) To serve as the advisory group for U.S. participation in the International Commission on Rules for the Approval of Electrical Equipment (CEE), the International Electrotechnical Commission (IEC), the Pan American Standards Commission (COPANT), the International Conference on Large High Tension Electric Systems (CIGRE), and other international organizations.

The final draft of the guidelines was completed in late November 1972. NEMA issued the guidelines as an Official Standards Proposal in January 1973. It was submitted to the American National Standards Institute for approval as an American National Standard and was approved by the Standards Institute on January 9, 1974.

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Use and Disposal of Askarel and Askarel-Soaked Materials in Electrical Equipment, C107. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the C107 Committee had the following members:

W. P. Papageorge, Chairman
A. M. Salazar, Secretary

Organization Represented	*Name of Representative*
Certified Ballast Manufacturers Association	N. R. Clark
	A. Pozefsky
Chem-Trol Pollution Services Inc	Louis E. Wagner
Doble Engineering Company	A. L. Rickley
Electrical Utilities Company	A. O. Hauser
	E. M. Moore (Alt)
Electric Light and Power Group	F. R. Lengefeld
	H. A. Onishi
	J. J. Cawley (Alt)

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Organization Represented	*Name of Representative*
Electronic Industries Association	Arnold S. Doty
Environmental Protection Agency	Kenneth J. Hood
General Services Administration	Charles C. Travis
Gilbert Associates Inc	R. J. Schatz
Institute of Electrical and Electronics Engineers, Inc	E. L. Rabb
Monsanto Company	W. P. Papageorge
	P. G. Benignus (Alt)
National Bureau of Standards	Stanley P. Wasik
National Electrical Manufacturers Association	K. C. Chang
	W. S. Grogan
	R. D. McClain
	H. R. Rowe
	Ken McGee (Alt)
Rollins-Purle, Inc	H. A. Alsentzer
Tennessee Valley Authority	William R. Nicholas
U.S. Department of Agriculture, Rural Electrification Administration	John Lentritz, Jr
U.S. Department of the Army	D. M. Crabtree

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American National Standard Guidelines for Handling and Disposal of Capacitor- and Transformer-Grade Askarels Containing Polychlorinated Biphenyls

1. Scope

This standard establishes guidelines for the safe use, maintenance, and disposal of askarel and askarel-soaked material used in capacitors and transformers.

2. General Information

2.1 **General.** The term "askarel" generally describes a broad class of nonflammable synthetic chlorinated hydrocarbon insulating liquids widely used in capacitors, transformers, reactors, and accessory equipment operated at power frequencies.

Askarels consisting of or containing polychlorinated biphenyls (PCBs) have been used in many applications for more than 40 years, but only recently was evidence discovered that PCBs are widely dispersed in the environment. Systematic investigations of the biological effects of PCBs have been undertaken within the past few years to establish the effects of specific formulations upon specific species. Some studies have shown that PCBs may be an environmental contaminant. Simultaneously, significant steps have been taken by U.S. industry to limit further releases of PCBs to the environment.

PCBs have been used in three broad types of applications for the past 40 years, as follows:

(1) "Open-ended" applications; for example, in paints, specialty inks, paper coatings, plastics, etc

(2) "Nominally closed" applications; for example, as the working fluid in hydraulic or heat-transfer systems

(3) "Closed electrical system" applications, specifically as the insulating fluid in certain kinds of transformers and capacitors[1]

[1] The Monsanto Company is the sole U.S. producer of PCBs. It has discontinued supplying the material for all applications given in 2.1(1) and 2.1(2).

Evaluations of the benefits, risks, and alternatives involved in the continued use of PCBs in closed electrical systems are summarized in 2.2 through 2.4.

2.2 **Benefits.** Askarel-filled transformers do not burn or sustain fire under conditions of internal electrical arcing.

Askarel-filled power and industrial capacitors are significantly smaller, more reliable, more durable, and safer than oil-filled capacitors. As a result, askarels have supplanted mineral oils in more than 90% of the power and industrial capacitors made today. Over the past few decades most of the equipment that incorporates such capacitors has been designed to take particular advantage of the size, safety, and reliability benefits of askarel capacitors (for example, many types are today less than 14% of the size of equivalent oil capacitors and have a life expectancy of 10 to more than 20 years).

Various federal, state, and local codes, therefore, require their continued use in or adjacent to public, commercial, and industrial buildings, which locations present the greatest potential danger to life and property.

2.3 **Risks.** In the United States, medical records over a nearly 40-year period show that the only adverse health effects experienced by U.S. workers exposed to askarels, either during the manufacture of these liquids or of electrical equipment containing these liquids, have been limited to occasional cases of nonchronic chloracne or other temporary skin lesions or irritations.

Askarel-filled transformers and capacitors are delivered to customers as sealed units from which there is no escape of askarel under normal operation. Although certain types of equipment failures can permit loss of some askarel to the environment, transformer failures are limited to approximately 0.02% of the units in service per year. With respect to capacitors, such losses are limited to approximately 0.02% of the askarel put into service per year. In addition, limited amounts of PCBs can get into the environment during the manufacture, delivery, improper use, maintenance, repair, and disposal of transformers and capacitors.

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Specific control measures have been instituted by individual manufacturers and are supplemented and strengthened by national standards and procedures such as this standard, which provides information to prevent the inadvertent loss of PCBs to the environment at all stages from initial askarel manufacture through ultimate disposal.

2.4 Alternatives. For technical and local and national code reasons, it would be impossible to replace most askarel-filled transformers now in service with oil-filled units of equivalent ratings without major construction changes that would be required to compensate for the fire resistance of the askarel-filled units. For certain applications and locations, dry-type transformers may replace askarel-filled transformers.

For new installations, although many of the foregoing limitations would still apply, building and installation design provisions could be made to accommodate the use of oil-filled, open dry-type, or sealed dry-type transformers, provided that necessary technical, code, physical size, and cost considerations are properly evaluated.

The principal alternative to askarels for capacitors is mineral oil, but such replacement would return capacitor technology to its pre-1932 level and would necessitate the redesign and replacement of such widely used equipment as fluorescent light fixtures and racks for power and induction-heating capacitors, which could not now accommodate the increased size of oil capacitors while maintaining their present ratings.

The cost of askarel liquids is about five to ten times more than mineral oil. Thus, long before there were any environmental concerns about PCBs, there was a strong economic incentive to find other, less expensive insulating liquids with the desirable characteristics of askarels. Since the 1930s at least ten major chemical or electrical companies have invested large amounts of time and money in this search, all with no success. Although potential substitutes that are more costly than askarels (such as fluorinated liquids) have also received some consideration, little is known about either their electrical performance or possible ill effects upon the environment. There are today no fluids that can be used as a direct replacement for askarels.

2.5 Interdepartmental Task Force on PCBs. An in-depth study of PCBs has recently been completed by five Executive Branch Departments of the federal government. This Interdepartmental Task Force on PCBs issued their report, entitled *Polychlorinated Biphenyls and the Environment*, in May 1972.[2]. The following conclusion is quoted from page 4 of this report:

"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."

Reference should be made to the Interdepartmental Task Force Report for additional information and conclusions.

3. Capacitor Guidelines

3.1 General. The environmental effects of askarels are under in-depth study by governmental and other agencies. Askarels have been considered relatively harmless to humans based on about 40 years of safe industrial usage. There has been no known instance of human injury when they were used under the normally accepted precautions and conditions of handling in both manufacturing and user applications.

Traces of askarels are being found in the environment and in fish and bird life. The long-term genetic and ecological effects are not yet completely understood. For these reasons, care should be taken to contain askarels and minimize their entry into the environment.

There are two general classes of askarels used by the electrical industry. The higher chlorinated grades are the more persistent in nature. Because of their high degree of nonflammability, they are used in transformers where personnel safety is of paramount importance.

Capacitor-grade askarel has a lower degree of chlorination (composed primarily of the 3-chlorine isomers of biphenyl) and a higher degree of biodegradability. Generally, it has not been found in animal life. It is used in capacitors, where the extreme degree of nonflammability required in transformers is of less importance.

Although capacitor- and transformer-grade askarels both contain members of the PCB family, they do differ in composition, degree of biodegradability, persistence in nature, electrical stability, chemical stability, and degree of nonflammability (both are recognized as nonflammable). It is for these reasons that Section 3 of this standard is intended to apply to capacitor-grade askarel.

[2] Available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va 22151.

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Table 1
Typical Properties of Aroclor 1016

Property	Test Method (See Note)	Typical Values
Color	APHA*	40, max
Condition	–	Clear
Specific Gravity at 25/15.5°C	ANSI C59.68-1965 (R1973) [2]	1.362–1.372
Acidity (mg KOH/g)	ANSI Z11.131-1964 (R1974) [3] ANSI Z11.59-1958 (R1971) [4]	0.010, max
Moisture	–	35 ppm, max
Refractive index at 25°C	ASTM D 1817-66 (1972) [5]	1.6215–1.6235
Inorganic (free) chlorides	ANSI C59.55-1963 (R1973) [6]	0.05 ppm, max
Pour point	ANSI Z11.5-1966 (R1972) [7]	–14°C or lower
Dielectric constant (1000 Hz at 100°C)	ANSI C59.22-1967 (R1973) [8]	4.70–4.90
Resistivity (500 V dc at 100°C, 0.1-inch gap)	ANSI C59.51-1965 (R1973) [9]	500 X 10^9 Ω · cm, min
Hydrolysis stability test (as chlorides)	ANSI C59.106-1970 [10]	0.5 ppm, max
Thermal stability test (as chlorides)	ANSI C59.111-1970 [11]	0.4 ppm, max
Distillation range (corrected) 10% distilled by weight 90% distilled by weight	ANSI A37.9-1974 [12]	 323°C, min 356°C, max
Higher-Boiling Homologues	ASTM D 3303-74 [1]	0.4%, max
Sulfates	ANSI C59.2-1974 [13]	None
Dielectric strength at 25°C	ANSI C59.19-1968 (R1973) [14]	35 kV, min
Flash point, Cleveland open cup	ANSI Z11.6-1973 [15]	338°F, min
Fire point	–	None to boiling point
Corrosion test (6 hours at 210°C with bright aluminum foil), change in weight of aluminum	–	0.0%
Viscosity at 100°F (SUS)†	ANSI Z11.2-1956 (R1971) [16]	71–81
Specific heat at 25°C	–	0.30
Coefficient of expansion	ANSI C59.57-1963 (R1973) [17]	0.00068 $cm^3/cm^3/°C$
Fixed chlorine	Carius	41.3 ± 0.5%
Power factor at 100°C, 60 Hz Bulk Drums	Munch [18]	 1%, max 4%, max

NOTE: Numbers in brackets refer to correspondingly numbered test methods in 5.1, References to the Text.

*American Public Health Association.

†Saybolt Universal seconds.

3.2 Capacitor-Grade Askarel. In September 1971 a new grade of capacitor impregnant, Aroclor 1016, was made available to the industry. This new grade contains a typical concentration of 0.4% by weight of the higher-boiling homologues of the chlorinated biphenyls. (See ASTM D 3303-74 [1].)[3] Aroclor 1016 replaces Aroclor 1242, which previously was the major capacitor impregnant and contained around 7% of the higher-boiling homologues (the more persistent in nature). This 0.4% level of the higher-boiling homologues should be the maximum concentration acceptable in any capacitor impregnant. Aroclor 1242 and 1254, previously used as impregnants, do not meet this requirement and should no longer be used in capacitors designed and manufactured for alternating-current applications.

Aroclor 1016 has the same Underwriters' Laboratories, Inc, nonflammability rating as Aroclor 1242. Its typical properties are given in Table 1.

3.3 Plant HouseKeeping and Employee Safety. The procedures and limits given in 3.3 are intended to be minimum requirements to be met by manufacturers and users of capacitors containing askarel. Handling, control, and disposal procedures are given, together

[3] Numbers in brackets refer to corresponding numbers in 5.1, References to the Text.

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with exposure limits and indicated antidotes and clean-up procedures.

3.3.1 **Material.** Askarel for use in capacitors should consist of homologues and isomers of chlorinated biphenyl with the concentration of the higher-boiling homologues at about 0.4%. (See ASTM D 3303-74 [1].) Aroclor 1016 is considered to be the standard impregnant meeting these requirements.

Commonly used solvents include benzene, kerosene, acetone, trichloroethane, trichloroethylene, and perchloroethylene. Typical vapor pressure data for Aroclor 1016 are:

0°C =	0.001 mmHg
25°C =	0.006 mmHg
150°C =	4.3 mmHg
200°C =	29.0 mmHg

At 25°C and 760 mmHg pressure, saturated air contains approximately 0.09 mg/l.

NOTE:
1 mg/l = 90.0 ppm (v/v)
1 ppm (v/v) = 0.011 mg/l

3.3.2 **Bulk Fluid Shipment, Receiving, and Transfer.** Shipment of askarel from point of manufacture to point of receiving should be done in closed containers such as rail tank cars, truck tanks, marine or barge tanks, or sealed drums. Containers should be labeled as to contents and carry a label cautioning against loss of fluid to the open environment. Containers used to transport askarel should not be used for storage or to transport other material without being completely cleaned of all traces of askarel. (Cleaning procedures must take cognizance of precautions against excessive exposure and of the need for proper disposal of contaminated cleansing solvents and materials as set forth in 3.5). Transfer from shipping containers to processing systems should be through closed piping or tubing with appropriate valves, pumps, etc. Provision should be made for trapping and disposing of fluid lost by leakage or spills from the transfer system and from the storage containers.

Drums to be retired from use should be cleaned before crushing, delivery to scrap dealers, or other disposal. Contaminated cleaning fluids and materials should be disposed of as indicated in 3.5.

3.3.3 **General Safety Precautions.** Although it is generally accepted that exposure to capacitor-grade askarel is not hazardous provided that simple precautions are taken, exposure should still be avoided.

3.3.3.1 **Vapors.** The odor of askarel is noticeable well below the maximum air concentrations considered safe. Up to 1.0 milligram per cubic metre of air has been determined to be the maximum safe level of exposure during an 8-hour workday. (See reference [19].) The procedure for performing the necessary analyses is contained in Section B3 of Appendix B. This procedure or its equivalent should be used.

Breathing vapor or fumes from heated askarel should be avoided. Provisions should be made for adequate ventilation and regulation of manufacturing operations to avoid open exposure to askarel (especially at temperatures of 55°C or higher). The gases produced when askarel is decomposed by very high temperatures (such as that of an electric arc) in the presence of air or organic insulating materials contain a high percentage of hydrogen chloride, and small percentages of carbon dioxide, carbon monoxide, and oxygen. Minute concentrations of this combination of gases are very unpleasant and irritating, thus giving ample warning of their presence. If exposure to high concentrations of askarel is necessary under emergency conditions, an approved gas mask or self-contained breathing apparatus should be worn. Such exposure should be under the surveillance of other personnel capable of effecting rescue in case of an accident. If the odor of askarel is detected by the person wearing protective equipment, he should immediately go into fresh air. All gas masks, respirators, and replacement parts should have U.S. Bureau of Mines approval and be maintained on a regular schedule in accordance with the manufacturer's recommendation.

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

Operating procedures should be such as to minimize or eliminate contact with askarels. Use of eye protection is recommended. The use of porous gloves that can absorb and retain askarels is to be avoided. Barrier creams[4] or resistant gloves[5] should be used if contact is unavoidable. Use of enclosed transfer and handling equipment, processing equipment, and mechanical washers reduces direct contact.

Medicinal washes or mild detergents followed by the application of cold cream will reduce the irritation resulting from the contact of an open cut or abrasion with askarel.

Safety glasses with side shields or a face shield should be worn when handling askarels. If liquid aska-

[4] For example, PLY No. 9 Gel (Milburn Company, Detroit, Mich), or Kerodex No. 71 (Ayerst Laboratories, New York, N.Y.), or the equivalent.

[5] For example, Edmont – Solvit 5-352 (Mersick of Bridgeport, Bridgeport, Conn), or the equivalent.

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rel contacts the eyes, the eyes should be irrigated immediately with large quantities of running water for 15 minutes and then examined by a physician. (A drop of castor oil has been found to reduce irritation.)

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

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

3.3.4 Manufacturing Housekeeping. Manufacturing equipment and operating procedures should safeguard against loss of askarels to the environment through proper containment and disposal procedures.

Enclosed systems of sealed piping, properly gasketed joints, valves, containers, and processing chambers should be used for any portion of the operation where askarel temperatures may exceed 55°C. Enclosure should preferably extend to all other portions of the system insofar as practicable.

Containment provisions should be established around all askarel processing areas to ensure against inadvertent loss to sewer systems by spillage, leakage, or other uncontrolled conditions or events.

Spills of askarel should be removed promptly by means of absorptive material, such as sawdust, or trapped and removed by pumping or other suitable means.

Waste fluids containing askarel not suitable for reconditioning or reuse should be collected (by means of traps, drip pans, trays, etc) from the various parts of the manufacturing and processing area (including washers or other cleaning devices). Disposal should be made in accordance with 3.5.

Wiper rags, clothing, and other extraneous materials saturated with askarels should be collected within the containment area for properly controlled laundering or disposal (see 3.5).

3.3.5 Disposal of Askarel Wastes. Methods for disposal of liquids and saturated solids generated by the manufacturing operation should be in accordance with those outlined in 3.5, and should include (but not be limited to) the following wastes:

(1) Contaminated liquid askarel that is unsuitable for reclaiming as a dielectric fluid

(2) Liquid askarel from solvent operations or water and detergent type washers

(3) Saturated earth or other absorbent media from filtering operations

(4) Saturated sawdust or other absorptive materials from spills

(5) Saturated filters from vapor-control devices and other filters

(6) Saturated wastes (paper, rags, etc)

(7) Saturated, spent gasket materials

(8) Askarel-contaminated vacuum pump oils

(9) Askarel-contaminated stream jet vacuum system condensates

3.3.6 Miscellaneous Procedures. Other safety considerations include the following:

(1) Spills by leakage from finished capacitors should be cleaned up promptly by means of absorbent media, which should then be moved to containers provided for that purpose within the containment area, and later disposed of properly.

(2) Askarel wastes should never be disposed of down effluent drains or sewers. The utmost care must be exercised to prevent accidental loss by these avenues to the environment.

(3) Capacitors failing tests or otherwise designated for disposal must be controlled and handled in accordance with the intent of the procedures given in 3.3.6(1) and 3.3.6(2), finally being disposed of by one of the means outlined in 3.5.

3.4 Control of Water Effluents. The industry goal is to eliminate askarel in plant water effluent streams. However, it is recognized that existing drain systems in capacitor manufacturing plants are probably contaminated as a result of past practices, and askarel traces may continue to show up in effluent streams for some time. However, the level should continue to decrease with the proper containment of askarel wastes and no further discharges into drain systems. Other sections of this standard provide that no askarel wastes of any kind be disposed of in any water effluent streams and that accidental spills be prevented from getting into such streams.

3.4.1 Concentration Limits. The 1972 Environmental Protection Agency proposals are to keep PCB levels in rivers and lakes below 0.01 part per billion. This is currently under review by the EPA and standards are expected to be promulgated in 1974. Plant effluent streams should be managed and controlled in a manner anticipating these government standards.

3.4.2 Monitoring Streams. On a regular basis consistent with plant situations, all effluent streams should be analyzed. The procedure for performing the necessary analyses is contained in Section B4 of Appendix B. This procedure or its equivalent should be used.

3.4.3 Methods for Minimizing Effluent Stream Contamination. The ideal approach is to isolate totally all effluent streams that could be contaminated with askarels during manufacturing processes and prevent them from being discharged from the plant. Carbon adsorption, limestone beds, and solvent extraction are tech-

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niques that can be applied to reduce the askarel content of effluent streams. These techniques may be most useful in cleaning up water used in plant processing and to permit recycling.

3.5 Scrap-Disposal Procedures. The manufacture and use of capacitors involve processes that produce askarel-saturated solids and liquids containing or composed entirely of askarel, which should be disposed of as wastes. Specific sources of these materials are described throughout this standard. They may be placed into three categories:

(1) Capacitor units impregnated with askarel, production and field rejects

(2) Manufacturing process liquid wastes containing askarel

(3) Solid waste purposely or accidently saturated with askarel

Disposal should be done in a manner that is consistent with proper concern for the environment and minimizes any release of askarels to the environment.

3.5.1 Disposal of Capacitor Units. Scrap capacitor units can be generated during manufacturing processes or during field service.

Production rejects are those capacitors that are rejected after the impregnation process in the course of production by the capacitor manufacturer. They may be rejected for mechanical or electrical reasons, or because of obsolescence.

Field rejects are those units that are rejected or, for other reasons, are to be scrapped after shipment from the plant where they were manufactured.

3.5.1.1 Production Rejects. Rejected capacitors in capacitor manufacturing plants represent a concentration of askarel. It is important that their disposition be made in a manner consistent with proper concern for the environment. Therefore, capacitors should be disposed of only in supervised dry landfill sites that meet all applicable state requirements.

Care should be exercised to ensure that no loss of liquid will occur during transportation to the disposal site.

Incineration of scrap capacitors in facilities designed to accept such solids should provide an alternative means of disposal as such services become available in the future.

3.5.1.2 Field Rejects. Small capacitors (defined as containing less than 2 pounds of askarel) are practically always used as components in other electrical or electromechanical equipment. Typical examples of large quantity usage of such capacitors are in fluorescent lamp ballasts and residential air conditioning equipment. Failure of such capacitors may result in scrapping of the device of which it is a part (as in a fluorescent ballast) or replacement and scrapping of the individual capacitor (as in a room air conditioner). However, the majority of such capacitors do not fail in service, but are scrapped as a result of wearing out or obsolescence of the devices in which the capacitors are used as components. Thus, the matter of disposal is characterized by a low concentration of small quantities of askarel throughout the country and, indeed, throughout the world. Fortunately, the nature of the devices and equipment in which such capacitors are used is such that they are normally disposed of in dry landfills as a matter of convenience. Since it is impractical at present to exercise any meaningful control over the disposition of the bulk of such devices and equipment, it is imperative that askarel used for impregnating small capacitors be limited to the recently introduced type, which contains a typical concentration of 0.4% of the higher-boiling homologues. (See ASTM D 3303-74 [1].)

Large capacitors (those incorporating more than 2 pounds of askarel) should be disposed of according to the procedure for production rejects (see 3.5.1.1).

3.5.2 Disposal of Liquid Wastes. All waste askarel or liquid wastes containing askarel should be disposed of in accordance with one of the procedures given in 3.5.2.1 through 3.5.2.3.

3.5.2.1 Incineration. Present knowledge indicates that proper incineration must involve a suitable balance between dwell time and temperature in the incinerator plus oxygen availability and, finally, suitable scrubbers to remove the HCl that will be formed; for example, 2-second dwell time at 2000°F and 3% excess oxygen in stack gas, or 1.5-second dwell time at 2700°F and 2% excess oxygen in stack gas.

These facilities should meet the applicable requirements of the state in which they are located, and should control effluents within the limits set forth in this standard.

3.5.2.2 Toxic and Hazardous Waste Disposal Sites. Certain landfill sites have been classified by state governments and the federal government as suitable for the disposal of toxic and hazardous liquids. Where such approved sites exist, they may be used for the disposal of liquid wastes described in this standard. (See Appendix A.)

3.5.2.3 Packaging and Shipment

3.5.2.3.1 Transportation to the disposal facility should be in containers that will prevent leakage and accidental loss of askarel to the environment.

3.5.2.3.2 Containers should be labeled as to contents and precautions relative to loss to the environment.

3.5.2.3.3 Containers used for this purpose should not be used for any such materials or retired from service until they are completely cleaned. Any

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solvents used in cleaning these containers will be contaminated with askarel and should be disposed of according to the same procedures described in 3.5.2.

3.5.3 **Disposal of Solid Wastes.** (See 3.5.1 for scrap capacitors.) All solid wastes that have been saturated with askarel should be disposed of by the following procedure:

(1) The saturated wastes should be placed into leakproof containers and transported to a supervised dry landfill site meeting state requirements. Alternatively, they can be disposed of by incineration in state-approved facilities.

(2) Solid absorbents used for spills can be disposed of uncontained in the supervised dry landfill site; transport to the site should be in closed containers. Alternatively, incineration can be used in accordance with 3.5.2. (See Appendix A for a listing of facilities.)

3.6 **Labeling.** Capacitor units vary greatly in size and in end use or application. Small capacitor units are frequently applied as a component of another piece of equipment, such as a fluorescent lighting ballast, a roadway or area lighting luminaire, a motor, etc. In such applications a label on the capacitor unit referencing approved disposal procedure would not normally be visible when the piece of equipment is disposed of.

For the foregoing reasons the methods of providing disposal instructions for small capacitors and large capacitors are treated separately in 3.6.1 and 3.6.2, respectively.

3.6.1 **Small Units.** Small capacitors are defined as those that contain askarel in quantities up to about 2 pounds each and in which the free liquid does not exceed 0.4 pound. They are hermetically sealed in metallic cases. Such capacitors are applied as a component of a large piece of equipment. Attaching a label to such equipment referencing this standard or describing disposal procedures would be of limited practical value.

3.6.2 **Large Units.** Large capacitor units are defined as those that contain more than 2 pounds of askarel. The capacitor manufacturer should affix a label in a conspicuous place, referencing this standard or describing disposal procedures consistent with it. This label should contain, as a minimum, the following information:

CAUTION: This capacitor contains a polychlorinated biphenyl (PCB). To avoid possible environmental contamination, it should be disposed of only in supervised dry landfill areas meeting state requirements or in incineration facilities designed for disposal of PCBs. See American National Standard C107.1-1974 for further information. Copies are available from American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

4. Transformer Guidelines

4.1 General

4.1.1 **Types of Transformer Askarels.**[6] Askarels of various compositional types are currently in use (for the general properties and types, see ASTM D 2283-73a [20]). Under arcing conditions, the gases produced, though predominantly consisting of noncombustible hydrogen chloride, can contain varying amounts of combustible gases depending upon the askarel type.

4.1.2 **Safety Precautions.** Based on about 40 years of safe industrial usage, askarels have been considered as relatively harmless materials to humans. There has been no known instance of human injury when askarels are used under the normally prescribed conditions of precaution and handling.

Although it has been generally thought that exposure to askarels is not hazardous provided that simple precautions are taken, exposure should still be avoided or minimized.

4.1.2.1 **Vapors.** The odor of askarel is noticeable well below the maximum safe air concentrations. Depending upon the composition of the askarel used, from 0.5 to 1.0 milligram per cubic metre of air has been determined to be the upper safe level of exposure during an 8-hour workday. (See reference [19].) The procedure for performing the necessary analyses is contained in Section B3 of Appendix B. This procedure or its equivalent should be used.

Breathing vapor or fumes from heated askarels should be avoided. High concentrations of vapors can cause irritation of the eyes, nose, throat, and upper respiratory tract. Provisions shall be made for adequate ventilation and regulation of manufacturing operations to avoid open exposure of hot askarels (55°C or higher). The gases produced when askarel is decomposed by very high temperatures (such as that of an electric arc) in the presence of air or organic insulating materials contain a high percentage of hydrogen chloride, and small percentages of other gases. Minute concentrations of this combination of gases are very unpleasant and irritating, thus giving ample warning of their presence. If exposure to high concentrations of askarels or its arced products is necessary under emergency conditions, an approved gas mask of the organic canister type, or self-contained breathing apparatus, must be worn. Such exposure should be under the surveillance of other personnel capable of effecting rescue in case of accident. If the odor of askarel or its arced products is detected

[6] The following trademarks are among those employed by electrical manufacturers to designate the askarels used in their products: Asbestol, Chlorextol, Inerteen, No-Flamol, Pyranol, and Saf-T-Kuhl.

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by the person wearing protective equipment, he should immediately go into fresh air. All gas masks, respirators, and replacement parts should have U.S. Bureau of Mines approval and be maintained on a regular schedule in accordance with the manufacturer's recommendation.

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

Operating procedures should require avoidance of contact with any askarels. The use of porous gloves that can absorb and retain askarels is to be avoided. Resistant gloves and aprons of the neoprene, polyethylene, or fluoroelastomer[3] type should be used if contact is unavoidable. In case of spillage on the clothing, the clothing should be removed as soon as practical, the skin washed, and the clothing laundered.

Medicinal washes or mild detergents followed by the application of cold cream will reduce the irritation resulting from the contact of an open cut or abrasion with askarel.

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

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

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

4.1.3 Transport Container Marking. Any container, such as tank cars, tank trucks, drums, cans, etc, used to transport transformer askarels, new or used, should be labeled with the following:

CAUTION: This product contains polychlorinated biphenyls (PCBs). Care should be taken to prevent entry into the environment through spills, leakage, use, vaporization, or disposal of liquid or containers. Avoid prolonged breathing of vapors or mists. Avoid contact with eyes or prolonged contact with skin. If skin contact occurs, remove by washing with soap and water. Following eye contact, flush with water. In case of spillage onto clothing, the clothing should be removed as soon as practical, skin washed, and clothing laundered.

4.1.4 Receiving, Handling, and Storage of Askarels. Askarels are shipped in tank cars, tank trucks, steel drums, metal cans, and test-sample containers. When received, all containers should be inspected for leaks.

4.1.4.1 Storage Tanks. Storage tanks should be erected so that inspection can be made for leaks or spills. Construction should be such that inadvertent leakage or spills are prevented from reaching streams and sanitary or storm sewers.

4.1.4.2 Tank Cars and Tank Trucks. All bulk shipment equipment should be inspected for leaks immediately upon receipt. Drain pans must be provided to prevent spillage from unloading hoses and connections. Askarel liquid collected in drain pans should be placed in drums labeled "SCRAP ASKAREL" for disposition.

4.1.4.3 Steel Drums, Cans, and Test-Sample Containers. On delivery, all such shipments should be carefully inspected for leaks. The containers should be stored indoors in an area especially selected for this purpose. A curb should enclose the area to provide a basin for containing the askarel from one or more containers should the containers be damaged. The area must not have a drain that is connected to a sanitary or storm sewer.

If an indoor storage area is not possible, the containers should be stored under a lean-to.

4.1.5 Control of Water Effluents. The industry goal is to eliminate askarel in plant water effluent streams. However, it is recognized that existing drain systems from manufacturing plants, repair shops, and installation sites may be contaminated as a result of past practices. Other sections of this standard provide that no askarel wastes of any kind be disposed of in any water effluent streams and that accidental spills be prevented from getting into such streams.

4.1.5.1 Concentration Limits. The 1972 Environmental Protection Agency proposals are to keep PCB levels in rivers and lakes below 0.01 part per billion. This is currently under review by the EPA and standards are expected to be promulgated in 1974. Plant effluent streams should be managed and controlled in a manner anticipating these government standards.

4.1.5.2 Monitoring Streams. All plant effluent streams should be monitored on a regular basis, consistent with plant situations. The procedure for performing the necessary analyses is contained in Section B4 of Appendix B. This procedure or its equivalent should be used.

[3] For example, Viton.

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4.1.5.3 Methods for Minimizing Effluent Stream Contamination. The ideal approach is to isolate totally all effluent streams that could be contaminated with askarels during manufacturing processes and prevent them from being discharged from the plant.

4.1.6 Disposal Procedures and Services

4.1.6.1 Sources of Materials Requiring Special Handling and Disposal Procedures. Liquids containing PCBs and solids containing or contaminated with PCBs may be obtained from any of the following sources: transport containers, transformer manufacturing processes, in-test failures, liquids contaminated beyond reclamation, in-service transformer leaks and failures; askarel-filled transformers scrapped for any reason, etc.

4.1.6.2 Classification for Disposal of Materials Containing PCBs. In general, there are three types of materials requiring disposal: liquids, burnable solid materials containing PCBs, and nonburnable solid materials contaminated with PCBs.

4.1.6.2.1 Liquids. Liquids containing PCBs requiring disposal by high-temperature incineration may consist of the following:

(1) PCBs contaminated with mineral oil.

(2) Mineral oil contaminated with PCBs.

(3) Nonreclaimable contaminated transformer askarels, arced askarels, askarels from manufacturing spills, and sump accumulation, etc, rich in PCBs, and askarels from holding basins, drip and drain pans, washings, sample jars and containers, etc.

4.1.6.2.2 Burnable Solid Waste Materials Containing PCBs. These materials can be disposed of by high-temperature incineration and consist of cellulosic materials, rags, pressboard, wood, sawdust, fuller's earth in bulk or in cloth bags, blotter papers, nitrile or cork gaskets, etc.

4.1.6.2.3 Nonburnable Solid Waste Materials Containing, or Contaminated with, PCBs. These materials may consist of coil structures, steel, copper, aluminum filter units of the steel mesh construction type, askarel drums, cans, etc.

Materials of this nature should be allowed to drain with the liquid collected in drip pans, etc. Further removal of adhering PCBs can be accomplished by washing or solvent extraction with kerosene or other approved washing liquids such as perchloroethylene or tricholoroethylene. Accumulated liquids can be disposed of as indicated in 4.1.6.2.1. Solid materials may be handled as normal scrap.

4.1.6.3 Shipment of Scrap Liquids for Disposal. All liquid scrap material should be placed in appropriate metal transport drums, properly labeled, for shipment to a company offering an acceptable disposal service.

4.1.6.4 Shipment of Burnable Solid Waste Material Containing PCBs for Disposal. Material of this type should be placed in open-head drums with suitable closures and with the drum properly labeled for shipment to a company offering an acceptable disposal service.

4.1.6.5 Liquid and Solid Waste Disposal Service Organizations

4.1.6.5.1 General. Disposal of askarels and askarel-soaked materials should be accomplished by means in which there is no significant release of askarel to the environment. At present, disposal is accomplished by carefully controlled incineration of liquids and soaked software, and by controlled landfill burial of apparatus and other hardware from which askarel has been previously drained and washed.

Present knowledge indicates that proper incineration must involve a suitable balance between dwell time and temperature in the incineration plus oxygen availability and, finally, suitable scrubbers to remove the HCl that will be formed; for example, 2-second dwell time at 2000°F and 3% excess oxygen in stack gas, or 1.5-second dwell time at 2700°F and 2% oxygen in stack gas.

These facilities should meet the applicable requirements of the state in which they are located and should control effluents within the limits set forth in this standard.

Controlled landfill or deep-well disposal can be used where permitted by federal, state, and local regulations.

4.1.6.5.2 Costs. In addition to the normal costs of collecting scrap liquids and solids for disposal, additional costs borne by the owner of such scrap include shipping containers, cost of transport to the disposal service organization, and a disposal fee usually based upon a per-gallon or per-pound charge.

4.1.6.5.3 Disposal Services. Organizations offering disposal services are listed in Appendix A, including their location, facilities available, types of material handled, and disposal procedures used. Specific shipping directions, disposal procedures, and costs should be obtained from the organization.

4.2 Specific Guidelines

4.2.1 Plant Housekeeping. It is necessary to assume that in filling equipment with askarel, and during further handling of this equipment, an askarel spill may occur. Therefore, it is necessary to provide facilities and a procedure for cleanup to prevent contamination.

4.2.1.1 Askarel Filling Area

4.2.1.1.1 The location of the askarel filling area should be adjacent to the test area and final shipping area to minimize the danger of damage of units during handling.

4.2.1.1.2 The main manufacturing area for filling equipment with askarel should be provided with impervious surface floors or suitable basins so con-

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structed that any inadvertent leakage or spills are prevented from reaching streams, sanitary sewers, or storm sewers. All askarel-handling equipment, such as pumps, hoses, etc, shall be of the askarel-resistant type.

4.2.1.1.3 *Drip* pans shall be provided for hose connections and filling valves.

4.2.1.2 **Special Containers for Scrap Materials**

4.2.1.2.1 Drums labeled "SCRAP ASKAREL" should be available for handling all spilled and waste askarel from sumps, failed units, drip pans, sample jars, etc.

4.2.1.2.2 Open-head drums with suitable closures and labeled "SCRAP BURNABLE ASKAREL WASTE" should be available for handling contaminated cellulose insulation, rags, paper pressboard, wood, gaskets, sawdust, etc.

4.2.1.2.3 Separate containers for handling steel, copper, and aluminum, each adequately marked, shall be provided for the components of contaminated core and coil assemblies. These containers are required for the various materials when repairing or scrapping assemblies.

4.2.1.2.4 Containers for supplies of material for absorbing small askarel spills or cleanup of larger spills should be provided.

4.2.1.3 **Conditioning of Askarels**

4.2.1.3.1 **Askarel Conditioning Equipment.** The conditioning unit should be located either in the storage tank area or in the main transformer manufacturing area for filling with askarel.

4.2.1.3.2 **Fuller's Earth.** Conditioning of new askarel or recycled askarel requires fuller's earth treatment. The spent fuller's earth in cartridges or bags, when replaced, should be allowed to drain thoroughly over drip pans to remove as much liquid askarel as possible. The cartridge units of steel mesh construction should be placed in the "STEEL CONTAMINATED WITH ASKAREL" container for disposition. Cloth bags filled with fuller's earth should be placed in the "SCRAP BURNABLE ASKAREL WASTE" container for disposition.

4.2.1.4 **Teardown of Units for Repair or Scrap**

4.2.1.4.1 Drain all askarel from the unit either into a holding tank for reuse or into the drum labeled "SCRAP ASKAREL" for disposition, and then allow sufficient time for all of the askarel to drain from the core and coils.

4.2.1.4.2 Remove the core and coil assembly from the transformer. Sufficient absorbent material should be placed on the floor to absorb any askarel fluid that still drips from the transformer.

4.2.1.4.3 Place all materials in the appropriate salvage containers during the dismantling for later disposition.

4.2.1.4.4 All used materials, including rags, sawdust, tape, etc, regardless of quantity, shall be put into the appropriate containers for disposition.

4.2.2 **Transformer Labeling**

4.2.2.1 **New Transformers.** All new transformers that contain PCBs shall have a label of adequate durability, permanently and prominently attached to the tank by the manufacturer, giving adequate warning and instructions. A suggested label includes the following:

CAUTION: The insulating liquid in this transformer contains polychlorinated biphenyls (PCBs). Care should be taken to prevent entry into the environment. In case of malfunction or leaks, consult the instruction manual or the manufacturer.

4.2.2.2 **In-Service Transformers.** The transformer manufacturer should make available suitable labels with a similar warning as shown in 4.2.2.1 for use on existing transformers.

4.2.3 **Information for Transformer Users**

4.2.3.1 **General.** Askarel-filled transformers are delivered to customers as sealed units from which there is no escape of askarel under normal operation. Although certain types of equipment failures can permit loss of some askarel to the environment, such cases are extremely rare.

4.2.3.2 **Transportation and Receiving.** Immediately upon receipt of the equipment and following any transportation or handling accident that could affect the integrity of the tank, bushings, or radiators, the transportation vehicle, tank, and fittings should be examined for any leakage or spillage that may have occurred in shipping. If leakage is evident, the cause should be corrected and the spillage soaked up with absorbent materials such as sawdust, followed by a cleanup of the affected area with rags soaked with kerosene or other approved solvent such as perchloroethylene or trichloroethylene. All materials used should be collected for proper disposition as described in 4.1.6.

4.2.3.3 **Installation and Periodic Inspection.** Following installation, the unit should again be inspected for any damage or leakage. It is recommended that periodic in-service inspections be made for any leaks.

4.2.3.4 **Filling, Filtering, or Drying Askarel.** Most askarel units are shipped with the proper amount of askarel, but if it becomes necessary to top off a unit, the manufacturer's instructions should be followed.

If it is necessary to dry an askarel unit or to treat an askarel unit with fuller's earth, instructions should be followed. When filtering or conditioning askarel, all of the precautions previously described for drip pans, proper disposal of filter media, etc, apply.

4.2.3.5 **Sampling.** It is common practice to sample askarel from a transformer for periodic maintenance testing. As previously described, such samples should be

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taken in a manner to avoid any contamination of the environment. Washings should be collected for proper disposal. Field and laboratory test samples, washings, etc, should also be collected for proper disposal.

4.2.3.6 Transformer Disposal. The ultimate disposal of an askarel-filled transformer may be accomplished in either of two ways:

(1) Complete drainage and dismantling with the proper disposal of the askarel and askarel-soaked components as described in 4.1.6.

(2) Disposition of askarel transformers by means of junk or scrap dealers. This should be avoided unless a transformer is first drained, followed by soaking the interior with a suitable solvent. Accumulated liquids and washings are to be disposed of as described in 4.1.6.

5. References

5.1 References to the Text

[1] Standard Method of Test for Rapid Gas Chromatographic Estimation of Higher Boiling Homologues of Chlorinated Biphenyls for Capacitor Askarels, ASTM D 3303-74

[2] American National Standard Method of Test for Specific Gravity of Askarels, C59.68-1965 (R1973) (ASTM D 1810-63 (1973))

[3] American National Standard Method of Test for Neutralization Number by Color-Indicator Titration, Z11.131-1964 (R1974) (ASTM D 974-64 (1973), IP 139/65)

[4] American National Standard Method of Test for Neutralization Number by Potentiometric Titration, Z11.59-1958 (R1971) (ASTM D 664-58 (1968), IP 177/64)

[5] Standard Method of Test for Density of Rubber Chemicals, ASTM D 1817-66 (1972)

[6] American National Standard Method of Test for Inorganic Chlorides in Askarels, C59.55-1963 (R1973) (ASTM D 1821-63 (1973))

[7] American National Standard Method of Test for Pour Point of Petroleum Oils, Z11.5-1966 (R1972) (ASTM D 97-66 (1971), IP 15/67)

[8] American National Standard Method of Test for Power Factor and Dielectric Constant of Electrical Insulating Liquids, C59.22-1967 (R1973) (ASTM D 924-65 (1973))

[9] American National Standard Method of Test for Specific Resistance (Resistivity) of Electrical Insulating Liquids, C59.51-1965 (R1973) (ASTM D 1169-64 (1973))

[10] American National Standard Method of Test for Hydrolyzable Chlorine Compounds in Chlorinated Aromatic Hydrocarbons (Askarels), C59.106-1970 (ASTM D 1820-65 (1971))

[11] American National Standard Method of Test for Thermal Stability of Chlorinated Aromatic Hydrocarbons (Askarels), C59.111-1970 (ASTM D 1936-64 (1971))

[12] American National Standard Method of Test for Distillation of Road Tars, A37.9-1974 (ASTM D20-72)

[13] American National Standard Methods of Testing Electrical Insulating Oils, C59.2-1974 (ASTM D.117-71 (1973))

[14] American National Standard Method of Test for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes, C59.19-1968 (R1973) (ASTM D 877-67 (1971))

[15] American National Standard Method of Test for Flash and Fire Points by Cleveland Open Cup, Z11.6-1973 (ASTM D 92-72, IP 36/67)

[16] American National Standard Method of Test for Saybolt Viscosity, Z11.2-1956 (R1971) (ASTM D 88-56 (1973))

[17] American National Standard Method of Test for Coefficient of Thermal Expansion of Electrical Insulating Liquids of Petroleum Origin, and Askarels, C59.57-1963 (R1973) (ASTM D 1903-63 (1973))

[18] MUNCH, R. H. Measuring the dissipation factor, dielectric constant, and resistivity of liquids. *Insulation/Circuits*, vol 16, Mar 1970, pp 46–49.

[19] Chlorodiphenyls. *Hygienic Guide Series*. Westmont, N.J.: American Industrial Hygiene Association, Jan–Feb 1965.

[20] Standard Specification for Chlorinated Aromatic Hydrocarbons (Askarels) for Transformers, ASTM D 2283-73a

5.2 General References

Aroclor® Polychlorinated Polyphenyls (Biphenyls). Technical Bulletin O-FF/1R. St. Louis: Monsanto Industrial Chemicals Company, Nov 1971.

DRINKER, C. K. Further observations on the possible systemic toxicity of certain of the chlorinated hydrocarbons. *Journal of Industrial Hygiene and Toxicology*, vol 21, 1939, pp 155–159.

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DRINKER, C. K.; WARREN, M. F.; and BENNET, G. A. The problem of possible systemic effects from certain chlorinated hydrocarbons. *Journal of Industrial Hygiene and Toxicology*, vol 19, 1937, pp 283–311.

ELKINS, H. B. *The Chemistry of Industrial Toxicology*. New York: John Wiley & Sons, Inc, 1959.

GREENBURG, L.; MAYERS, M. R.; and SMITH, A. R. The systemic effects resulting from exposure to certain chlorinated hydrocarbons. *Journal of Industrial Hygiene and Toxicology*, vol 21, 1939, pp 29–38.

Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment. Cincinnati: American Conference of Governmental Industrial Hygienists, 1973.

TREON, J. F.; CLEVELAND, F. P.; CAPPEL, J.; and ATCHLEY, R. W. The toxicity of the vapors of Aroclor 1242 and Aroclor 1254. *American Industrial Hygiene Association Quarterly*, vol 17, 1956, pp 204–213.

6. Revision of American National Standards Referred to in This Document

When the American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply.

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Appendixes

(These Appendixes are not a part of American National Standard Guidelines for Handling and Disposal of Capacitor- and Transformer-Grade Askarels Containing Polychlorinated Biphenyls, C107.1-1974, but are included for information purposes only.)

Appendix A

Disposal Services

In addition to the supervised dry landfill sites that may be used for the disposal of askarel-containing scrap, the following additional known facilities and services have been established, and others may be available:[a]

Chem-Trol Pollution Services, Inc
P.O. Box 200
1550 Balmer Road
Model City, N.Y. 14107
Phone: 716 754-8231

This organization has facilities and services capable of handling:

(1) Liquids. Askarels alone or mixed with solvents or oils. Disposal by high-temperature incineration.

(2) Solids (software). Askarel-soaked compounds, rags cartons, absorbing earths, etc. Disposal by incineration or scientific landfill.

(3) Solids (hardware). Capacitors, transformer tanks, cores, askarel-soaked metals. Disposal by scientific landfill. Has solvent extraction capability.

Monsanto Company
800 North Lindbergh Boulevard
St. Louis, Mo 63166
Phone: 314 694-3352

This organization has facilities and services capable of handling askarel liquids alone or mixed with other oils or solvents by high-temperature incineration. Liquid is pumped through a gun with atomizing steam into incinerator. Temperatures are maintained at 2000°F-2500°F with auxiliary natural gas. Exit gases are quenched to 180°F by contact with water. Gas is then passed through a high-energy venturi scrubber for removal of particulates. Before exhausting to air (110°F), gases are passed through a packed column scrubber to remove HCl.

Nuclear Engineering Company
Eastern Division
P.O. Box 146
Morehead, Ky 40351
Phone: 606 784-6611

Nuclear Engineering Company
Disposal Division
Sheffield, Ill. 61361
Phone: 815 454-2624

This organization provides containerization, transportation, and disposal services of all liquids and solids (including hardware). Disposal is in controlled chemical and scientific landfill area. Licensed by Atomic Energy Commission for radioactive waste disposal. The organization also has two West Coast locations, in the states of California and Washington.

Rollins Environmental Services, Inc
P.O. Box 2349
Wilmington, Del 19899
Phone: 302 658-8451

This organization has facilities and services capable of handling:

(1) Liquids. Askarel alone or mixed with solvents or oils. Disposal is by high-temperature incineration.

(2) Solids (software). Askarel-soaked compounds, rags, cartons, absorbing earths, etc. Disposal is by incineration at combustion temperatures up to 2500°F. Incineration gases are scrubbed, and entrained solids are removed before exhausting to air.

Rollins Environmental Services maintains disposal facilities in the following areas:

Philadelphia/Camden:
Rollins Environmental Services, Inc
Route 322
Logan Township
Bridgeport, N.J. 08014

[a] The listing given herein is representative of some of the sources that provide this service, and is not presumed to be complete. Any other organizations that wish to be listed should notify the Standards Institute so that they may be included in the next edition of this standard.

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Baton Rouge:
Rollins Environmental Services, Inc
Scenic Highway & West Cheatham Lane
Scotlandville
East Baton Rouge Parish, La 70807

Houston:
Rollins Environmental Services, Inc
Tidal Road & Highway 134
Deer Park, Tex 77536

Appendix B

Analytical Procedures and Laboratory Service Organizations

B1. General

Analytical procedures for determining PCBs in air, water, and sediments are given in Sections B3 and B4.

B2. Laboratories

The following laboratories are representative of those offering services for PCB analyses:*

Carus Chemical Corporation
1375 Eighth Street
La Salle, Ill. 61301
Phone: 815 223-1500

Limnetics, Inc. (Subsidiary of Carus Corporation)
6132 West Fond du Lac Avenue
Milwaukee, Wis 53218
Phone: 414 461-9500

Gollob Analytical Service Corporation
47 Industrial Road
Berkeley Heights, N.J. 07922
Phone: 201 464-3331

B3. An Analytical Procedure for the Determination of Airborne PCBs

B3.1 Scope. This procedure is based on techniques used by the Monsanto Industrial Chemical Company for the isolation and determination of PCBs in water, soil/sediment, and biological materials. Absolute confirmation of PCB structures is not obtained with this method. Where needed, additional structure proof should be obtained using techniques such as mass spectrometry for further identification of gas chromatography fractions.

B3.2 Principle. Airborne PCBs are absorbed in toluene by drawing the air through one or more fritted bubblers or impingers in cylinders filled with toluene. After a suitable amount of air is sampled, the scrubbing solvent is diluted or concentrated, and interfering components, if present, are removed by chemical treatment and column absorption chromatography. The amount and type of PCBs present are determined by electron capture gas chromatography (EC/GC).

B3.3 Reagents

(1) Hexane: Pesticide grade.

(2) Toluene: Pesticide grade.

(3) Sodium sulfate: Anhydrous, granular, analytical reagent (AR) grade. Heat at 400°C for 1 hour prior to use.

(4) Alumina adsorption: For chromatographic analysis, 80/200 mesh. Heat at 400°C for a minimum period of 4 hours and deactivate with 5% (w/w) distilled water.

For alumina column preparation fill a chromatographic column with hexane up to the point where the reservoir joins the column, and push a glass wool plug to the bottom with a glass rod. In a 50-ml beaker measure 35 ml (about 30 grams) of deactivated alumina, and pour this slowly into the column. Tap or vibrate the column to settle the alumina, and top the alumina with 2 to 3 cm of anhydrous sodium sulfate. Wash the column with 50 to 100 ml of hexane prior to the addition of the sample.

(5) Distilled water: Extracted with hexane to re-

*The listing given herein is representative of some of the sources that provide this service, and is not presumed to be complete. Any other organizations that wish to be listed should notify the Standards Institute so that they may be included in the next edition of this standard.

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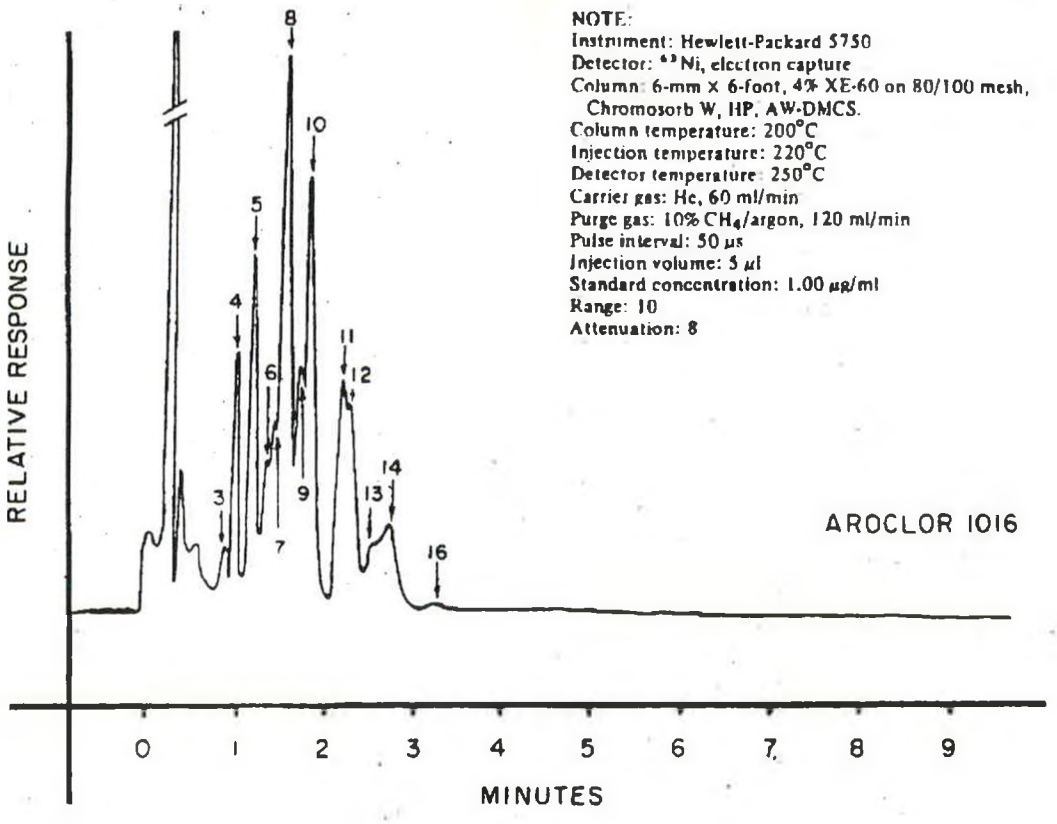


Fig. B1
Aroclor 1016 Electron Capture Chromatogram

move hexane-soluble electron capturing impurities.

(6) Sulfuric acid: AR grade, specific gravity = 1.84.

(7) Potassium hydroxide: AR grade.

(8) Ethanol: Formula 2B.

(9) Alcoholic potassium hydroxide, 2.5% (w/v): Dissolve about 12.5 grams of AR grade KOH in 500 ml of ethanol.

(10) Sulfuric acid-water, 9:1 (v/v): Carefully add 270 ml of AR grade sulfuric acid to 30 ml of distilled water in a 500-ml iced beaker.

(11) PCB standards: Aroclor 1016, 1221, 1242, 1248, 1254, and 1260. (See Fig. B1 through B7.)

B3.4 Apparatus

(1) Gas scrubbing bottles, high form, ground-glass joint, fritted coarse disks.

(2) Separatory funnels equipped with ground-glass stoppers and TFE-fluorocarbon stopcocks; capacities of 125, 250, 500, 1000, and 2000 ml.

(3) Kunderna-Danish evaporative concentrators, 500-ml capacity, equipped with three-ball Snyder columns and graduated 5-ml capacity vials.

(4) Chromatographic columns, glass, 10 inches X 20 mm (OD), with a 5-inch X 50-mm (OD) reservoir at the top, equipped with TFE-fluorocarbon stopcocks.

(5) Flat-bottomed boiling flasks, 125 ml capacity.

(6) Liebig condenser, 200 mm in length.

(7) Hot plates.

(8) Water bath.

(9) 10-μl syringes.

(10) Dry-test meter or wet-test gas meter.

(11) Laboratory vacuum pump.

(12) Rotating vacuum evaporator.

(13) Usual laboratory glassware.

B3.5 Sampling. The air to be sampled for airborne PCBs is drawn through a gas scrubber (or scrubbers) and a dry-test meter using a laboratory vacuum pump. See Fig. B8. The sampling flow rate is controlled by bleeding in air via a needle valve located between the

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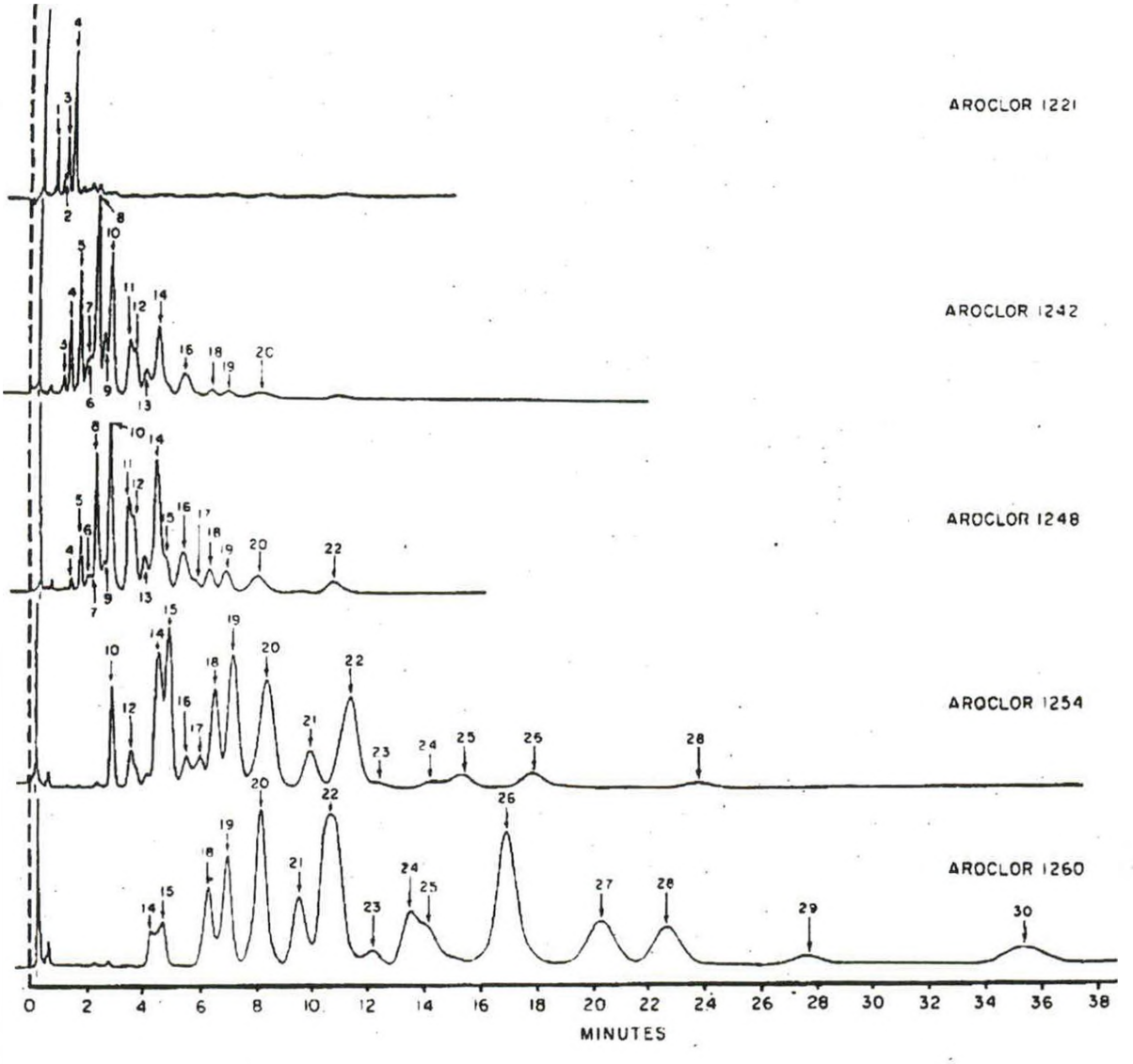


Fig. B2
Comparison of Electron Capture Chromatograms for Aroclor 1221, 1242, 1248, 1254, and 1260

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NOTE:
Instrument: Hewlett-Packard 5750
Detector: ^{63}Ni electron capture
Column: 6-mm × 6-foot, 4% XE-60 on 80/100 mesh, Chromosorb W, HP, AW-DMCS
Column temperature: 170°C
Injection temperature: 220°C
Detector temperature: 250°C
Carrier gas: He, 60 ml/min
Purge gas: 10% CH_4/argon, 120 ml/min
Pulse interval: 50 μs
Injection volume: 5 μl
Standard concentration: 1.48 μg/ml
Range: 10
Attenuation: 4

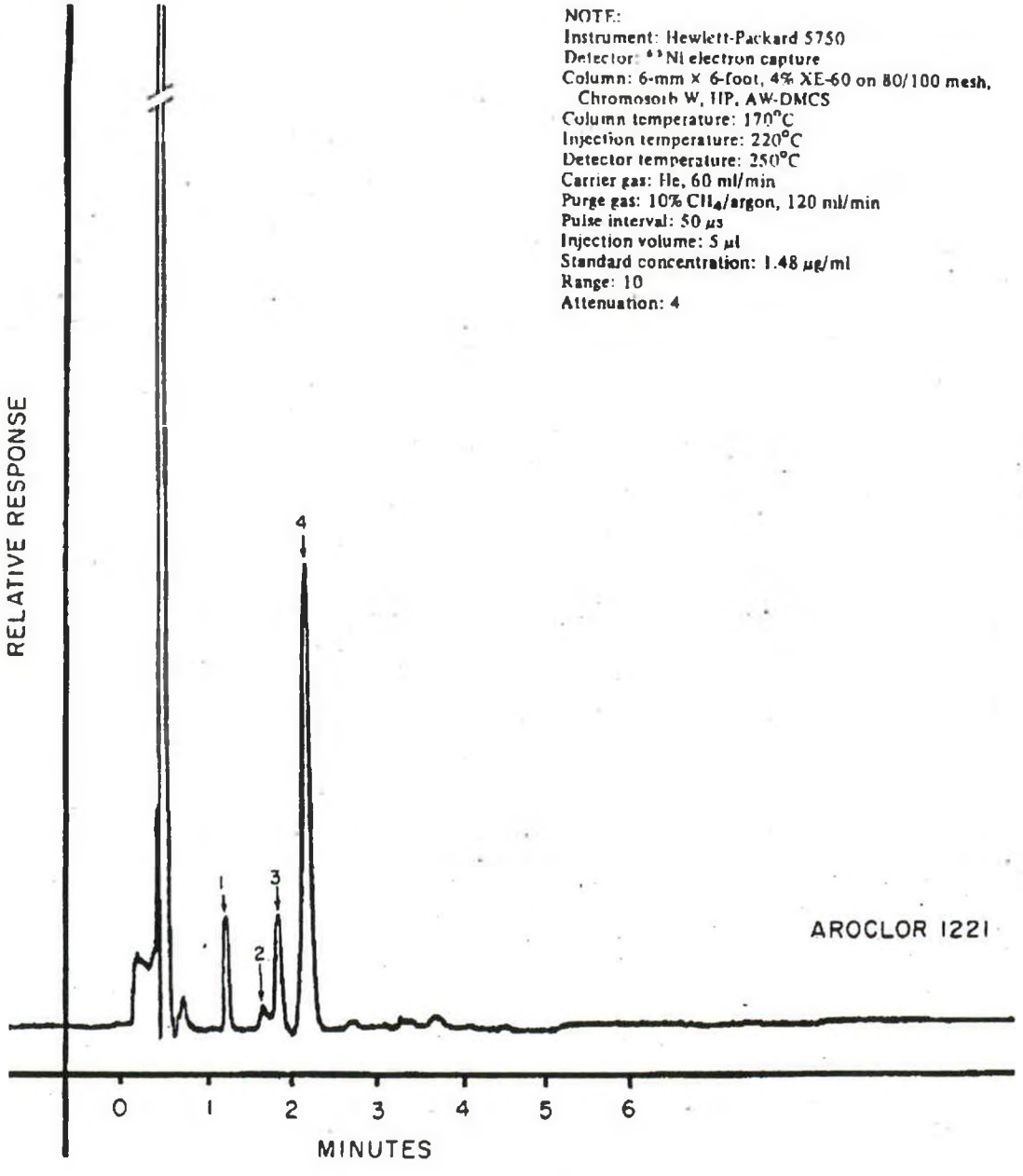


Fig. B3
Aroclor 1221 Electron Capture Chromatogram

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NOTE:
Instrument: Hewlett-Packard 5750
Detector: ^{63}Ni electron capture
Column: 6-mm x 6-foot, 4% XE-60 on 80/100 mesh, Chromosorb W, HP, AW-DMCS
Column temperature: 190°C
Injection temperature: 220°C
Detector temperature: 250°C
Carrier gas: He, 60 ml/min
Purge gas: 10% CH_4/argon, 120 ml/min
Pulse interval: 50 μs
Injection volume: 5 μl
Standard concentration: 1.03 μg/ml
Range: 10
Attenuation: 8

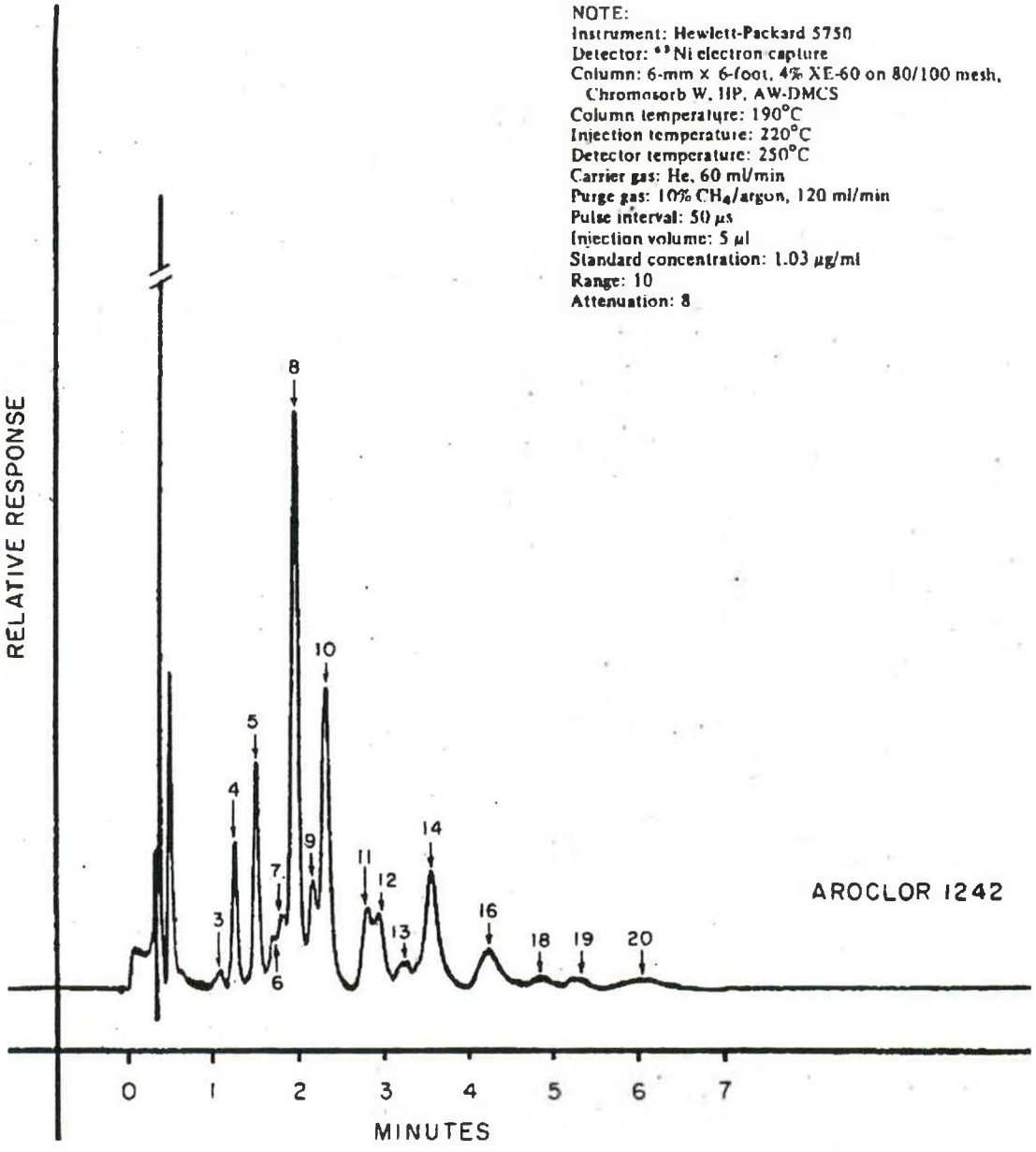


Fig. B4
Aroclor 1242 Electron Capture Chromatogram

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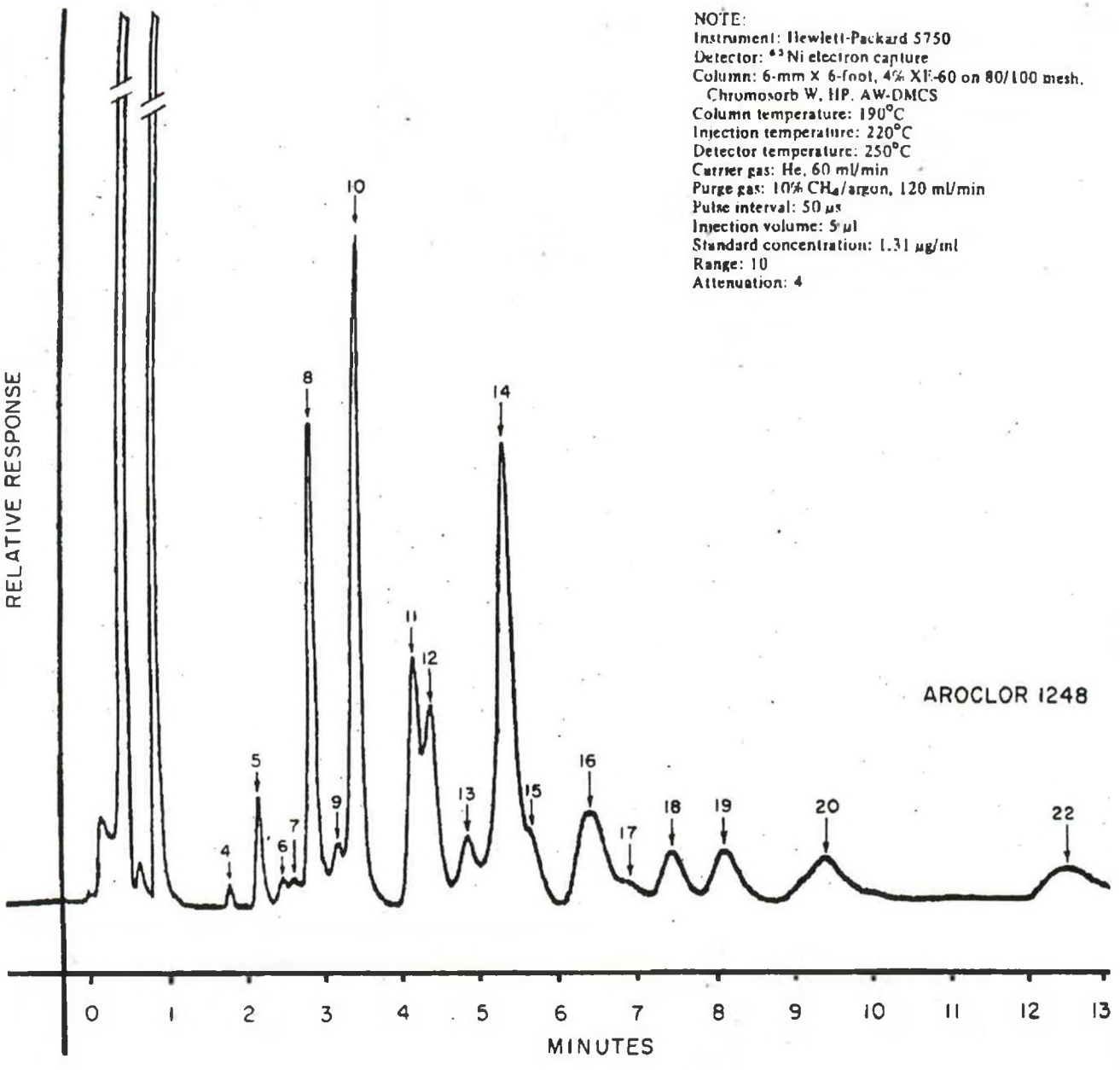


Fig. B5
Aroclor 1248 Electron Capture Chromatogram

NOTE:
Instrument: Hewlett-Packard 5750
Detector: ^{63}Ni electron capture
Column: 6-mm × 6-foot, 4% XE-60 on 80/100 mesh, Chromosorb W, HP, AW-DMCS
Column temperature: 205°C
Injection temperature: 220°C
Detector temperature: 250°C
Carrier gas: He, 60 ml/min
Purge gas: 10% CH_4/argon, 120 ml/min
Pulse interval: 50 μs
Injection volume: 5 μl
Standard concentration: 1.02 μg/ml
Range: 10
Attenuation: 8

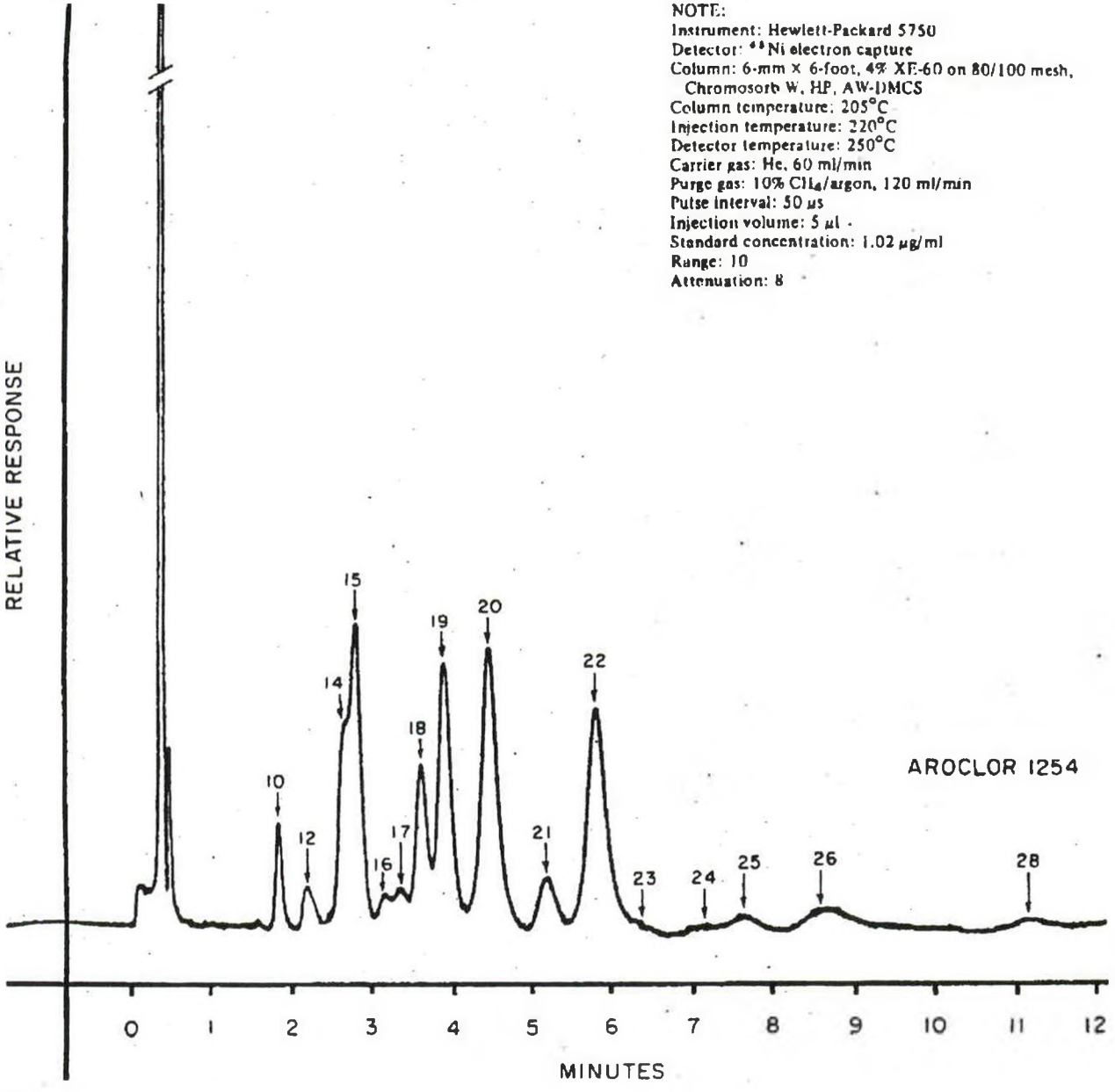


Fig. B6
Aroclor 1254 Electron Capture Chromatogram

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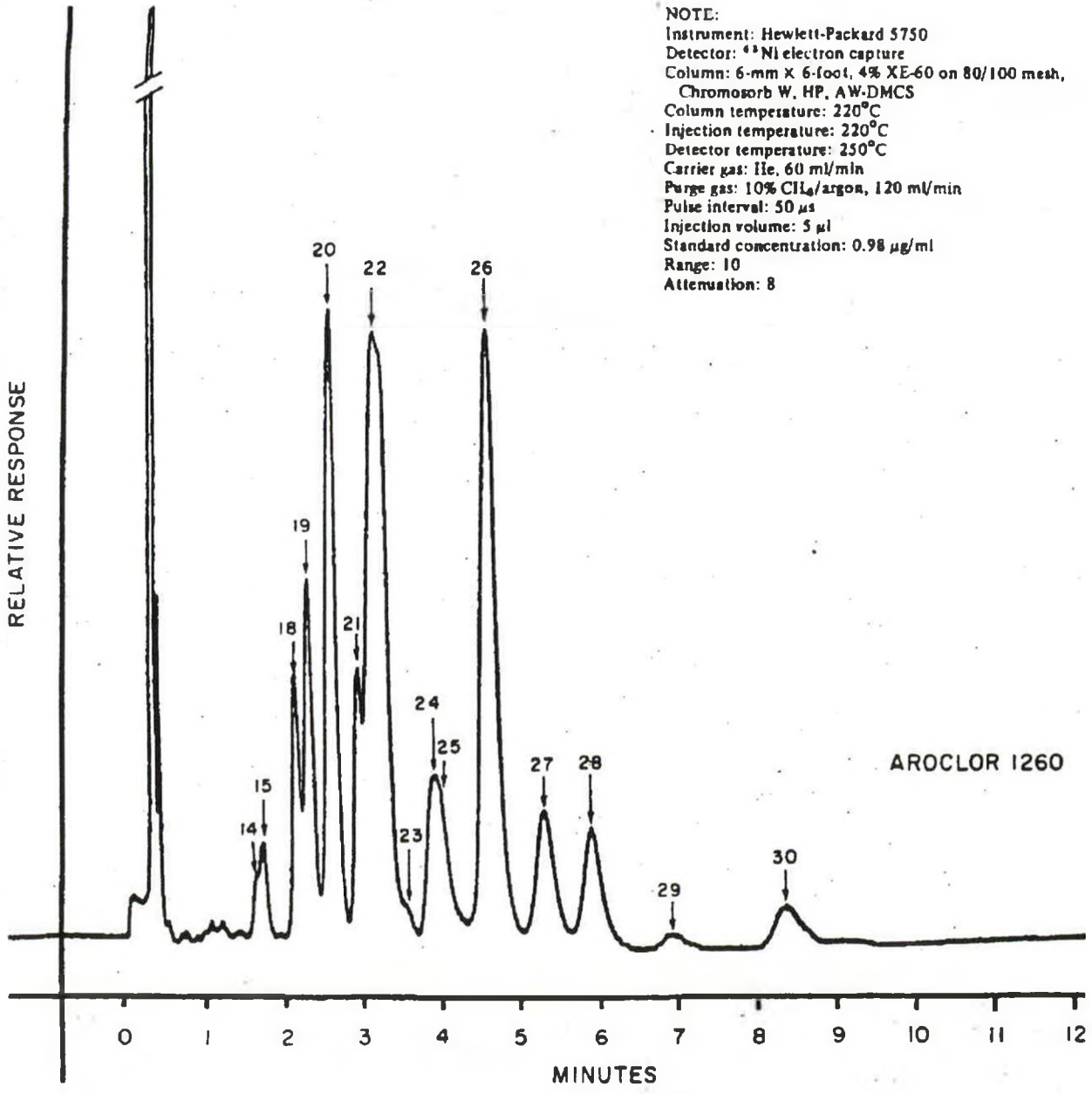


Fig. B7
Aroclor 1260 Electron Capture Chromatogram

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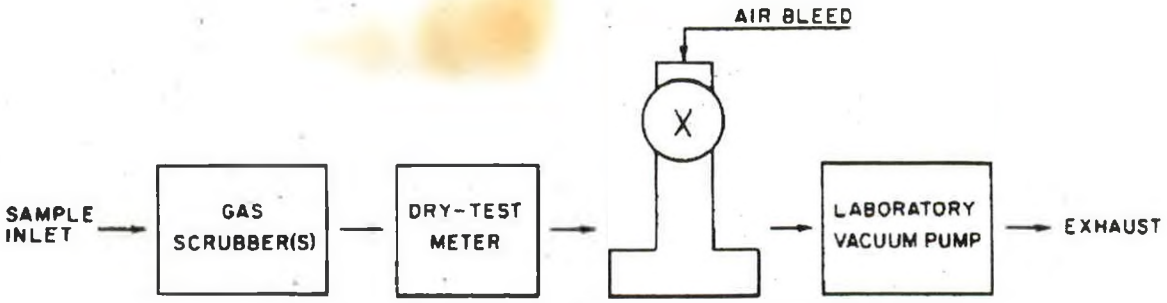


Fig. B8
Sampling Train

pump and the meter. At the end of the sampling period, the metered gas volumes are corrected for temperature and pressure to cubic metres at 25°C and 760 mmHg.

It is important to note that neither the capacity nor the efficiency of the gas scrubber(s) for removal of airborne PCBs have been experimentally evaluated. For this reason, it is best to minimize the sampling flow rate and maximize the sampling time period to obtain measurable amounts of PBCs. When high flow rates must be employed or a larger capacity may be needed, it is recommended that several gas scrubbers be used in tandem.

It is cautioned that until the efficiency and capacity of the toluene gas scrubber have been experimentally established, this procedure should be used only to measure relative PCB levels sampled under equivalent conditions.

B3.6 Procedure

(1) After scrubbing the desired amount of air, record the metered volume, pressure, and temperature.

(2) Quantitatively transfer the scrubbing solvent to a round-bottomed flask and reduce the volume to approximately 2 ml by rotary vacuum evaporation.

(3) Quantitatively transfer the concentrate to a 30-ml beaker with the aid of several small portions of toluene.

(4) Inject a fraction of a microlitre of the concentrate into the gas chromatograph to check for interferences and determine the approximate level of PCBs present. If no interferences are present, dilute or concentrate the sample to a known volume, as determined by the electron capture chromatogram, and proceed with the gas chromatographic analysis.

(5) If interferences are present, proceed with the chemical treatment and column chromatographic cleanup procedures.

(6) Transfer the concentrate to a 125-ml extraction flask with the aid of several small portions of solvent.

(7) Evaporate the concentrate just to dryness with a gentle stream of dry, filtered air and add 25 ml of 2.5% alcoholic potassium hydroxide.

(8) Add a boiling chip, put a water condenser in place, and allow the solution to reflux for 45 minutes.

(9) After cooling, transfer the solution to a 250-ml separatory funnel with the aid of 25 ml of distilled water.

(10) Rinse the extraction flask with 25 ml of hexane and add it to the separatory funnel.

(11) Stopper the separatory funnel and shake vigorously for at least 1 minute. Allow the layers to separate, and transfer the lower aqueous phase to a second separatory funnel.

(12) Extract the saponification solution with a second 25-ml portion of hexane. After the layers have separated, add the first hexane extract to the second separatory funnel, and transfer the aqueous alcohol layer to the original separatory funnel.

(13) Repeat the extraction with a third 25-ml portion of hexane. Discard the saponification solution and combine the hexane extracts.

(14) Carefully add 25 ml of the sulfuric acid solution (9:1 concentrated sulfuric acid–water) to the hexane extracts.

(15) Stopper the separatory funnel and shake vigorously for at least 1 minute. Allow the layers to separate, and discard the lower aqueous acid layer. Repeat this step until the acid layer is colorless.

(16) Wash the hexane with a 25-ml portion of water. Discard the water wash.

(17) Filter the hexane extract through a 4-inch funnel, plugged with glass wool that is covered with a layer of sodium sulfate, into a Kunderna-Danish evaporative concentrator.

(18) Add a small boiling chip, put the Snyder column in place, and reduce the hexane volume to less

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than 5 ml by heating the apparatus in a 80°C to 90°C water bath.

(19) After cooling, remove the 5-ml graduated tube and transfer the hexane extract to an alumina adsorption column, washing it in with several 5-ml portions of hexane.

(20) Carefully add 100 ml of hexane to the column reservoir, and collect the total eluent in either a 250-ml volumetric flask or a Kunderna-Danish evaporative concentrator.

(21) If the column eluent is collected in a volumetric flask, dilute to volume with hexane, and proceed with the gas chromatographic analysis.

(22) If the column eluent is collected in a Kunderna-Danish evaporative concentrator, reduce solvent volume, cool, dilute to volume, and proceed with gas chromatographic analysis.

B3.7 Electron Capture Gas Chromatographic Procedure

(1) Instrument: Gas chromatograph (for example, Hewlett-Packard Model 5750, or the equivalent)

(2) Detector: High-temperature ^{63}Ni, electron capture cell

(3) Column: 6-mm × 6-foot glass column, 4% XE-60 on 80/100 mesh, Chromosorb W, HP, AW-DMCS

(4) Column temperature: 160°C to 190°C

(5) Injection port temperature: 195°C to 215°C

(6) Detector temperature: 300°C

(7) Pulse interval: 50 μs

(8) Flow rates: Helium carrier, approximately 60 ml/min; argon-methane purge, approximately 120 ml/min

Using EC/GC as the determinative step, inject, in duplicate, 1 to 10 μl of each solution into the chromatograph. By comparison with standard solutions injected, in duplicate, under the same operating conditions, determine the amount and type of Aroclor using the individual or total peak height and area methods.

B3.8 Sample Concentration. Concentration of sample extracts is necessary, prior to cleanup by chromatographic or chemical means, to reduce sample size and increase sensitivity. The preferred method of concentrating allows minimum loss through volatilization or chemical decomposition and requires a minimum time. The three methods of solvent volume reduction most commonly used are evaporation by exposure to a stream of air, evaporation employing a Kunderna-Danish evaporative concentrator equipped with a Snyder column, and evaporation under reduced pressure. All three techniques have been used without encountering any significant losses from volatization or chemical alternation. However, the Kunderna-Danish evaporative concentrator and the stream-of-air methods are easier to use.

B3.9 Column Adsorption Chromatography and Chemical Cleanup. Silica gel, a magnesia silica gel.[9] and alumina deactivated with 0%, 1.0%, 1.5%, 2.0%, and 5% water were investigated as adsorbants for the elimination of interferences. Alumina (5% water) was found to be more effective and reproducible than either silica gel or a magnesia silica gel.[9] The activity of alumina varies with age and lot; therefore, 5% water was added to the alumina, after heating for a minimum of 4 hours at 400°C, to ensure a reproducible activity.

Saponification, and subsequent extraction of the sample with sulfuric acid, is an effective way to remove a number of chlorinated hydrocarbon interferences as well as other matrix interferences. PCBs are not affected.

B3.10 Column Performance. Column performance is the key to effective gas chromatographic analysis and, as such, the choice of column materials is particularly important. Ideally, the support employed should be inert, mechanically strong, and of high surface area. Chromosorb W, HP, AW-DMCS fulfills these requirements and is recommended for this work.

A variety of polar and nonpolar liquid phases have been investigated. The following columns have been found to provide adequate separation, etc, for use in PCB analysis by electron capture: 4% (w/w) DC-200, SF-96, OV-17, SE-30, SE-54, XE-60, Apiezon L, and 6% QF-1. DC-200 and XE-60 or QF-1 have been found to be the most suitable of these liquid phases.

Another important consideration when working with an extremely sensitive detector and, consequently, low levels of materials is column conditioning. With polar phases such as XE-60 and QF-1, operating a new column overnight at a temperature 25°C to 50°C higher than that to be used during analysis results in a more stable column. A no-flow conditioning technique is employed to condition nonpolar columns. The column is purged with carrier gas, heated for 30 minutes at an elevated temperature without carrier flow, and then cooled to room temperature. At the end of this cycle, the carrier flow is resumed and the conditioning is completed as in the case of the polar liquid phase. Two precautions should be observed: during conditioning, the column should not be connected to the detector, and the maximum safe temperature of the liquid phase should not be exceeded.

Since all liquid substrates bleed to one degree or another and columns eventually degrade, all new columns should be characterized with two column performance indicators: the number of theoretical plates (N) and a tailing factor (T). p,p'-DDT is employed to check these parameters because it is known to degrade on

[9] For example, Florisil.

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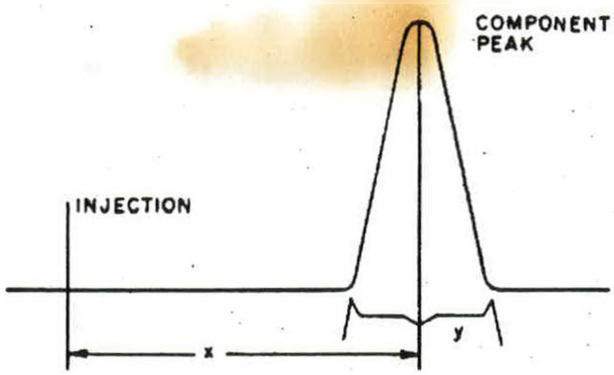


Fig. B9
Calculating Column Efficiency

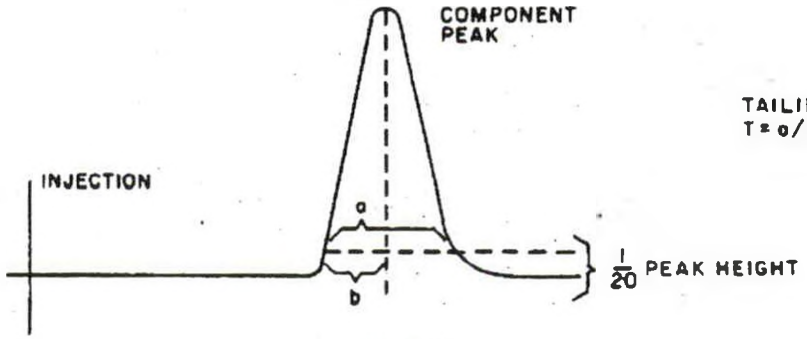


Fig. B10
Calculating the Tailing Factor

"poor" columns. In this manner, one can determine whether the performance of a new column is satisfactory and when the column performance begins to fall off. A column is considered good if the number of theoretical plates per foot is of the order of 400 to 500, with tailing factors of 1.0 to 1.3. Calculation of these parameters is shown in Fig. B9 and B10. Additionally, there should be no significant extraneous peaks upon injection of a pure p,p'-DDT standard.

Other chromatographic conditions that can be adjusted are column temperature and flow rates. Although resolution of a mixture increases with decreasing temperature, a temperature should be chosen that allows the elution of all components within a convenient time period. The flow rates shown are optimum for a given instrument, column, and detector system. These should be adjusted if better results can be achieved.

Any system of instrument and column suitable for chlorinated pesticide analysis is satisfactory for PCB analysis. The use of the high-temperature ^{63}Ni electron capture cell is highly recommended. The ability to operate at higher temperatures prevents maintenance problems due to contamination from high-boiling components. Glass columns also should be employed.

B3.11 Detection and Measurement. Quantitative determinations employing the electron capture detector are nonstoichiometric measurements made by comparing peak heights or areas for known concentrations with those for unknown compositions. Three variations of the peak height or area quantification procedures have been employed:

Case I. EC gas chromatogram of PCB unknown, unchanged with respect to standard PCB with no evidence of interferences

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Case II. EC gas chromatogram of PCB unknown, altered with respect to standard PCB with no evidence of interferences

Case III. EC gas chromatogram of PCB unknown, unchanged with respect to standard PCB with evidence of interference

The amount of PCBs in Case I samples is determined by preparing a plot of the major peak height or area versus concentration. With Case III samples, a peak free from interference is used. When dominant interferences are present, one or more of the chemical cleanup procedures is employed.

In all cases, the response of the electron capture detector must be linear for quantitative analysis.

B3.12 Contamination. In determining PCBs in biological materials by electron capture gas chromatography, laboratory sources of contamination can be a major problem. The samples and extracts should never be allowed to come in contact with materials other than glass, TFE-fluorocarbon, or metal. Laboratory glassware should be thoroughly washed with hot, soapy water, and rinsed with distilled water, acetone, and then hexane. All equipment should also be rinsed again with hexane just prior to use, and blanks should be frequently carried through all steps of the procedures to ensure against the possibility of contamination.

B3.13 Sensitivity

(1) Concentration: 2 ppb (parts per billion)
(2) Absolute sensitivity: 0.5×10^{-9} gram
(3) Volume injected: 5 µl
(4) Final volume of extract: 5 ml
(5) Sample size: 250 ml

B4. Analysis of Water and Sediment for PCBs

B4.1 Scope. This methodology is used by the Monsanto Industrial Chemical Company for the determination of the amount and type of PCBs in water and sediment samples. Absolute confirmation of PCB structures is not obtained with this method. Structure proof can be obtained using additional techniques such as mass spectrometry to further identify the gas chromatography fractions.

B4.2 Principle. The PCBs in water and sediment samples are extracted into an organic solvent. Interfering components are then removed from the extracts by chemical treatment and column adsorption chromatography. The amount and type of PCBs present are determined by electron capture gas chromatography (EC/GC).

B4.3 Reagents

(1) Hexane: Pesticide grade.
(2) Acetonitrile: Pesticide grade.
(3) Sodium sulfate: Anhydrous, granular, analytical reagent (AR) grade. Heat at 400°C for 1 hour prior to use.
(4) Alumina adsorption: For chromatographic analysis, 80/200 mesh. Heat at 400°C for a minimum of 4 hours and deactivate with 5% (w/w) distilled water.

For alumina column preparation fill a chromatographic column with hexane up to the point where the reservoir joins the column, and push a glass wool plug to the bottom with a glass rod. In a 50-ml beaker measure 35 ml (about 30 grams) of deactivated alumina, and pour this slowly into the column. Tap or vibrate the column to settle the alumina, and top the alumina with 2 to 3 cm of anhydrous sodium sulfate. Wash the column with 50 to 100 ml of hexane prior to the addition of the sample.

(5) Distilled water: Extracted with hexane to remove hexane-soluble electron capturing impurities.
(6) Sulfuric acid: AR grade, specific gravity = 1.84.
(7) Potassium hydroxide: AR grade.
(8) Ethanol: Formula 2B.
(9) Alcoholic potassium hydroxide, 2.5% (w/v): Dissolve about 12.5 grams of AR grade KOH in 500 ml of ethanol.
(10) Sulfuric acid–water, 9:1 (v/v): Carefully add 270 ml of AR grade sulfuric acid to 30 ml of distilled water in a 500-ml iced beaker.
(11) PCB standards: Aroclor 1242, 1248, 1254, and 1260. (See Fig. B2 and Fig. B4 through B7.)

B4.4 Apparatus

(1) Separatory funnels equipped with ground-glass stoppers and TFE-fluorcarbon stopcocks; capacities of 125, 250, 500, 1000, and 2000 ml.
(2) Kunderna-Danish evaporative concentrators, 500-ml capacity, equipped with three-ball Snyder columns and graduated 5-ml capacity vials.
(3) Chromatographic columns, glass, 10 inches × 20 mm (OD) with a 5-inch × 50-mm (OD) reservoir at the top, equipped with TFE-fluorocarbon stopcocks.
(4) Sintered glass filter funnels, 600-ml capacity, 90-mm disk diameter, medium porosity.
(5) Flat-bottomed boiling flasks, 125-ml capacity.
(6) Liebig condenser, 200 mm in length.
(7) Hot plates.
(8) Water bath.
(9) Reciprocating variable-speed shaker.
(10) 10-µl syringes.
(11) 32-oz all-glass mortars and pestles.
(12) 8-inch × 12-inch × 2-inch (2-1/2 qt) heat-resistant glass baking dishes.

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(13) U.S. Standard sieve, No. 30.
(14) Usual laboratory glassware.

B4.5 Sampling. It is to be assumed that a rather wide variety of sampling techniques may be employed in collecting samples submitted for analysis. For this reason, water and sediment samples should be treated as given in B4.5.1 and B4.5.2.

B4.5.1 Water. Where possible, the entire water sample, including the container in which it was collected, should be extracted with hexane. With larger samples, where this is not physically possible, the containers should be simply agitated and a 250-ml portion used for the analysis. (See B4.6.)

B4.5.2 Sediment. Any excess water should be decanted, and the entire sediment transferred to a glass baking dish to air-dry at room temperature. The dried material should be transferred from the dish into a mortar and ground. The ground sediment should be sieved, remixed, and a 250-gram portion taken for analysis. (See B4.7.)

B4.6 Extraction of Water Samples

(1) After agitating, transfer the entire aqueous sample or a 250-ml aliquot into a graduated glass cylinder. Record the volume of the sample and quantitatively transfer it to a separatory funnel with distilled water.

(2) Rinse the graduated cylinder with two 50-ml portions of hexane and add each to the separatory funnel.

(3) Stopper the separatory funnel and shake vigorously for at least 1 minute. Allow the layers to separate, and transfer the lower aqueous phase to a second separatory funnel.

(4) Extract the water sample a second time with a 50-ml portion of hexane. After the layers have separated, add the first hexane extract to the second separatory funnel, and transfer the aqueous layer to the original separatory funnel.

(5) Repeat the extraction with a third 50-ml portion of hexane. Discard the aqueous layer and combine the hexane extracts.

(6) Filter the combined extracts through a 4-inch funnel, plugged with glass wool that is covered with sodium sulfate. Collect the filtrate in a Kunderna-Danish evaporative concentrator, add a small boiling chip, put the Snyder column in place, and reduce the hexane volume to less than 5 ml by heating the apparatus in an 80°C-to 90°C water bath. (CAUTION: Solvent vapors must be vented into a hood.)

(7) After cooling, remove the 5-ml graduated tube and transfer the hexane extract to an alumina adsorption column, washing it in with several 5-ml portions of hexane.

(8) Carefully add 100 ml of hexane to the column reservoir, and collect the total eluent in either a 250-ml volumetric flask or a Kunderna-Danish evaporative concentrator.

(9) If the column eluent is collected in a volumetric flask, dilute to volume with hexane, and proceed with the gas chromatographic analysis.

(10) If the column eluent is collected in a Kunderna-Danish evaporative concentrator, reduce solvent volume, cool, dilute to volume, and proceed with the gas chromatographic analysis.

B4.7 Extraction of Sediment and Soil Samples

(1) Decant off any excess water and transfer the entire sediment sample to a glass baking dish. Air-dry at ambient temperature (heat should be applied).

(2) When dry, transfer the soil/sediment to a mortar and grind. Sieve the ground material through a No. 30 mesh sieve and weigh 250 grams (to the nearest 0.01 gram) into a 16-ounce narrow-neck screw-cap (aluminum-foil liner) glass bottle.

(3) Moisten the soil with about 10 ml of water and add 150 ml of acetonitrile. Cap the bottle tightly, and mechanically shake it for a minimum period of 1 hour.

(4) Quantitatively transfer the acetronitrile extract into a 600-ml sintered glass filter funnel containing a 1/4-inch layer of anhydrous sodium sulfate. Collect the filtrate in a 600-ml beaker (vacuum filtration may be necessary).

(5) After the acetronitrile has completely drained into the beaker, wash the bottle twice with 50-ml portions of acetonitrile, adding each wash to the funnel after the previous wash has completely percolated through the sediment.

(6) Quantitatively transfer the extract to a Kunderna-Danish evaporative concentrator, add a small boiling chip, put the Snyder column in place, and reduce the solvent volume to less than 5 ml by heating the apparatus in an 80°C to 90°C water bath. (CAUTION: Solvent vapors must be vented into a hood.)

(7) After cooling, remove the 5-ml graduated tube and transfer the concentrate of extracts to a 125-ml extraction flask with the aid of several small portions of solvent.

(8) Evaporate the extract just to dryness with a gentle stream of dry, filtered nitrogen and add 25 ml of 2.5% alcoholic potassium hydroxide.

(9) Add a boiling chip, put a water condenser in place, and allow the solution to reflux for 45 minutes.

(10) After cooling, transfer the solution to a 250-ml separatory funnel with the aid of 25 ml of distilled water.

(11) Rinse the extraction flask with 25 ml of hexane and add it to the separatory funnel.

(12) Stopper the separatory funnel and shake it

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vigorously for at least 1 minute. Allow the layers to separate, and transfer the lower aqueous phase to a second separatory funnel.

(13) Extract the saponification solution with a second 25-ml portion of hexane. After the layers have separated, add the first hexane extract to the second separatory funnel and transfer the aqueous alcohol layer to the original separatory funnel.

(14) Repeat the extraction with a third 25-ml portion of hexane. Discard the saponification solution and combine the hexane extracts.

(15) Carefully add 25 ml of the sulfuric acid solution (9:1 concentrated sulfuric acid–water) to the hexane extracts.

(16) Stopper the separatory funnel and shake vigorously for at least 1 minute. Allow the layers to separate, and discard the lower aqueous acid layer. Repeat this step until the acid layer is colorless.

(17) Wash the hexane with a 25-ml portion of water. Discard the water wash.

(18) Filter the hexane extract through a 4-inch funnel, plugged with glass wool that is covered with a layer of sodium sulfate, into a Kunderna-Danish evaporative concentrator.

(19) Add a small boiling chip, put the Snyder column in place, and reduce the hexane volume to less than 5 ml by heating the apparatus in an 80°C to 90°C water bath.

(20) After cooling, remove the 5-ml graduated tube and transfer the hexane extract to an alumina adsorption column, washing it in with several 5-ml portions of hexane.

(21) Carefully add 100 ml of hexane to the column reservoir, and collect the total eluent in either a 250-ml volumetric flask or a Kunderna-Danish evaporative concentrator.

(22) If the column eluent is collected in a volumetric flask, dilute to volume with hexane, and proceed with the gas chromatographic analysis.

(23) If the column eluent is collected in a Kunderna-Danish evaporative concentrator, reduce solvent volume, cool, dilute to volume, and proceed with gas chromatographic analysis.

B4.8 Electron Capture Gas Chromatographic Procedure

(1) Instrument: Gas chromatograph (for example, Hewlett-Packard Model 5750, or the equivalent)

(2) Detector: High-temperature ^{63}Ni, electron capture cell

(3) Column: 6-mm X 6-foot glass column, 4% XE-60 on 80/100 mesh, Chromosorb W, HP, AW-DMCS

(4) Column temperature: 160°C

(5) Injection port temperature: 195°C

(6) Detector temperature: 300°C

(7) Pulse interval: 50 μs

(8) Flow rates: Helium carrier, approximately 60 ml/min; argon-methane purge, approximately 120 ml/min

Using EC/GC as the determinative step, inject, in duplicate, 1 to 10 μl of each solution into the chromatograph. By comparison with standard solutions injected, in duplicate, under the same operating conditions, determine the amount and type of Aroclor using the individual or total peak height and area methods.

The electron capture detector should also be used to guide the isolation procedures. Water and sediment extracts can be checked for the presence of PCBs or interferences, or both, by injection of microlitre portions of the extracts at various points in the extraction and concentration schemes. In this manner it can be determined whether the sample needs to be concentrated or diluted and whether the cleanup procedures should be employed.

B4.9 Extraction. The extraction of PCBs from water, employing hexane as the extractant, has been found to be quantitative and sufficiently simple and rapid for use as a routine procedure.

The evaluation of this method was based on spiking water samples with standard acetone solutions of PCBs. The spiking method consisted of adding the PCB in 25 to 50 μl of acetone to 500 ml of tap water in a 32-ounce narrow-neck screw-cap jar. After the sample was thoroughly mixed, duplicate 225- to 250-ml aliquots were taken and subjected to the proposed sample preparation and worked up as outlined. The results were quantified by preparing a calibration curve using standard hexane solutions of the PCBs used to spike the water samples. The major isomer peak height was used to construct the calibration plot.

The average recovery and deviation achieved substantiated the applicability of the method for the quantitative recovery and analysis of PCBs from water at the ppb-ppm level.

No PCB recovery experiments from spiked sediment and soil samples have been performed. Instead, several of the residual solids representative of some of the types of sediment or soil analyzed were reextracted with hexane/acetone (40:60) in a soxhlet extractor to test for the efficiency of the acetonitrile extraction step. The hexane, after isolation by dilution with distilled water, was then carried through the purification steps. Recoveries by soxhlet extraction have indicated that the acetonitrile extraction of PCBs was essentially quantitative in the cases checked.

B4.10 Sample Concentration. Concentration of sample extracts is necessary, prior to cleanup by chromato-

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graphic or chemical means, to reduce sample size and increase sensitivity. The preferred method of concentrating allows minimum loss through volatilization or chemical decomposition and requires a minimum time. The three methods of solvent volume reduction most commonly used are evaporation by exposure to a stream of air, evaporation employing a Kunderna-Danish evaporative concentrator equipped with a Snyder column, and evaporation under reduced pressure. All three techniques have been used, and no significant losses from volatilization or chemical alternation have been encountered. However, the Kunderna-Danish evaporative concentrator and the stream-of-air methods are easier to use.

B4.11 Column Adsorption Chromatography and Chemical Cleanup. Silica gel, a magnesia silica gel,[9] and alumina deactivated with 0%, 1.0%, 1.5%, 2.0%, and 5% water were investigated as adsorbants for the elimination of interferences. Alumina (5% water) was found to be more effective and reproducible than either silica gel or a magnesia silica gel,[9] The activity of alumina varies with age and lot; therefore 5% water is added to the alumina, after heating for a minimum of 4 hours at 400°C, to ensure a reproducible activity.

Saponification, and subsequent extraction of the sample with sulfuric acid, is an effective way to remove a number of chlorinated hydrocarbon interferences as well as other matrix interferences. PCBs are not affected.

B4.12 Column Performance. Column performance is the key to effective gas chromatographic analysis and, as such, the choice of column materials is particularly important. Ideally, the support employed should be inert, mechanically strong, and of high surface area. For these reasons, Chromosorb W, HP, AW-DMCS is recommended for this work.

A variety of polar and nonpolar liquid phases have been investigated. The following columns have been found to provide adequate separation, etc, for use in PCB analysis by electron capture: 4% (w/w) DC-200, SF-96, OV-17, SE-30, SE-54, XE-60, Apiezon L, and 6% QF-1. DC-200 and XE-60 or QF-1 are the most suitable of these liquid phases.

Another important consideration when working with an extremely sensitive detector and, consequently, low levels of materials is column conditioning. With polar phases such as XE-60 and QF-1, operating a new column overnight at a temperature 25°C to 50°C higher than that to be used during analysis results in a more stable column. A no-flow conditioning technique is employed to condition nonpolar columns. The column is purged with carrier gas, heated for 30 minutes at an elevated temperature without carrier flow, and then cooled to room temperature. At the end of this cycle, the carrier flow is resumed and the conditioning is completed as in the case of the polar liquid phase. Two precautions should be observed: during conditioning, the column should not be connected to the detector, and the maximum safe temperature of the liquid phase should not be exceeded.

Since all liquid substrates bleed to one degree or another and columns eventually degrade, all new columns should be characterized with two column performance indicators: the number of theoretical plates (N) and a tailing factor (T). p,p'-DDT is employed to check these parameters because it is known to degrade on "poor" columns. In this manner, one can determine whether the performance of a new column is satisfactory and when the column performance begins to fall off. A column is considered good if the number of theoretical plates per foot is of the order of 400 to 500, with tailing factors of 1.0 to 1.3. Calculation of these parameters is shown in Fig. B9 and B10. Additionally, there should be no significant extraneous peaks upon injection of a pure p,p'-DDT standard.

Other chromatographic conditions that can be adjusted are column temperature and flow rates. Although resolution of a mixture increases with decreasing temperature, a temperature should be chosen that allows the elution of all components within a convenient time period. The temperatures given are optimum for 42% chlorinated biphenyl; temperatures are increased when specifically analyzing for the higher chlorinated biphenyls; that is, 54%, 60%, etc. The flow rates shown are optimum for a given instrument, column, and detector system. These should be adjusted if better results can be achieved.

Any system of instrument and column suitable for chlorinated pesticide analysis is satisfactory for PCB analysis. The use of the high-temperature ^{63}Ni electron capture cell is highly recommended. The ability to operate at higher temperatures prevents maintenance problems due to contamination from high-boiling components. Glass columns also should be employed.

B4.13 Detection and Measurement. Quantitative determinations employing the electron capture detector are nonstoichiometric measurements made by comparing peak heights or areas for known concentrations with those for unknown compositions. Except for sharp peaks, peak area measurements are usually more reproducible than peak height measurements but are extremely time consuming unless a recording integrator is employed. However, peak height measurements are as accurate as disk integration of triangulation and, if the

[9] For example, Florisil.

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peak shape represents a Gaussian curve, the height may be considered independent of the base. Consequently, peak height measurements are generally used. Three variations of the peak height or area quantification procedures have been employed.

Case I. EC gas chromatogram of PCB unknown, unchanged with respect to standard PCB with no evidence of interferences

Case II. EC gas chromatogram of PCB unknown, altered with respect to standard PCB with no evidence of interferences

Case III. EC gas chromatogram of PCB unknown, unchanged with respect to standard PCB with evidence of interference

The amount of PCBs in Case I samples is determined by preparing a plot of the major peak height or area versus concentration. For Case II, a plot is prepared of the total sum of all major peaks versus concentration. With Case III samples, a peak free from interference is used. When dominant interferences are present, one or more of the chemical cleanup procedures is employed.

In all cases, the response of the electron capture detector must be linear for quantitative analysis.

B4.14 Contamination. In determining PCBs in water, soil, and sediment by electron capture gas chromatography, laboratory sources of contamination can be a major problem. The samples and extracts should never be allowed to come in contact with materials other than glass, TFE-fluorocarbon, or metal. Laboratory glassware should be thoroughly washed with hot, soapy water and rinsed with distilled water, acetone, and then hexane. All equipment should also be rinsed again with hexane just prior to use, and blanks should be frequently carried through all steps of the procedures to ensure against the possibility of contamination.

B4.15 Sensitivity

(1) Concentration: 2 ppb
(2) Absolute sensitivity: 0.5×10^{-9} gram
(3) Volume injected: 5 μl
(4) Final volume of extract: 5 ml
(5) Sample size: 250 ml

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American National Standards

The standard in this booklet is one of nearly 5,600 standards approved to date by the American National Standards Institute, formerly the USA Standards Institute.

The Standards Institute provides the machinery for creating voluntary standards. It serves to eliminate duplication of standards activities and to weld conflicting standards into single, nationally accepted standards under the designation "American National Standards."

Each standard represents general agreement among maker, seller, and user groups as to the best current practice with regard to some specific problem. Thus the completed standards cut across the whole fabric of production, distribution, and consumption of goods and services. American National Standards, by reason of Institute procedures, reflect a national consensus of manufacturers, consumers, and scientific, technical, and professional organizations, and governmental agencies. The completed standards are used widely by industry and commerce and often by municipal, state, and federal governments.

The Standards Institute, under whose auspices this work is being done, is the United States clearinghouse and coordinating body for standards activity on the national level. It is a federation of trade associations, technical societies, professional groups, and consumer organizations. Some 1,000 companies are affiliated with the Institute as company members.

The American National Standards Institute is the United States member of the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the Pan American Standards Commission (COPANT). Through these channels American industry makes its position felt on the international level. American National Standards are on file in the libraries of the national standards bodies of more than 50 countries.

For a free list of all American National Standards, write:

American National Standards Institute, Inc

1430 Broadway **New York, N. Y. 10018**

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TABLE I

Code No.	Trash	Disposal Spec #	L-Order #	Toxic	Pollutant	Flammable	Label
1.	Trichloroethylene	597077	14704	X	X	-	Blue
2.	Liquid Paint	597077	14704	X	-	X	Blue
3.	Dried Up Paint	597077	14704	-	-	-	White
4.	Solvents-Thinners	597077	14704	X	-	X	Blue
5.	Varnish-Liquid	597077	14704	X	-	X	Blue
6.	Varnish-Dried Up	597077	None	-	-	-	White
7.	Oils	597077	14704	-	X	X	Blue
8.	Acids	597077	14704	X	X	-	Blue
9.	Caustics (NAOH,etc.)	597077	14704	X	X	-	Blue
10.	Cyanide Waste	597077	14704	X	X	-	Blue
11.	Chromate or Chromic Acid Waste	597077	14704	X	X	-	Blue
12.	Chromate or Chromic Acid Waste After Treatment Per P.S. 597008 if not liquid form. If in liquid form see page one,(4) for white label material.	597077	None	-	-	-	White
13.	Inerteen Liquid or Liquids contaminated with Inerteen	597077	16353	X	X	-	Orange
14.	Solid Waste Contaminated with Inerteen Rags, Sawdust, paper, Bad Capacitors, etc.	597077	16353	X	X	-	Red
15.	Sludge from Tin Plating Tanks if not liquid form.	597077	-	-	-	-	White
16.	Sludge from Bonderizing Tanks in A35 and E50. If not in liquid form. If liquid form, see page one, (4) for white label material.	597077	-	-	-	-	White
17.	Regular Trash, Boxes, Wood, Paper, Etc.	597077	-	-	-	-	White
18.	Soap from #1 Tank In B-20 and #1 Tank E50 and Acid Tanks in B-20 and #1 tank in A35 shall be pumped into a truck and hauled away by approved disposal company.	597077	14704	X	X	-	

NOTE 1: All blue labels shall have disposal spec number and code number listed as follows: Code #7 use 597077/7. 7 meaning drum contains oil.

NOTE 2: Any scrap products which have oil in them and are being scraped to County Dump must be drained of oil before being sent to dump.

Date: 1-6-76 P.S. 597077

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Approved OMB
44-R1387
Approval Expires:
July 30, 1972

U.S. DEPARTMENT OF LABOR

Form No. OSHA-
May, 1971

MATERIAL SAFETY DATA SHEET

SECTION I

MANUFACTURER'S NAME: MONSANTO COMPANY	EMERGENCY TELEPHONE NO.: (314) 694-1000
ADDRESS (Number, Street, City, State, and ZIP Code): 800 North Lindbergh Boulevard, St. Louis, Missouri 63166	
CHEMICAL NAME AND SYNONYMS: Mixture	TRADE NAME AND SYNONYMS: Aroclor 1016, MCS 1016
CHEMICAL FAMILY: Chlorinated aromatic	FORMULA: Mixture

SECTION II HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)

POOR QUALITY ORIGINAL

SECTION III PHYSICAL DATA

BOILING POINT (°F.) 760 mm	325°C	SPECIFIC GRAVITY (H_2O = 1) (25/15.5°C)	1.367
VAPOR PRESSURE (mm Hg.) (155-195°C)	3 mm	PERCENT VOLATILE BY VOLUME (%)	N.A.
VAPOR DENSITY (AIR = 1)	Not Avail	EVAPORATION RATE (BUAC = 1)	<1
SOLUBILITY IN WATER 20°C negligible	<0.01%		
APPEARANCE AND ODOR	colorless oil	slight aromatic odor	

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) C.O.C. 180°C	FLAMMABLE LIMITS	LEL	UEL
		N.A.	N.A.

EXTINGUISHING MEDIA: Water, foam, CO_2 or dry chemical

SPECIAL FIRE FIGHTING PROCEDURES: Respiratory protection when fighting fires where exposure to vapors or gases is possible.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Highly toxic gases (chlorides and chlorine) can be evolved in fires of this product.

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Address Secretary at:
National Electrical Manufacturers Association
155 East 44th St., New York, N. Y. 10017
Telephone: 212-682-1500

american national standards institute, inc.

C107

MINUTES: ANSI COMMITTEE, C107, ON USE AND DISPOSAL OF ASKAREL AND ASKAREL SOAKED MATERIALS

PLACE OF MEETING: NATIONAL BUREAU OF STANDARDS
GAITHERSBURG, MD.

DATE AND TIME: TUESDAY, SEPTEMBER 14, 1971
9:15 A.M. - 2:30 P.M.

MEMBERS PRESENT:

Certified Ballast Manufacturers Association (CBMA)	
N. R. Clark	Universal Manufacturing Company
Dr. A. Pozefsky	General Electric Company
Edison Electric Institute (EEI)	
F. R. Long [illegible]	Union Electric Co.
Institute of Electrical and Electronic Engineers, Inc. (IEEE)	
E. L. Raab	General Electric Company
National Electrical Manufacturers Association (NEMA)	
W. S. Grogan	Allis-Chalmers Corporation
E. G. Hammer (Representing H. R. Rowe)	McGraw-Edison Power Systems Division
J. F. Kuzela	Sangamo Electric Company
R. D. McClain	Westinghouse Electric Corporation
W. C. Reinhardt	Central Moloney Transformer Division Colt Industries
Government	
David H. Crabtree	Department of the Army
Earl Pershing Floyd	Environmental Protection Agency
Dr. Allen Jennings	Environmental Protection Agency
Dr. John Leutritz, Jr.	Rural Electrification Administration Department of Agriculture
William R. Nicholas	Tennessee Valley Authority
Arthur A. Thue	Department of the Army
Charles C. Travis	General Services Administration
Dr. Stanley P. Wasik	National Bureau of Standards
Individuals	
P. G. Benignus	Monsanto Company
C. W. Hart	Rollins-Purle Inc.
A. O. Hauser	Electrical Utilities Company
W. P. Papageorge	Monsanto Company
A. L. Rickley	Doble Engineering Company
G. P. Taggart (Representing Louis L. Wagner)	Chem-Trol Pollution Services Inc.

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MEMBERS ABSENT:

NONE

OTHERS PRESENT:

T. K. Sloat	Westinghouse Electric Corporation
A. M. Salazar	NEMA Staff

PRESIDING OFFICER: W. P. Papageorge, Chairman

I. APPROVAL OF PREVIOUS MINUTES

This being the first meeting of this ANSI Committee, no previous minutes were submitted for approval.

II. ELECTION OF PERMANENT CHAIRMAN AND VICE-CHAIRMAN

On motion seconded, Mr. W. P. Papageorge was unanimously elected as permanent Chairman. The election of a Vice-Chairman was tabled until the next meeting.

III. PURPOSE OF THIS MEETING

The Committee noted that the purpose of this meeting and scope, objectives and organizations that agreed to participate in this activity, were covered in the Secretary's letters of May 1, 1971 and August 12, 1971. Copies of these letters are attached as EXHIBITS "A" and "B", respectively, for the record.

IV. PCB'S AS POTENTIAL ENVIRONMENTAL CONTAMINANTS

The Chairman briefed the Committee on the subject, along the lines of his written report, prepared from a tape recording made at this meeting, attached as EXHIBIT "C". Questions with respect to areas covered in the report were discussed and answered during the presentation.

V. SPECIFIC ACTIONS TAKEN AT THIS MEETING

After some discussion with respect to the next steps to be taken by this Committee, the following actions were unanimously approved:

A. The Chairman was authorized to appoint a Steering Committee to:

1. Serve as advisor to the Chairman and otherwise assist him in the performance of his office in the interim between meetings of ANSI C107.

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2. Provide the Chairman with recommendations for appointment of Subcommittees, to develop specific recommendations with respect to the following areas covered in the approved scope and proposed objectives of this Committee:

a. Procedures and guides for safe use, maintenance and disposal of askarel and askarel-soaked materials used in electrical equipment.

b. Serve as a source for technical information and advice for Federal, State and local authorities and for the information of all others concerned.

c. Encourage the development of suitable disposal facilities and maintain a list of their capabilities and locations, for the information of all concerned.

d. Serve as the advisory group for US participation in CEE, IEC, COPANT, CIGRE and other international organizations.

B. Concurred with the Chairman's opinion, expressed during his presentation under Item IV of these minutes, that of the current Bills in Congress, Senator Phillip Hart's Bill establishing the "Toxic Substances Control Act of 1971" appears to take precedence. The Chairman was, accordingly, requested to advise on the formation of this ANSI Committee and on its scope and objectives, at the October Senate's Subcommittee Hearings on this Bill. Members of the NEMA Delegation indicated that they will investigate the possibility of having a NEMA statement available for these Hearings.

SECRETARY'S NOTE

For completeness of the record, at a subsequent special meeting held at NEMA Headquarters, it was noted that the Manufacturers Chemists Association (MCA) expects to testify at the Hearings and will support the Hart Bill, subject to certain "due process" amendments and will oppose the "tougher" Spong Amendments. In view of the fact that the MCA stand is in line with NEMA's previous positions on other Bills, such as on product safety and international standards cooperation, it was recommended

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that NEMA should support the MCA stand, subject, of course, to any changes that may develop at the Hearing. This was subsequently approved and such a statement is available for submission at an appropriate time.

It has been determined that the MCA testimony has been postponed indefinitely, due to changes in scheduling of substances to be considered. It is understood that detergents was the substance under consideration at the October 15, 1971 Hearing, for example.

C. Noted that, as is the case for most ANSI Committees, this Committee will function as an executive group to consider and take appropriate action on recommendations to be prepared by Subcommittees and Working Groups. The ultimate action to be authorized by the Committee will be letter ballots to secure the necessary consensus of all member organizations and individuals represented on the Committee.

Based on this type of operation, the Committee noted that the number of meetings may be as few as one to three a year, while Subcommittees and Working Groups may be meeting several times a year to develop recommendations.

VI. TIME AND PLACE OF THE NEXT MEETING

Left to the call of the Chair.

VII. ADJOURNMENT

There being no further business before the Committee, the meeting was adjourned at 2:30 P.M., having recessed for lunch between the hours of 12:30 P.M. - 1:15 P.M.

A. M. Salazar
Secretary
ANSI C107 Committee

AMS:dk

ATTACHMENTS: EXHIBITS "A" -"C"

NPC00023924

770740

american national standards institute, inc.

Address Secretary at:
National Electrical Manufacturers Association
155 East 44th St., New York, N. Y. 10017
Telephone: 212-682-1500

ANSI Committee, C107

May 1, 1971

Dear Sir:

The Monsanto Company, the sole U. S. producer of polychlorinated biphenyls (PCB's) and the National Electrical Manufacturers Association (NEMA) have joined in recommending the formation of an American National Standards Committee with the objective of developing recommended procedures for the use, maintenance, and disposal of askarel and askarel-soaked materials. The Committee, designated as C107, was recently approved by the American National Standards Institute (ANSI).

The formation of the Committee is considered essential to supplement the efforts of the Monsanto Company and the U. S. transformer and capacitor manufacturers in their efforts to control the use, maintenance, and disposal of askarel and askarel-soaked materials. Askarels consist of or contain polychlorinated biphenyls which can become persistent environmental contaminants. Contact with the environment should be minimized.

An organization meeting will be held for a review of the pertinent background leading to the formation of the Committee, the establishment of objectives and appointment of appropriate subcommittees. It will be held at a central location and at a convenient time, either during the week of May 31 or June 7, 1971.

To insure representation of all concerned, your organization is invited and encouraged to participate. It would, therefore, be very much appreciated if you would supply me with the name(s) and addresses of persons you will designate to represent your organization by MAY 15, 1971.

Attached, for your information in complying with this request, is the scope approved by ANSI and a list of organizations being invited to participate.

I sincerely hope that your organization can actively participate in this most important activity and that you or your representative can fit the proposed June session into your schedule

Sincerely yours,

A. M. Salazar, Secretary
ANSI Committee, C107

AMS:dk

NPC00023925

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AMERICAN NATIONAL STANDARDS COMMITTEE, C107,
ON USE AND DISPOSAL OF ASKAREL USED IN ELECTRICAL EQUIPMENT

CHAIRMAN: W. P. Papageorge, Manager
Environmental Control
Monsanto Company
800 N. Lindbergh Blvd.
St. Louis, Mo. 63166

SECRETARY: A. M. Salazar, Executive Secretary
Power Equipment Division
National Electrical Mfrs. Assn.
155 E. 44th St.
New York, N. Y. 10017

APPROVED SCOPE:

Procedures and guides for safe use, maintenance and disposal of askarel and askarel-soaked materials used in electrical equipment.

PROPOSED OBJECTIVES:

In addition to developing the procedures and guides referred to in the scope, above, it shall be the objectives of the ANSI Committee to:

1. Serve as a source for technical information and advice for Federal, State and local authorities and for the information of all others concerned.

2. Encourage the development of suitable disposal facilities and maintain a list of their capabilities and locations, for the information of all concerned.

3. Serve as the advisory group for US participation in CEE, IEC, COPANT, SEGRA and other international organizations.

NPC00023926

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LIST OF NATIONAL AND GOVERNMENT GROUPS
INVITED TO JOIN THE ANSI COMMITTEE, C107,
ON USE AND DISPOSAL OF ASKAREL USED IN ELECTRICAL EQUIPMENT

NATIONAL

AMERICAN PUBLIC POWER ASSOCIATION
2600 Virginia Ave. N.W.
Washington, D. C. 20037

Alex Rodin, General Manager

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race Street
Philadelphia, Pa. 19103

William T. Cavanaugh, Managing Director

ASSOCIATION OF AMERICAN RAILROADS
1920 L Street, N.W.
Washington, D. C. 20036

Thomas M. Goodfellow, President

ASSOCIATION OF EDISON ILLUMINATING COMPANIES
51 E. 42nd St.
New York, N. Y. 10017

W. Floyd-Jones, Secretary

AUTOMOBILE MANUFACTURERS ASSOCIATION, INC.
320 New Center Building
Detroit, Mich. 48202

Thomas C. Mann, President

CERTIFIED BALLAST MANUFACTURERS ASSOCIATION
2120 Keith Building
Cleveland, Ohio 44115

M. R. Davies, Secretary-Treasurer

EDISON ELECTRIC INSTITUTE
750 Third Ave.
New York, N. Y. 10017

W. Donham Crawford, Managing Director

NPC00023927

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NATIONAL (Cont'd)

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS, INC.
345 E. 47th St.
New York, N. Y. 10017

Donald G. Fink, General Manager

MANUFACTURING CHEMISTS ASSOCIATION
1825 Connecticut Ave., N.W.
Washington, D. C. 20009

William J. Driver, President

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
155 E. 44th St.
New York, N. Y. 10017

A. M. Salazar, Executive Secretary, Power Equipment Division

NATIONAL FIRE PROTECTION ASSOCIATION
60 Batterymarch St.
Boston, Mass. 02110

Charles S. Morgan, General Manager

UNDERWRITERS' LABORATORIES, INC.
207 E. Ohio Street
Chicago, Ill. 60611

Baron Whitaker, President

WATER POLLUTION CONTROL FEDERATION
3900 Wisconsin Ave., N.W.
Washington, D. C. 20016

Robert A. Canham, Executive Secretary

NPC00023928

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GOVERNMENT

ATOMIC ENERGY COMMISSION
Washington, D. C. 20545

Glenn T. Seaborg, Chairman

DEPARTMENT OF THE ARMY
The Pentagon
Washington, D. C. 20310

Lt. General E. J. Clarke, Chief of Engineers

DEPARTMENT OF INTERIOR
C Street Between 18th and 19th Sts. NW
Washington, D. C. 20240

James R. Smith, Assistant Secretary - Water and Power Development
Ellis L. Armstrong, Commissioner of Reclamation
Henry R. Richmond, Administrator Bonneville Power Administration
Carl L. Klein, Assistant Secretary - Water Quality and Research

ENVIRONMENTAL PROTECTION AGENCY
1626 K St. NW
Washington, D. C. 20460

William D. Ruckelhaus, Administrator

FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
5600 Fishers Lane
Rockville, Md. 20852

Charles C. Edwards, Commissioner of Food and Drugs

GENERAL SERVICES ADMINISTRATION
FEDERAL SUPPLY SERVICE
Washington, D. C. 20406

A. F. Sampson, Commissioner
C. C. Travis, Director Standardization Division

NPC00023929

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GOVERNMENT (Cont'd)

NATIONAL BUREAU OF STANDARDS
Washington, D. C. 20234

Lewis M. Branscomb, Director

RURAL ELECTRIFICATION ADMINISTRATION
DEPARTMENT OF AGRICULTURE
14th St. and Independence Ave. S.W.
Washington, D. C. 20250

David W. Hamil, Administrator

TENNESSEE VALLEY AUTHORITY
New Sprankle Building
Knoxville, Tenn. 37902

James F. Watson, Manager of Power

INDIVIDUALS

CHEM-TROL POLLUTION SERVICES INC.
4818 Lake Ave.
Blasdell, N. Y. 14219

Lewis E. Wagner, President

DOBLE ENGINEERING CO.
P.O. Box 105
Belmont, Mass. 02178

R. I. Lowe, President

ELECTRICAL UTILITIES CO.
2427 St. Vincent Ave.
La Salle, Ill. 61301

A. O. Hauser

NPC00023930

770746

INDIVIDUALS (Cont'd)

MONSANTO COMPANY
800 N. Lindbergh Blvd.
St. Louis, Mo. 63166

W. P. Papageorge, Manager Environmental Control
P. G. Benignus, Marketing Manager, Dielectric Fluids

ROLLINS-PURLE INC.
3208 Concord Pike
Wilmington, Delaware 19803

John E. O'Brien, President

NPC00023931

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american national standards institute, inc

Address Secretary at
National Electrical Manufacturers Association
155 East 44th St., New York, N.Y. 10017
Telephone: 212 682 [illegible]

August 12, 1971

TO ALL RESPONDENTS TO THE
MAY 1, 1971 LETTER, ESTABLISHING
THE ANSI COMMITTEE C107 ON USE
AND DISPOSAL OF ASKAREL USED
IN ELECTRICAL EQUIPMENT
(SEE ATTACHMENT #1 FOR LIST OF RESPONDENTS)

SUBJECT: ORGANIZATION MEETING

Gentlemen:

Since issuing the May 1, 1971 letter, another copy of which is enclosed for your convenience, it became necessary to shift the date of the Organization Meeting from the month of June to the month of September, 1971. Our check of schedules for meetings of other national groups of possible interest to this Group, pretty much dictates that the Organization Meeting should be planned for the week of September 13, 1971.

The Chairman, Mr. W. P. Papageorge, of the Monsanto Company, accordingly called the meeting for Tuesday, September 14, 1971. At the invitation of Dr. Stanley P. Wasik, of the National Bureau of Standards (NBS), the meeting will convene at 9:00 A.M. in Dining Room #3 at the NBS facilities in Gaithersburg, Md.

The NBS is providing a limousine for transportation between the NBS and a convenient hotel. The hotel most often used for such groups as ours is the Sheraton Hotel in Silver Springs, Md. Limousine service to this hotel is readily available at the Washington National Airport and the trip between the hotel and the NBS is approximately one half hour.

For your convenience, I have blocked off tentative room reservations for all of us, which should be confirmed on the attache hotel reservation form by each person. Attached, also, is an attendance card, which should be filled out and returned to me IMMEDIATELY. So that you can complete your travel plans, it is anticipated that the adjournment time will be about 4:00 P.M., in order to complete the planned agenda.

In calling the meeting, the Chairman stressed the importance of moving on this problem, in view of Congressman Ryan's Bill to prohibit PCB's, even in contained vessels. A copy of the Bill, H.R. 10085 and Congressman Ryan's statements in the Congressional Record of July 26 and July 29 are attached (ATTACHMENT #2). There may or may not be sufficient time to work with the Bill, dependent on the extent of pressure that may be put on this problem by the Administration or other interested groups and speed of action is certainly indicated.

Cont'd-

For your further information, Mr. Papageorge will initiate the discussions at the meeting by giving a comprehensive background report and summary of actions taken so far. He feels that the least that should be accomplished at this meeting is to appoint appropriate subcommittees to investigate and provide recommendations in such areas as were listed in the statement of proposed objectives, attached to the enclosed May 1, 1971 letter.

Sincerely yours,

A. M. Salazar, Secretary
ANSI Committee, C107

AMS:dk
Enc.
Att:
CC: B.H. Falk
C.A. Parris
Other National and
Government Groups Contacted.
T.K. Sloat
J.C. Rissinger
Sava Sherr, IEEE Staff
M. Pisciotta, ANSI Staff
J.J. Kark, NEMA Staff

NPC00023933

770749

RESPONDENTS

NATIONAL

CERTIFIED BALLAST MANUFACTURERS ASSOCIATION

Dr. A. Pozefsky
General Electric Company
Industrial and Power Capacitor Products Dept.
John Street
Hudson Falls, N. Y. 12839

N. R. Clark
Universal Manufacturing Company
902 Crescent Ave.
Bridgeport, Conn. 06607

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS, INC.

E. L. Raab, Manager - Insulation Systems Section
General Electric Company
Power Distribution Division
100 Woodlawn Ave.
Pittsfield, Mass. 01201

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

D. E. Allen, Manager, Marketing Services
Power Distribution Division
Allis-Chalmers Corporation
Columbus & Preble Aves.
Pittsburgh, Pa. 15233

J. F. Kuzela, Engineering Manager
Power Capacitors
Sangamo Electric Company
P.O. Box 359
Springfield, Ill. 62705

R. D. McClain
Westinghouse Electric Corporation
P.O. Box 341
Bloomington, Ind. 47402

W. C. Reinhardt, Manager
Research and Development
Central Moloney Transformer Division
Colt Industries
P.O. Box 101
St. Louis, Mo. 63166

H. R. Rowe, General Manager
Lighting & Capacitor Products
McGraw-Edison Power Systems Division
P.O. Box 160
South Milwaukee, Wis. 53172

ATTACH

NPC00023934

770750

GOVERNMENT

DEPARTMENT OF THE ARMY

David M. Crabtree, Chief of the Electrical Engg. Section
Facilities Engineering Division
Office of the Chief of Engineers
Department of the Army
Washington, D. C. 20314

ENVIRONMENTAL PROTECTION AGENCY

Earl Pershing Floyd
5555 Ridge Ave.
Cincinnati, Ohio 45213

GENERAL SERVICES ADMINISTRATION

Reuben T. Morgan
Federal Supply Service, Room 507
General Services Administration
Washington, D. C. 20406

Aaron J. Woloshin
Office of Environmental Affairs
General Services Administration
Washington, D. C. 20405

NATIONAL BUREAU OF STANDARDS

Dr. Stanley P. Wasik
Research Chemist
National Bureau of Standards
Room A145 Chemistry Building
Washington, D. C. 20234

RURAL ELECTRIFICATION ADMINISTRATION
DEPARTMENT OF AGRICULTURE

Dr. John Leutritz, Jr.
Timber Products Specialist
Distribution Engineering Branch
Power Supply, Management and
Engineering Standards Division
Rural Electrification Administration
Washington, D. C. 20250

TENNESSEE VALLEY AUTHORITY

William R. Nicholas
Assistant Chief of the Water Quality Branch
In the Division of Environmental Research and Development
Office of Health and Environmental Science.
Tennessee Valley Authority
Chattanooga, Tenn. 37401

ATTACHMENT #1

NPC00023935

INDIVIDUALS

CHEM-TROL POLLUTION SERVICES INC.

Louis E. Wagner, President
4818 Lake Ave.
Blasdell, N. Y. 14219

DOBLE ENGINEERING COMPANY

A. L. Rickley, Vice President
32 Locust Street
Belmont, Mass. 02178

ELECTRICAL UTILITIES COMPANY

A. O. Hauser, President
2427 St. Vincent Ave.
La Salle, Ill. 61301

MONSANTO COMPANY

W. P. Papageorge, Manager Environmental Control
800 N. Lindbergh Blvd.
St. Louis, Mo. 63166

P. G. Benignus, Marketing Manager,
Dielectric Fluids

ROLLINS-PURLE INC.

H. A. Alsentzer
P.O. Box 2349
Wilmington, Delaware 19899

C. W. Hart

P. Williamson

MONSANTO'S PCB PROGRAM

W. B. PAPAGEORGE

Presented at ANSI Committee C-107
Meeting - September 14, 1971

I appreciate the opportunity to share Monsanto's PCB experience with you and I hope the information I have can help this committee plan and achieve its objectives.

We at Monsanto first heard of PCB's as potential environmental contaminants in early 1967 when we received copies of a talk given in Sweden by Professors Widmark and Jensen of the University of Stockholm. In their paper they described how they were able to identify a material which had been interfering with pesticide analyses as being polychlorinated biphenyls.

Our laboratories began work on the development of analytical methodology to confirm that PCB's indeed were being found in the environment. During 1968 and 1969 as methodology improved the evidence continued to indicate that the higher chlorinated biphenyls were being identified in the tissues of fish and birds.

During this period Monsanto mounted an extensive program aimed at acquiring more knowledge about PCB's and their effect on environment. We perfected our analytical methods, we started animal toxicity studies, began biodegradation work and evaluated alternative materials for those applications we felt were contributing substantially to contamination.

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Our animal toxicity work was similar to the type we would have undertaken if we had wished to have FDA approval for food use. Chronic toxicity and reproduction studies were made on leghorn chickens. Two year chronic feeding studies were started on rats and dogs. Three generation reproduction studies were made on rats.

The PCB's used in the tests were Monsanto's Aroclor 1242, Aroclor 1254 and Aroclor 1260. These were selected since they represented the more commonly used PCB mixtures. The animals were fed concentrations of 1 ppm, 10 ppm and 100 ppm in their normal diets. The results to date indicate that at the levels used the rats and dogs showed no effects with Aroclor 1242. At 100 ppm both the rats and dogs exhibited decreased weight gains and enlarged livers. The chickens were affected by Aroclor 1242 at the 10 ppm level. The hatchability of the eggs was significantly reduced.

To summarize what I've said about Monsanto's sponsored animal toxicity work the highly chlorinated polychlorinated biphenyls at 100 ppm in the animal diet does have some effect on mammals. The lower chlorinated polychlorinated biphenyls at 10 ppm in the diet has some effect on leghorn chickens, and I say specifically leghorn chickens because there is mounting evidence that there are definite species variations as determined by the Patuxent Laboratories here in Maryland with four types of wild birds. There is a species variation noted which frustrates many scien-

I was asked what we know about the effect on marine life. Monsanto did sponsor static fish toxicity work and we were completely frustrated because these PCB's have the tendency to plate out on surfaces. Our information was garbled because in the static testing we were really exposing the fish to PCB environments a lot less than we thought we were. The data was so distorted it was meaningless. In the meantime, we found that there are many competent laboratories looking at fish and the effects on fish that we decided that maybe this is an area that is best left to the experts.

We have been in touch with laboratories such as the Water Quality Laboratory of Duluth, Minnesota. They have conducted studies which indicate there is some effect on some species. There has been some work done in the Columbia, Missouri Bureau of Interior Fish-Pesticide Laboratory which indicates, for example, magnification about 50,000 times. By that I mean that the amount of PCB detected in the fish tissues was 50,000 times that present in the water environment in which this fish was exposed.

There have been reports of fish kills and some very drastic effects attributed to PCB's. I've tried to get evidence that these things have occurred. I have not been able to confirm any reported incident.

We have talked with scientists at the Gulf-Breeze, Florida Commercial Fisheries Laboratory. They have conducted studies

with crab and shrimp. This is the laboratory that did detect a build-up in crab and also the lethal effect on juvenile shrimp. Very, very low concentrations - 5 ppb in the water - do destroy juvenile shrimp.

There is a growing thought among many of the responsible scientists that this environmental problem is most complex and it is not really any one insult that is the demise of any particular species, but it could be the cumulative effect of all insults a creature is exposed to and usually the last insult is the one that gets blamed. Dr. Tom Duke of Gulf-Breeze is a proponent of this theory and he is conducting studies to substantiate this. It could be the lack or presence of oxygen, the lack or presence of proper nutrients in the environment, the lack or presence of the proper temperature conditions, the exposure to a DDT or a cadmium or a mercury or an arsenic, and along comes a PCB and the fish dies. PCB might get blamed. This is the kind of thing that does happen in the environment.

There is a growing concern that we should be considering to a greater degree chronic effects of all these materials rather than relying on the old acute studies that used to serve as a screening for many, many chemicals. I have sketchy data on marine life. We know that it does build up in the marine environment and there is, of course, the published evidence that it does affect the fish-eating birds.

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There is some indication in the Duluth studies that reproduction and survival of the fry is affected. There seems to be minimal affect on adult fish.

It was suggested earlier that I might want to review the manufacture of PCB's, the many applications in which it was used and what our present program is. To the best of my information, it was 1929 that these materials were introduced as very attractive fluids for use in transformers, and there are many in this audience that are more familiar with this development than I am. PCB's were used in transformers as an insulating cooling fluid because they are more resistant to breakdown, less apt to explode and burst into flames and cause property damage and human injury.

Through the years, additional uses were found for these materials because of these properties that I mentioned earlier. They— gradually at first, and of course with increasing amounts,- ended up in applications that Monsanto through its in-house usage referred to as plasticizer usages. That is not a very good description, but it fit our needs for many years, and you'll find us using that expression. These are uses such as in paint formulations, the specialty ink uses, the plasticizer in sealants, adhesives, and paper coatings of all sorts.

There was a use that was a real thorn in our side and you'll see at least some of the earlier articles on PCB's referring to pesticide use. There were some studies conducted by the Department of Agriculture in which PCB's were used to extend the effect of

life of pesticides such as lindane. It was never intended for broadcasting as we visualize DDT was on food crops, cotton crops, or orchards. The only widespread use that I could find was a limited trial to help prevent or curtail the dutch elm disease, and that proved to be a failure. The other uses were extremely small in private formulations that were used to spray or coat hard surfaces - shelving, corners of floors and all for the typical crawling type insects such as the roach and silverfish. In fact it was so small that Monsanto did not market directly to pesticide formulators; we gave this business to our distributors. On the other hand, this use did cause considerable emotion and was used by some to explain the presence of PCB's in remote areas. We wrote to the Department of Agriculture suggesting that during 1970 when pesticides were being re-registered that PCB's not be approved. Finally in October they did put out a notice to that effect.

We have had questions raised, "Is it in my shower curtains at home? Is it in the draperies? In the Carpeting?" The answer to those is "not very likely". And I use those words because we really don't know. If it was put into these applications it was so small we, Monsanto, were not aware of it. It was not used in automobile tires; it was not used in brake linings.

Other major uses include the use in hydraulic fluids which are fire resistant. Monsanto marketed these fluids under the trademark Pydraul. I am sure some of you remember the Livet

(GM Hydraulic Plant)

Michigan fire?/ This was a disastrous fire in terms of property damage and was really a high mark in terms of convincing industry that there was a need for fire resistant hydraulic fluids. But the application is not the type that is maintained to a degree where everything is leakproof. Many of these connections leak, hoses burst, and the tendency is to keep producing by adding more fluid. So it is conceivable that many of these hydraulic fluids ended up in the sewer. I do not intend to criticize the customers of our products. From the knowledge that we had at that time of the material the practice was considered acceptable.

Another fairly widespread application of PCB's is the use of these fluids as a heat transfer media to achieve high temperatures, have a fire resistant transfer fluid, and avoid the installation of high pressure equipment. These materials were ideally suited for this application. We thought at one time that these were adaptable to close control and proper maintenance where we could logically call them closed systems. Some recent evidence indicated that we were wrong and I'll get into that when I discuss our present applications.

One application that was a fairly significant one and one that in our thinking is associated with coatings is the use in carbonless reproduction paper. With the emphasis on recycling paper wastes and with the persistance of PCB's there is a problem developing in that PCB's are being found in many paper products and many of these paper products end up in food packaging.

Initially the evidence we were getting seemed to point to the higher chlorinated materials as environmental pollutants. As soon as we were aware of this, we sent a letter to all of our customers telling them that what little we knew indicated that these materials could be an environmental problem, and care should be exercised in handling. When the results came in on our chicken toxicity studies they indicated that the lower chlorinated materials might be a problem regarding birds. We decided, as a company, that we better place some restrictions on these materials because there were to us some uses that deserved to be kept in spite of the problems that we saw facing us.

We decided that we've got to get out of those applications where we felt there was no earthly chance—or it was beyond our ability—to control the introduction into the environment, so we got out of all the so-called plasticizer applications. August 30, 1970 was the targeted effective date.

We then went into a very active program of reformulating the hydraulic fluids. There again, it required a lot of testing. We had to run these new materials through the Underwriters Laboratories for approval on fire resistance. They had to be compatible with the machinery then in use. This is not easily done, but it was done.

We decided that we could and must continue to supply the transformer manufacturer, the capacitor manufacturer, and at that

time closed heat transfer systems based primarily on our concept that fire resistance was important in heat transfer.

To pick up the point that was raised earlier about foreign imports, we are to the best of our ability trying to monitor imports. To this day, we have no information that any have arrived in this country. On the other hand, we are getting some reports that some of our former customers have made inquiries of the foreign producers. I am also told by some Canadian provincial agency people that they had heard and were going to further investigate that PCB's were entering Canada and from there moved into the United States. I have talked to representatives of the Japanese producer, the Kanegafuchi Company, and I am led to believe that they are most reluctant to enter this business. On the other hand, the Japanese producers are the producers that are being accused of entering the U.S. market. I have talked to representatives of the French companies. They assure me that they don't want any part of this business.

In May, 1970 Congressman William Fitz Ryan introduced a proposed bill which would in essence place into law the very things that Monsanto had proposed doing on a voluntary basis. The bill provided that PCB's be banned except for those situations where the Secretary of HEW would give special permission or license.

We went through the latter part of '70 and early part of this year feeling, however, that we were still walking on thin ice.

But we thought that we had made some tremendous strides in the right direction to preserve those uses which we thought were essential while eliminating those uses which were grossly contaminating the environment. This summer our hopes of control in the heat transfer business vanished when we found that a user of PCB did not appreciate the problem, did not maintain his equipment and created the recent chicken, egg, fishmeal problem.

Because of this incident, Congressman Ryan withdrew the first bill that was submitted and has now placed before the same committee a bill which totally bans PCB and does not provide for any use whatever. And there are, of course, penalties for the marketing, manufacture, or use of PCB in this country. A very drastic measure which does cause or can cause a lot of concern among those of us who feel that PCB has a place in our society under proper conditions.

As a result of this incident, we were forced to re-evaluate our position. We decided that, although heat transfer systems could be closed units, we are still at the mercy of the attitude of the operator of the equipment and we continuously faced the situation where even a pinhole leak can create tremendous problems before it can be discovered. So we have taken, again, an arbitrary position and informed all of our customers in the food (whether it's animal or human food), packaging business, and the pharmaceutical business, that we will no longer supply them heat transfer fluids which contain PCB's.

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In addition, we will no longer market to any new heat transfer applications. Our efforts will be concentrated on reducing those that we market today. This business should decrease as time goes on.

To get back to legislation ... as many of you probably know, there is before Senator Phillip Hart's committee a bill referred to as the Toxic Substances Act of 1971. The purpose of this bill is to prevent the introduction into our society of hazardous materials. It also provides for the review of materials now in our society and the curtailment of the use of the more hazardous ones. Initial hearings were held in August, to which a select few individuals were invited to testify. PCB was brought out as an example of a material introduced into society and thought at one time to be most valuable, but is now considered a serious threat to all of us.

The meetings will be resumed in October; I do not know the exact date as yet, and I'm led to believe that this would be the opportunity for industry to speak up in its behalf. I am sure that since PCB's were brought up as an example of the type of substance this bill is supposed to prevent that Monsanto as sole producer in this country will be either invited or we will choose to ask to be invited (we don't know at this point just what is the proper approach here) to speak on the merits of retaining PCB's in transformers, capacitors and fire resistant heat transfer systems, non-food applications.

I mention this bill because it is our opinion, and we could be wrong, that rather than act on Congressman Ryan's bill, which is specific toward PCB's, we suspect that the Toxic Substances Act will have in it provisions which will refer to such materials as PCB's.

We feel we have good technical data to justify our staying in the business for limited applications. But we cannot overlook the emotions that have set in. And believe me there are many and they are deep. It is difficult to combat emotions, as you know, and the references in the popular press to hazardous poisons and birth defects, which have not been substantiated, are most difficult to overcome. Although we talk about persistant versions of PCB and degradable versions of PCB I suspect, and this is a personal opinion, that there would be many who just discount this kind of information. This is a very real problem; in my opinion it is a difficult problem.

As a little more background let me describe what I understood from a meeting we held last week with representatives of the Food and Drug Administration. It is my personal opinion that the Food and Drug people are as conscientious as can be in trying to cope with the PCB problem. They are objective people trying to work with a minimum of data. I suspect they are as frustrated as any group of people can be as to what is the right way to go. There are tremendous pressures on the Food and Drug people that as well as the Department of Agriculture brought about...

These agencies are trying to objectively cope with the problem and at the same time trying to somehow live with these pressures that are being applied.

The FDA people really don't at this point in time have much information that will lead them to a regulation as to how much PCB should be tolerated in food. They have established some guidelines based on what little information they have from their own laboratories and the information that Monsanto has shared with them. The FDA will permit fish at 5 ppm on the marketplace; milk at .2 ppm or less; eggs .5 ppm; poultry (they have a double standard) 5 ppm in the fatty tissue and 5 ppm in the muscle tissue.

Another problem that is disturbing to the FDA, is the recycle paper problem. The cereal boxes, the cracker boxes, all of these boxes that are made from what is known as chipboard, are made from recycle paper. Fairly high levels of PCB's are being found in this recycle board. It probably comes from about three or four different sources. It may come from some ink application in the past, some adhesive application, some coating application, as well as the carbonless reproduction paper application. There have been some pilot studies made by the American Paper Institute to isolate the carbonless reproduction paper from the recycle batch. They still found PCB's in that batch. They are probably looking at maybe the second or third generation of recycle. And with the emphasis on recycle, I cannot see any way out of this dilemma except that there will be more and more PCB's in these cartons.

A thought we must all keep in mind, too, is that we've got to live with the PCB's we introduced into the environment for the past 40 years. They have not disappeared overnight; they will not disappear overnight. We do not have any tests that tell us how long it will take. We can only made an educated guess and we might say they will be out there for another generation, 25 to 30 years yet. Hopefully, it will be a decreasing amount as time goes on.

Monsanto has conducted biodegradation tests on its products. We have three programs that are now active. One program we are conducting in our laboratories in Ruabon, Wales in which we are making what I would refer to as scientifically basic studies in terms of which isomers are most degradable and with what type of microbe. This is a little bit on the impractical side at this point in time. We have as a consultant, Professor Charles Evans of Bangor University in South Wales, who is a noted authority worldwide in this kind of activity. He has isolated at least three microbes that seem to thrive on polychlorinated biphenyls. These microbes he developed from soil that he obtained from his garden. What this tells us is that there are microbes out there in the environment that will eventually destroy these materials.

In the St. Louis area, we have two types of tests going. One is the use of river water with its normal biota in it, in which we introduced these polychlorinated biphenyls and look for the disappearance rate. It is a very quick and rather unsophisticated type of study. The other type of test is the one that simulates

those conditions which are apt to be found in a normal municipal sewage treatment plant. It's an aerobic test using an activated sludge from a St. Louis waste treatment plant. As a standard, we use a soft detergent because it is well known to other laboratories. What we are doing, really is using our expertize that we established back in the days when the hard versus soft detergent controversy was quite common. And we are using these soft detergents that do degrade as our controls and comparing the PCB's to these controls. The studies so far show that there are isomers within each of these mixtures that do degrade. The lower the chlorine level, the faster they disappear, the higher the chlorine level the more resistant they are. Which only confirms what many of us had suspected. We were not too surprised by this data.

I will attempt to summarize ... I think we can conclude that PCB's are in the environment. There is no question about it. Many of these PCB's are manmade and were introduced to the environment because of our lack of understanding of what these materials can do to the environment. In this country Monsanto, as sole producer, has attempted to improve the situation by limiting the applications to which these materials are used. Studies today would indicate that these PCB's are not and cannot be classified as highly toxic. There is still a lot of information that is needed to help us determine the long term effect on human beings. We feel that the properties of these materials make them, at least as of today, the most suitable material for use in transformers, capacitors and heat transfer systems. We also believe that under proper conditions we can control the amount of these

that do enter the environment to the point where the adverse effects are not great and that the benefits we derive far outweigh the minor adverse effects that we might notice. Now there are many of us in the transformer and capacitor application that have made tremendous strides in controlling these materials. I suspect our objective is to further improve our ability to control this material. In my personal opinion the emotion that is now prevailing regarding PCB's is something that we must contend with. Whether we believe in it or not, there are many people that sincerely believe PCB's should be totally banned.

9/14/71

ANSI C107
NBS, Gaithersburg

NAME	AFFILIATING COMPANY	TITLE
F. R. Lengefeld	Union Electric Co. Elect. System & Equip Comm.	Mgr. - Elect. Engr. Dept.
A. L. Jennings	EPA, Office Water Programs Div. Oil & Hazardous Materials	Chemist
E. P. Floyd	EPA, Solid Waste Research, ORM	Chemist
W. S. Grogan	NEMA, Allis-Chalmers Pittsburgh Plant	Product Mgr. Small Power Transformers
C. W. Hart	Rollins-Purle, Inc.	Director - Technical Progress
J. Leutritz, Jr.	USDA - REA - Power Supply Elec, Maint, & Std. Div.	Timber Products Specialist
D. M. Crabtree	Office, Chief of Engineers Dept. of Army, ENGMC-FU Wash. DC 20314	Elec. Engr.
A. A. Thue	Office, Chief of Engineers Dept. of Army Wash. DC 20314	Chem. Engr.
W. R. Nicholas	Div. Envirn. Res. & Dev. Tennessee Valley Authority	Asst. Chief Water Quality Br.
G. P. Taggart	Chem-Trol Pollution Services Blasdell, NY	Chem. Engr.
W. C. Reinhardt	Rep. NEMA Chairman of NEMA Delagation Central Moloney, Inc.	Mgr. Materials & Processes
E. L. Raab	Rep. IEEE General Electric Co.	Mgr.- Insulation Systems
S. P. Wasik	Nat'l Bur. Standards	Chemist
A. Pozefsky	Rep. Certified Ballast Mfgr. General Electric Co.	Mgr. - Engineeri: Capacitor Dept.
T. K. Sloat	Rep. NEMA Westinghouse Elec. Corp. Sharon, PA	Mgr. - Fluids Insulation Sec.
P. G. Benignus	Monsanto St. Louis, MO	Dielectrics

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C. C. Travis	Gen. Services Admin. Wash. DC (FMC)	Special Assist for Consumer & Environ. Program
A. [redacted]	**Doble Eng. Co.**	**Vice President**
N. R. Clark	Certified Ballast Mfgr. Universal Manufacturing Corp.	Vice Pres. & Gen Mgr. of Capacito: Div.
E. G. Hammer	Rep. NEMA McGraw Edison Power Syst. Div.	Chief Engr. Capacitor Prod.
A. Hauser	Electrical Utilities Co. La Salle, IL	Chairman
W. P. Papa George	Monsanto	Mgr. Pollution Control
A. M. Salazar	NEMA Staff	Exec. Soc. Power Equip. Div.
R. D. McClain	[redacted]	Mgr. Cap. Unit Engr.
J. F. Kuzela	NEMA CP-1 Sangamo Elec. Co. Springfield, IL	Engr. - Mgr. Cap. Equip.

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KFD Pd. NL (Book 3)

National Elec'l Mfrs. Assn.
November 17, 1971

Date for meetings of Transformer and Capacitor Working Groups on Askarel changed to Wednesday, December 15, 1971, because of conflicts of two members. Please rush wire or phone if new date is NOT OK. Agenda follows:

A.M. Salazar, NEMA
FAX, New York, N.Y.

1. David M. Crabtree, Chief of the Electrical Engg. Section - Facilities Engg. Division
   Office of the Chief of Engineers
   Dept. of the Army
   Washington, D. C. 2

COPY

Chg. Div. 8

(Book 3 Cont'd)

2. W. S. Grogan, Product Manager
   Allis-Chalmers Corporation (412-322-4400)
   Columbus & Preble Aves.
   Pittsburgh, Pa. 15233
3. P. G. Benignus, Marketing Manager
   Monsanto Company
   800 N. Lindbergh Blvd.
   St. Louis, Mo.

COPY

CC: F.R. Lengefeld
W.C. Reinhardt
Dr. A. Pozefsky
N.R. Clark
E.L. Raab
J.F. Kuzela
R.D. McClain
W.P. Papageorge
T.K. Sloat
ErG. Hammer
Dr. E.M. Moore

COPY

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From : Engineering Department
WIN
Date : November 18, 1971
Subject: ANSI C-107 Use and Disposal of Askarels

BLOOMINGTON WORKS

Mr. J. B. Brittain
Engineering Manager

cc: Mr. D. M. Sauter
General Manager

Mr. Al Salazar, Secretary for ANSI C-107, called this morning to ask me to serve on the task force to draft a proposal for methods for using, maintaining and disposing of capacitors with askarel impregnants. I agreed to serve, and the first meeting will be in Chicago, December 14 or 15. Other members will be Messrs. Pozefsky, Chairman (G.E.), Clark (Universal Manufacturing), Hammer (McGraw Edison), Kuzela (Sangamo), and Dr. Moore (E.U.C.).

He further stated that minutes of the Gaithersburg meeting are to be mailed today, and that the Steering Committee has been appointed, composed of Messrs. Papageorge, Chairman (Monsanto), Clark, Langenfeld (Union Electric Company), Rheinhardt (Maloney), Raab (G.E.), Johnson (E.P.A.) and Dr. Moore.

The Steering Committee has designated the above Capacitor Task Force and a companion Transformer Task Force to draft proposed procedures to be followed in the use, maintenance and disposal of apparatus containing askarels. These drafts will then be considered by the main committee.

Robert D. McClain, Manager
Capacitor Unit Engineering

RDMcC:kb

FORM 1184-U

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ENGINEER'S TRIP REPORT
WESTINGHOUSE FORM 3811 G

FILE SHEET6BN

NOTE 1 - The Engineer reporting is responsible for the prompt delivery of his reports to all interested persons and for seeing that all points requiring action are cleared up without delay.
2 - For long reports give a summary of important points and recommendations.

CF2376

For Westinghouse Representatives only.

DATE Sept. 17, 1971

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☐		MR.
☐		MR.

VISIT - NAME _____ NEG. _____

LOCATION _____ G.O. _____ S.O. _____ SER. O. _____

PURPOSE OF TRIP ANSI Meeting - Committee C-107

CONFERENCE HELD AT Washington, D. C. DATE Sept. 14, 1971

THOSE PRESENT _____

SUMMARY:

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SIGNED (ENGINEER) R. L. Schwab APPROVED

DEPARTMENT	DIVISION	LOCATION	PAGE
			1

770773

INITIAL ORGANIZATIONAL MEETING OF
AMERICAN NATIONAL STANDARDS INSTITUTE
COMMITTEE C-107

W. P. Papgeorge of Monsanto was elected permanant chairman. Mr. A. M. Slaear of the NEMA staff was appointed secretary.

A steering committee will be appointed to:

1. Act as an advising group for the chairman on all matters.

2. Recommend subcommittees and select members of the subcommittees on problems as outlined in the scope.

3. Act as an advisory Group for all other National and International Societies.

The objectives of Committee C-107 are:

1. To prepare methods for the proper handling and maintenance of polychlorinated biphenyl liquids.

2. To prepare methods for the proper disposal of liquid polychlorinated biphenyl scrap.

3. To prepare methods for the proper disposal of solids contaminated with polychlorinated biphenyl liquids.

4. To communicate knowledge on all the polychlorinated biphenyls to all capacitor and transformer users and manufacturers.

Twenty-five representatives of various industries, societies and government agencies were in attendance and a list of those present is attached.

Mr. Papageorge gave a history of the environmental pollution studies first started in 1966 in Sweden on the PCB's and carrying thru to the latest information.

Uses of PCB's starting in 1929 are as follows:

1. Capacitors
2. Transformers
3. Plasticizers for paints
4. Plasticizers for paper coatings
5. Heat transfer medium
6. Used on carbon reproduction paper
7. Hydralic fluid (Tydrals - trade name)

All sales except for the following have been discontinued.

1. Transformers
2. Capacitors
3. Closed heat transfer systems

The usage has been reduced more than 50%. The higher chlorinated isomers have been reduced by the introduction of Monsanto 1016 material which fractionates the higher chlorinated isomers from the trichlor-tetrachlorobiphenyl materials.

The world wide usage is felt to be double that of the United States.

Sweden has banned the use of PCB's except for capacitors and transformers.

Congressman Ryan originally introduced a bill banning the sale of PCB's except for limited applications such as capacitors and transformers. He more recently has withdrawn this bill and introduced another with calls for the elimination of all manufacture of the PCB's. It was felt this bill would not get out of committee during this session of Congress and the PCB question would become a part of the work of the committee now planning action on control of materials under the Toxic Substances Act.

Hearings have been held on such substances as mercury, arsenic and atomic wastes and will resume in October. It may be possible this act will be passed this year.

The Food and Drug Administration has been under pressure from Congressman Ryan and Mr. Nadar for guide lines for all food stuffs. They have established the following maximum limits.

5 ppm or less in fish
.2 ppm in milk
5 ppm in fatty parts of chicken
5 ppm in muscle tissues of chickens
.5 ppm in eggs

The FDA has very recently appointed a task force headed by Dr. Burger of the office of Science and Technology to study the PCB problem. Representatives of several government agencies will be a part of this task force.

By the end of the year all manufacturers of capacitors will be using aroclor 1016 which has less than 0.4% of isomers above the tetrachlorobiphenyl.

The chairman of ANSI C-107 will contact the chairman of the Toxic Substances Hearing and make him aware of the C-107 committee. NEMA may

likewise advise the chairman of the need for the PCB's in closed systems.

The chairman of ANSI C-107 is to meet with Dr. Burger on Sept. 15 and advise him of the formation of the ANSI Committee.

The most significant statement made during the review of the current work was the fact that the trichlorobiphenyl was the substance found recently in chickens.

A final report of animal studies by Monsanto started in 1969 is expected in October 1971.

As soon as the official minutes of this meeting are available they will be circulated to the interested parties.

T. K. Sloat
9-17-71

american national standards institute, inc.

Address Secretary at
National Electrical Manufacturers Association
155 East 44th St., New York, N. Y. 10017
Telephone: 212-682-1500

C107

November 18, 1971

TO ALL MEMBERS OF THE SPECIAL WORKING GROUPS TO PREPARE PRELIMINARY RECOMMENDATIONS FOR THE CAPACITOR AND TRANSFORMER SUBCOMMITTEES, OF THE ANSI COMMITTEE, C107, ON USE AND DISPOSAL OF ASKAREL AND ASKAREL-SOAKED MATERIALS

WORKING GROUP ON TRANSFORMERS
Messrs: E.L. Raab, GE Co. - CHAIRMAN
D.M. Crabtree, Dept. of the Army
W.S. Grogan, Allis-Chalmers
F.R. Lengefeld, Union Electric
W.C. Reinhardt, Central Moloney
A.L. Rickley, Doble Engineering
T.K. Sloat, Westinghouse
P.G. Benignus, Monsanto - EX OFFICIO
W.P. Papageorge, Monsanto - EX OFFICIO

WORKING GROUP ON CAPACITORS
Messrs: Dr. A. Pozefsky, GE Co. - CHAIRMAN
N.R. Clark, Universal Mfg. Co.
E.G. Hammer, McGraw-Edison
J.F. Kuzela, Sangamo Electric
R.D. McClain, Westinghouse
E.M. Moore, Electric Utilities
(Person to be named by EEI)
P.G. Benignus, Monsanto - EX OFFICIO
W.P. Papageorge, Monsanto - EX OFFICIO

SUBJECT: AGENDA FOR THE WEDNESDAY, DECEMBER 15, 1971 MEETINGS

Gentlemen:

As you were notified by telephone on the subject, and confirmed by wire, the meetings will convene at 10:00 A.M. to 5:00 P.M. at the O'Hare Inn, near the airport in Chicago, Ill.

The purpose of the meetings is to consider, in depth, the following part of the scope and objectives of ANSI C107, in particular and, (1) specifically delineate the areas that should be considered for national standardization and/or implementation and, (2) initiate steps to draft recommendations for consideration by the Capacitor and Transformer Subcommittees:

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"Procedures and guides for safe use, maintenance and disposal of askarel and askarel-soaked materials used in electrical equipment."

As indicated on the telephone, pursuant with the action taken at the September 14, 1971 meeting of ANSI C107, the Chairman appointed a Steering Committee to "- - - serve as advisor and otherwise assist him in the performance of his office in the interim between meetings of ANSI C107." The membership of the Steering Committee is covered in ATTACHMENT #1.

The Chairman met with the Steering Committee on October 11, 1971 and the Capacitor and Transformer Subcommittees and the special Working Groups were appointed. In view of the nearness of the first meeting of the Working Groups, each member was contacted by telephone; and, by carbon copy of this letter to the full membership of ANSI C107, the members of the Subcommittees are hereby being notified of their appointment to these Groups. (Subcommittee membership is also included in ATTACHMENT #1).

As also indicated on the telephone, the format for the December 15, 1971 meetings is as follows:

1. Brief session on the items of information listed in ATTACHMENT #2. (Both Working Groups).

   Members are URGED to review ATTACHMENT #2 in advance of the meeting and be prepared to discuss any questions at the meeting.

2. Each Working Group will meet separately for the balance of the morning and join together for luncheon.

3. Each Working Group will continue with their separate meetings until approximately 3:30 P.M., when they will again meet together to review progress jointly.

A review of available publications and projects under way relating to mineral oil or askarel, resulted in the following:

1. AIEE No. 76 (December 1958) - Proposed Guide for Maintenance of Transformer Askarel (copy enclosed for both Working Groups).

   Mr. E. L. Raab, Chairman of the Transformer Working Group will distribute copies of the latest draft revision to bring this publication up-to-date.

2. IEEE #64 (March 1969) - IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment (copy enclosed for both Working Groups).

3. Doble Engineering Company's Guide for Maintenance of Transformer Askarel - (copies to be distributed to both Working Groups at the meetings).

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4. IEEE Project #P423 (authorized in March 1970) - Specification of New Askarel.

5. IEEE Project #P424 (authorized in March 1971) - Detection of Gases in Oil-Immersed Transformers.

6. ANSI C57 Terminology on Oil (ATTACHMENT #3).

For your further information, the Chairman of each Working Group plans to supplement this letter with a formal agenda for each meeting.

Sincerely yours,

A. M. Salazar, Secretary
ANSI C107

AMS:dk
Enc.
Attachments
CC: All Other Members of ANSI C107 Committee
J.C. Rissinger
C.K. Poarch, EEI Staff
J.J. Kark, NEMA Staff
Sava Sherr, IEEE Staff
M.A. Pisciotta, ANSI Staff

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STEERING COMMITTEE OF ANSI C107

CHAIRMAN: P. G. Benignus
Monsanto Company

N. R. Clark
Universal Manufacturing Company

Dr. E. M. Moore
Electrical Utilities Company

H. Johnson
Environmental Protection Agency

E. L. Raab
General Electric Company

F. R. Lengefeld
Union Electric Co.

W. C. Reinhardt
Central Moloney Transformer Division

TRANSFORMER (TR) AND CAPACITOR (C) SUBCOMMITTEES

CBMA

N. R. Clark Universal Manufacturing Company	C
Dr. A. Pozefsky - CHAIRMAN General Electric Company	C

EEI

F. R. Lengefeld Union Electric	TR & C

IEEE

E. L. Raab - CHAIRMAN	TR & C

NEMA

W. S. Grogan Allis-Chalmers Corporation	TR
E. G. Hammer McGraw-Edison Power Systems Division	C
J. F. Kuzela Sangamo Electric Company	C
R. D. McClain Westinghouse Electric Corporation	C
W. C. Reinhardt Central Moloney Transformer Division	TR
H. R. Rowe McGraw-Edison Power Systems	C
T. K. Sloat Westinghouse Electric Corporation	TR

ATTACHMENT #1

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GOVERNMENT

D. M. Crabtree Department of the Army	TR
H. Johnson Environmental Protection Agency	TR & C
Dr. John Leutritz, Jr. Rural Electrification Administration Department of Agriculture	TR & C
W. R. Nicholas Tennessee Valley Authority	TR & C
A. A. Thue Department of the Army	TR

INDIVIDUALS

P. G. Benignus Monsanto Company	TR & C
C. W. Hart Rollins-Purle Inc.	TR & C
A. O. Hauser Electrical Utilities Company	C
Dr. E. M. Moore Electrical Utilities Company	C
W. P. Papageorge Monsanto Company	TR & C
A. L. Rickley Doble Engineering Company	TR
G. P. Taggart Chem-Trol Pollution Services Inc.	TR & C

ATTACHMENT #1

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PCBs - The Electrical Industry

Steering Committee - ANSI - C107
St. Louis, Mo. 11/11/71

Pertinent comments relative to PCBs for use by the electrical industry and for consideration by the sub-committees on capacitors and transformers, include:

1. The electrical industry has no suitable fire-resistant dielectric fluid replacement for PCBs, polychlorinated biphenyls used in the askarel class of transformers and capacitors.

2. Because of this essential need and as the capacitors and transformers are hermetically sealed, Monsanto continues to supply selected PCB fluids for use only in this particular electrical apparatus and only as "make-up" fluid (no new systems) in a few carefully regulated closed system heat transfer applications.

3. Because the higher chlorinated PCBs persist in the environment, Monsanto has removed essentially all of the penta and hexachlorobiphenyl compounds from capacitor askarel. The new product used exclusively is called Aroclor 1016. Also the hexachlorobiphenyl compounds have been removed from use in the askarel type transformer fluids.

4. Strict and effective steps have been taken to avoid introduction of PCBs into the environment at Monsanto's plants and by

the facilities used where askarel type transformers and capacitors are made.

5. By discontinuing sale of PCBs for non-electrical applications, about 75 percent of the more persistent types have been removed from commerce.

6. The posture of the FDA includes:

   a) "We reject the need and in fact the feasibility as some have proposed for an outright ban on the substances. Although the use of PCBs requires control, an outright ban is not feasible and would not be in the best interest of the consumer."

   b) "All available evidence indicates that PCBs (in terms of acute toxicity) are classifiable as being of moderate toxicity." It was noted that PCBs are less toxic than DDT which is one of the safest pesticides to humans in acute toxicity terms.

7. When fed orally to standard test animals PCBs were found essentially non-toxic.

8. FDA guide lines for maximum levels of PCB allowed in food products are:

Fish	5 ppm
Chickens	5 ppm
Milk	0.2 ppm
Eggs	0.5 ppm
Catfish meal	0.3 ppm

9. Prolonged exposure of PCB liquid or vapor to the skin should be avoided to prevent possibility of chloroacne.
10. Prolonged exposure to vapors from hot PCBs should be avoided to prevent possible damage to the liver and kidney. 0.5 to 1.0 mg per cubic meter of air has been determined to be the maximum safe level of exposure during an 8 hour work day.
11. There is no evidence from extensive animal studies that PCBs are carcinogenic.
12. When PCBs are decomposed by an electric arc the gas formed is virtually entirely hydrogen chloride. If phosgene gas is formed at all, the amount is barely discernable.
13. Steps taken and judgements made to dispose of scrap PCB materials from the electrical industry include:
    a) Monsanto and others provide special high temperature incineration and gas scrubber facilities to completely destroy scrap PCB fluids. The scrap fluid may be sent to Monsanto Co., Sauget, Ill., attention supervisor Dept. A246 for incineration at 3 cents per pound.
    b) All Monsanto PCB product labels carry this message which is also being placed onto askarel transformers.
    c) It is the concensus that it is not feasible to collect and incinerate failed capacitors, at this time. They should be buried in a land-fill remote from lakes, streams or other sources of water.

    The incineration equipment already designed to take the place of land-fills has been demonstrated fully capable

of destroying the smaller capacitors as used for fluorescent ballast and motor-run purposes in air conditioners, etc. This equipment is also capable of destroying the impregnated paper and plastic film core structures removed from the larger power capacitors.

It is foreseen that eventually this type equipment will come into use to replace many land-fills. Until such time the faied capacitors should be buried in land-fills.

d) The solubility of PCBs in water is extremely low, in the range of 50 to 200 parts per billion, and the concensus is that PCB fluids do not migrate when buried in the soil.

e) Solid scrap transformer insulation including coils and cores should be drained free from PCBs followed by flushing or solvent extraction, using such solvents as perchloroethylene, or trichloroethylene employed in vapor degreasing. The scrap fluid mixtures should then be incinerated under conditions similar to those provided by Monsanto to destroy the PCBs.

P. G. Benignus
11/10/71

ANSI C57 TERMINOLOGY ON OIL

The The term "oil" includes the following insulating and cooling liquids:

1. Uninhibited Oil - Uninhibited oil is mineral transformer oil to which no symthetic oxidation inhibitor has been added.

2. Inhibited Oil - Inhibited oil is mineral transformer oil to which a synthetic oxidation inhibitor has been added.

3. Askarel - Askarel is a synthetic nonflammable insulating liquid which, when decomposed by an electric arc, evolves only nonexplosive gaseous mixtures.

ATTACHMENT #3

NPC00023971

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AIEE
No. 76
Dec. 1958

Proposed Guide
for
MAINTENANCE OF TRANSFORMER ASKAREL

(Published for trial use)

AIEE No. 76

Published by
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West Thirty-ninth Street, New York 18, N. Y.

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ACKNOWLEDGMENT

The Institute wishes to acknowledge its indebtedness to those who have so freely given their time and knowledge, and have conducted experimental work on which many of the AIEE publications are based.

The work of preparing this Guide was carried out by members of the Insulating Fluids Subcommittee of the AIEE Transformers Committee. The members of the subcommittee are:

C. P. Xenis, *Chairman*

R. G. Call
F. C. Doble
J. G. Ford
E. E. Gilcrease
R. B. Kaufman
L. M. Limpus
W. H. Meade
J. C. Parker
E. L. Raab
W. W. Satterlee
C. E. Welsh

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PROPOSED GUIDE

for

MAINTENANCE OF TRANSFORMER ASKAREL

I INTRODUCTION

The term askarel generally describes a widely-used, broad class of non-flammable synthetic halogenated hydrocarbon insulating liquid. As treated in this Guide it applies solely to askarel used in transformers, reactors, and accessory equipment operated at power frequencies. Certain essential properties must be retained if askarel is to perform reliably its dual role of electrical insulation and heat-transfer agent.

It must have adequate dielectric strength to withstand the electric stresses imposed in service. It must retain a sufficiently low viscosity so that its ability to circulate and transfer heat is not impaired. The dielectric losses should not become excessive. It should not be allowed to become so deteriorated or contaminated that it adversely affects other materials in the apparatus.

This guide attempts to assist the power equipment operator in his efforts to maintain askarel in serviceable condition. It recommends standardized tests and evaluation procedures. Methods are outlined for reconditioning and reclaiming askarel whenever necessary.

II ECONOMIC FACTORS

In Section III of this Guide askarel is classified on the basis of significant characteristics. Many of the undesirable characteristics of used askarel can be corrected by reconditioning or reclaiming, if economic considerations justify it. The alternate choice is to replace with new askarel.

A review of the experiences of many users of electric equipment reveals a wide variation in the actual cost data involved in the reconditioning or reclaiming of askarel. This variation can be attributed to the amount and condition of askarel involved, laboratory and shop facilities, whether the work is performed at one central or several distant locations and the availability of qualified personnel.

Askarel that contains water and insoluble contaminants can be reconditioned by mechanical means using a conventional filter press. If soluble and/or colloidal contaminants are present in the askarel, reclaiming can be done with a special filter press that uses minerals such as activated clay, activated alumina or aluminum hydroxide. These processes can be operated at a cost of from 2 to 10 cents per gallon for reconditioning and at a higher range of costs for reclaiming, depending on the quantity involved and the facilities available.

To determine if reconditioning or reclaiming of askarel, where possible, is economically justifiable, a number of factors must be considered. Some of these factors are as follows:

1. Value of askarel being considered for processing
2. Cost of processing materials
3. Total cost of process vs quality of end-product
4. Equipment maintenance and amortization
5. Cost of collection and storage
6. Labor and transportation costs
7. Laboratory cost
8. Loss of askarel during reprocessing
9. Cost of scavengers and make-up chemicals if addition is necessary and desirable
10. Cost of disposing of processing material and scrap askarel.

III CLASSIFICATION OF USED ASKAREL

It is extremely difficult, if not impossible, to indicate the value of specific tests and recommended test limits for all possible existing applications of askarel. It should also be recognized that with the present state of knowledge no one test can be used as the sole criterion of condition of askarel. It is possible, however, to summarize the value and importance of current tests and to suggest methods of treatment for the askarel being examined, such methods being based on current industry experience. Askarel may be placed in the following classifications based upon composite evaluation of significant characteristics and on field and laboratory screening tests. (Refer to Section VII—*Testing Procedures*)

GROUP I

This group contains askarel which is in satisfactory condition for continued use.

GROUP II

This group contains askarel which requires only minor reconditioning for further service (Reconditioning is the removal of moisture and insoluble contaminants. The usual method employed is dry paper filtration.) (Refer to Section VIII—*Methods of Reconditioning and Reclaiming Used Askarel*)

GROUP III

This group contains askarel in poor condition. It should be reclaimed or discarded determined upon economic considerations. (Reclamation involves the use of methods and processes which result in a beneficial chemical change in the askarel. Possible means employed are treatments

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with adsorption agents, aqueous extraction or washing procedures, alkali treatments, etc.) (Refer to Section VIII—*Methods of Reconditioning and Reclaiming Used Askarel*)

GROUP IV

This group contains askarel in such poor condition and requiring such drastic treatment that it is not feasible either technically or economically to attempt reclamation. An example of such a condition would be excessive oil contamination of an askarel.

IV ASTM ASKAREL TESTS AND THEIR SIGNIFICANCE

There are a number of tests than can be applied to transformer askarel as a basis for their classification as indicated in the foregoing. It is recommended wherever possible that tests be the latest revisions accepted as standards or tentative standards by ASTM. These tests and their significance are as follows —

Test	ASTM Designation
1 Dielectric Strength	D 901, D 877
2. Free Chlorides	D 901
3 Neutralization Number	D 901, D 974, D 664
4 Viscosity	D 901, D 88, D 445
5. Pour Point	D 901, D 97
6 Volume of Oil (percent)	D 901
7 Fire Point	D 901, D 92
8 Specific Gravity	D 901
9 Refractive Index	D 901
10 Color	D 901, D 155
11 Power Factor	D 901, D 924, D 150
12 Dielectric Constant	D 901, D 924, D 150

1. Dielectric Strength—D 901 and D 877

The dielectric strength of an askarel is the average voltage gradient at which electric failure or breakdown occurs under prescribed conditions. This test is made to determine whether an askarel has adequate electrical strength and may, in certain instances, reveal the presence of deleterious contaminants but is not necessarily an indication of its other properties.

2. *Free Chlorides—D 901

Askarel may contain free chlorides as a result of imperfect refining or contamination from other sources. Such free chlorides are undesirable because of their possible corrosive action or other deleterious effects in the presence of moisture. Aside from extraneous contamination, free chlorides may also result when the material is subjected to an electric arc or heated above a limiting temperature of 200C if the askarel does not contain a scavenger. This test indicates the presence of these free chlorides.

*The wording of the current D 901 pertaining to free chlorides requires revision in order to recognize the general industry usage of scavenger agents

3. Neutralization Number—D 901, D 974, and D 664

Neutralization number for used askarel is, in general, a measure of their acidic constituents and is measured as the milligrams of potassium hydroxide required to neutralize one gram of askarel under prescribed conditions. Askarel, unlike insulating oil, does not oxidize even under severe service conditions. Consequently, this test will indicate an acid condition obtained either by electric arcing or by contamination from other materials or sources.

4. Viscosity—D 901, D 88, and D 445

The viscosity of an askarel is its resistance to uniformly continuous flow, without turbulence, inertia, or other forces, and is usually determined by measuring the time of flow of a given quantity of the liquid, at a given temperature (37.8C (100F) unless otherwise specified), under controlled conditions. Viscosity is an intrinsic property of askarel dependent upon basic chemical composition and type. Under certain conditions, significant changes in viscosity of askarel in service may indicate evaporative losses of volatile components or contamination from other sources (i.e. mineral oils, sealing compounds).

5. Pour Point—D 901 and D 97

The pour point of an askarel is that temperature at which the liquid just flows under prescribed conditions. The pour point has little significance with respect to minor contamination or deterioration but may be useful for type identification.

6. Volume of Oil in Askarel—D 901

This method covers a procedure for the determination of the percentage, by volume, of oil in askarel. In evaluating used askarel, this test has considerable significance in maintaining prescribed nonflammability characteristics where oil contamination has been indicated by other test procedures.

7. Fire Point—D 901 and D 92

The fire point of a material is that temperature to which the material must be heated in order to support combustion when exposed to the atmosphere under prescribed conditions. Askarel, as such, has no fire point. The test is only of value, therefore, in showing whether the material has the non-flammable characteristics required of an askarel or has a large amount of combustible contaminant.

8. Specific Gravity—D 901

The specific gravity of an askarel is the ratio of the weights of equal volumes of askarel and water at 15.56C (60F). Specific gravity may be useful for type identification or to determine marked compositional changes.

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9. Refractive Index—D 901

The refractive index of an askarel, in common with all light-transmitting substances, may be defined as the ratio of the velocity of light in a vacuum to its velocity in the substance, under prescribed conditions. The refractive index of an askarel varies with its composition, and with the nature and amount of contaminants held in solution. Changes in refractive index on askarels in service may be useful in estimating compositional change and degree of soluble contamination.

10. Color D 901 and D 155

The color of an askarel is determined by transmitted light and is expressed by a numerical value based on comparison with a series of color standards under prescribed conditions. Color is chiefly significant as an indicator of soluble contamination in askarel. However, color in itself has limited value as a measure of serviceability since it may or may not correlate with physical and electrical characteristics of the liquid.

11. Power Factor—D 901, D 924 and D 150

Power factor is the ratio of the power dissipated in the askarel in watts to the product of the effective voltage and current in volt-amperes, when tested with a sinusoidal field under prescribed conditions. Since askarel is not subject to oxidation, an increase of power factor value of the askarel in service may be attributed to the presence of moisture or other contaminants. Depending upon type of apparatus and application, high power factor due to contamination other than by moisture seldom impairs the serviceability of the askarel, however, the high power factor may result in excessive heating of the device in which it is used.

12. Dielectric Constant—D 901, D 924 and D 150

The dielectric constant of an askarel is a measure of its relative ability to store electrostatic energy. It may be useful as an indication of composition and purity of an askarel.

V OTHER CRITERIA WHICH MAY BE HELPFUL IN EVALUATING THE QUALITY OF ASKAREL IN SERVICE

1. Visual Condition

This test indicates the presence of free water and sediment such as metal particles, carbon, dirt, solid insulation fragments, etc. Askarels containing metallo-organic hydrogen chloride scavengers may show some precipitation of the scavenger at low temperatures because of limited solubility. Under normal operating conditions, such material readily and rapidly redissolves and does not impair serviceability. One method of visually examining an askarel sample is to observe a representative sample in a clear glass tube or bottle. If the askarel by visual examination is clear, then the appropriate tests should be applied to classify the askarel in the proper group as initially defined above. If insoluble contaminants are present, valuable information may be obtained by filtering the askarel and identifying the residue. The askarel filtrate should be examined and classified in the same manner as a clear askarel sample.

A method for visual condition is currently under investigation by ASTM.

2. Water

Water may be present in several forms. The presence of free water may be disclosed by visual examination in the form of an immiscible layer, separated droplets or a cloud dispersed throughout the askarel. This type of water invariably results in decreased dielectric strength which may be restored by filtration or other suitable means. It is significant to note that free water, less dense than askarel, will separate at the top surface of the askarel. Water in solution cannot be detected visually and is normally determined by either physical or chemical means. One method under ASTM consideration is the Karl Fischer reagent method.

3. Askarel Insoluble Matter

Occasionally samples taken from equipment in service will show insoluble matter which might be composed of many types of material, i.e., fibers, dirt, water, carbon, insulating materials, etc. Under certain circumstances, it may be desirable to subject such residues to laboratory analysis.

4. Hydrogen Chloride Scavengers

Suitable quantitative methods for the estimation of the commonly used scavenger agents are available and at present are under consideration by ASTM.

5. Resistivity

The resistivity of askarel is a measure of its electrical insulating properties under prescribed conditions of test. High resistivity reflects low content of free ions and ion forming particles and normally indicates a low concentration of conductive contaminants.

VI SAMPLING

The sampling of askarel is important from the standpoint of evaluating quality. Particular care must be taken to prevent samples of askarel from coming in contact with moisture or other materials which may contaminate it. It is important that the procedures and the precautions outlined in the latest revision of ASTM Designation [illegible] pertaining to the sampling of askarel be [illegible]

VII TESTING PROCEDURES

The procedures for testing askarels are [illegible]

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similar to those for testing mineral oil and they depend to some extent on the testing equipment available. Most users of askarel find that testing is accomplished best in adequately-equipped laboratories. However, some users of transformers find it desirable to make "Field Screening Tests." Unlike mineral oil, askarel does not oxidize; consequently, sludge tests are unnecessary. Standard methods for testing askrael have been assembled by the ASTM Designation D 901.

(A) Field Screening

Field screening tests are usually made to determine which samples of askarel may require laboratory investigation. Since most tests of askarel can be done best with laboratory equipment and trained personnel, field tests are usually limited to visual inspection and dielectric strength.

No standardized procedure is available at the present time, for performing field tests on used askarel nor for classification.* Portable dielectric test sets have been available for some time and have proved satisfactory. Visual condition is at present a matter of personal opinion when the liquid is viewed in a glass container. (See Section V). In addition to the above tests, some operators with suitable field equipment and trained personnel may wish to gain additional information by use of a power factor test. In interpreting results of these tests consideration must be given to other characteristics of the askarel under test.

(B) Laboratory Screening

Askarel requiring laboratory evaluation will vary widely in condition depending upon the degree of contamination. There are many tests of a research nature which could be applied, but the general use of such tests would be impractical. The following tests, therefore, are believed to be adequate for classifying used askarel and when used should be performed in the order indicated.

Visual Condition
Water Content
Dielectric Strength
Free Chlorides
Power Factor or Resistivity
Neutralization Number
Volume of Oil (percent)

VIII METHODS OF RECONDITIONING AND RECLAIMING USED ASKAREL

A. GENERAL

Askarel can be reconditioned and reclaimed and restored to good operating condition in many instances. Since askarel does not oxidize the problem resolves itself to the removal of free moisture and other insoluble particles (reconditioning) and to the removal of certain soluble or colloidal contaminants such as varnishes, gums, resins, certain plastics, rubber-like materials, etc. (reclamation) with which the askarel may have come in contact. In addition askarel which has been exposed to temperatures in excess of 200C or to an electric arc will liberate hydrogen chloride gas and carbon. Special treatment is required for askarel which has been thus exposed.

There is no practical method of removing insulating oil from askarel. Askarel contaminated with oil sufficiently to affect its non-flammable characteristics must be discarded.

Only metallic hoses should be used in the handling of askarel since rubber and rubber-like compounds are attacked by it resulting in contamination of the askarel as well as deterioration of the hose. When recirculation methods are used the askarel should be taken near the top of the tank and returned at the bottom since free water and most of the sediment are found near the top surface of the askarel. Since such a procedure can introduce air into the askarel, sufficient time (two hours or more) should be allowed for the air to escape before reenergizing the apparatus. It is suggested that further detail be obtained from the manufacturer of the apparatus when desired. Considerable savings can frequently be realized in processing used askarel if it is allowed to remain in its container undisturbed for at least 24 hours so that water and suspended solids can separate from the askarel. Because of the ease with which askarel can be contaminated by insulating oil, reconditioning or reclaiming equipment should be reserved solely for use with askarel.

B. TREATMENT AFTER EXPOSURE TO HIGH TEMPERATURE OR AN ELECTRIC ARC

When askarel has been exposed to an electric arc or high temperature, dry nitrogen should be bubbled through the askarel for four to six hours. Approximately 220 cubic feet of nitrogen should be used for each 100 gallons of askarel. The treatment should be started as soon as practical as any hydrogen chloride liberated in combination with moisture will quickly attack exposed materials in contact with the askarel. This procedure is recommended even though the askarel contains a hydrogen chloride scavenger.

The nitrogen should be admitted at the bottom of the tank or container and the container should only be vented sufficiently to allow the nitrogen to escape in order to prevent the entrance of moisture and the formation of hydrochloric acid. Except while treating with nitrogen, the tank or container should be kept sealed, to prevent the entrance of moisture, until the askarel is removed.

When askarel has been subjected to arcing or high temperature, samples should be promptly taken and tested for color, free chlorides, neutralization number and visual condition. A laboratory check following recommended reclamation must

*To be determined by industry questionnaire.

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oils on a relatively small quantity of the askarel will indicate whether it is practical to reclaim it.

C. RECONDITIONING OF ASKAREL

The reconditioning of askarel, that is, the removal of water and other insoluble contaminants may be accomplished with a conventional filter press.

Filter presses vary somewhat in form, but are based upon the principle of forcing askarel under pressure through a series of absorbing materials such as paper. Filters of this type are capable of removing carbon, water, and other solid particles when they are in suspension but paper alone cannot remove them effectively when they are dissolved or in colloidal form. These devices will not remove air but in fact tend to aerate the askarel.

The water-removing ability of the filter press is dependent upon the dryness of the filter papers, and consequently ovens must be provided to dry the paper before use. When filtering askarel containing water the filter papers rapidly come into equilibrium with the water content of the askarel and from that time on the filtered askarel may contain water up to 100 percent of saturation at the temperature at which the filtering is done. Since the amount of dissolved water at saturation increases markedly with increasing temperature, filtering at low temperature is more effective in removing water. However, the temperature should not be so low that any hydrogen chloride scavenger present is precipitated out of solution.

The necessity of changing the filter papers is usually determined by an inspection of papers, an increase in input pressure, a lowering in the dielectric strength or a rise in water content of the filtered askarel.

D. RECLAIMING OF ASKAREL

Methods of reclaiming askarel to remove soluble or colloidal contaminants involve the use of materials such as activated clay, activated alumina, or aluminum hydroxide. While gravity or pressure percolation through activated clay has been used to some extent for reclaiming askarel, most askarel has been reclaimed using special filter presses in combination with activated clay. Figure 1 shows one such device in which a mixing tank is provided and a larger space is incorporated in the frames between sections of filter papers. About one fourth of the clay required to charge the press is mixed with a relatively small quantity of askarel in the mixing tank and the filter then operated to recirculate the askarel and thus deposit a cake of clay on the surface of the paper. Additional clay and askarel are mixed and recirculated until the desired cake has been established. The filter press is then ready to be used for reclaiming the askarel.

The arrangement shown in Figure 2 is similar except that the full charge of clay is placed in the auxiliary tank and the askarel is forced up through it. The askarel then passes through a wire screen prior to entering the filter press to remove practically all the clay. A relatively small quantity of askarel is used to fill the tank and wet the clay before the unit is ready to use.

Periodic tests on the output of these devices for the characteristic being improved will determine the necessity for changing the filter press papers or recharging with clay. The clay must be thoroughly dried before being used and temperatures ranging from 180C to 300C are recommended. Excessive amounts of clay and a high reclaiming temperature should be avoided since the use of large amounts of highly-active clay at high temperature would be expected to selectively absorb scavengers or stabilizers which the askarel may contain. Amounts of clay up to 0.1 percent by weight of the askarel treated and temperatures up to 60C will have no appreciable effect on the scavenger content.

To judge the sufficiency of reclamation, samples should be tested for color, free chlorides, neutralization number, dielectric strength, water content and power factor or resistivity. After the askarel has been reclaimed it is advisable to test for unreacted and reacted scavenger content in order to determine if scavenger should be added.

Much of the askarel left in the reclaimer can be saved by passing clean dry compressed air or dry nitrogen through the device at the end of the reclaiming operation.

IX ADDITION OF SCAVENGERS

As previously stated askarel which has been exposed to temperatures in excess of 200C or to an electric arc will liberate hydrogen chloride gas some of which dissolves. In order to minimize the effect of soluble hydrogen chloride on apparatus materials, askarel usually contains a small percentage of a certain chemical commonly called a "scavenger" or "getter," to mitigate the effects of the hydrogen chloride. Various manufacturers use different chemicals for this purpose, tin tetraphenyl and phenoxypropene oxide being the most common. Most askarel currently in use contains scavengers, however, there may be cases where the scavenger was not originally included or requires replacement.

Tin tetraphenyl is a white crystalline compound melting at 227C. Phenoxypropene oxide is a colorless liquid at ordinary temperatures. Small concentrations can effectively minimize the damage to apparatus parts which might be caused by the formation of hydrogen chloride. Concentrations on the order of 0.1 percent to 0.2 percent are ordinarily used. These scavengers have good dielectric properties, are nonvolatile and introduce no abnormal fire or explosion hazard.

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Before any scavenger is added to an askarel the manufacturer of the apparatus in which the askarel will be used should be consulted as to the amounts and method of addition. It is extremely important that the scavenger be of approved purity and that it be added in the recommended procedure. In general the scavenger is mixed with a small quantity of the askarel and then poured in the top of the apparatus. Extreme care must be taken to see that any containers, funnels, etc., (used) are clean, dry, and made of materials unaffected by the askarel.

X SPECIAL CONSIDERATIONS

A. Askarel Used Under Light Arcing Condition

Askarel is used, to some extent, in apparatus where it is subjected to light intermittent arcing such as in self-contained induction regulators, where operating switches are continually producing slight arcs, in transformer deenergizing switches etc. Under normal operating conditions deterioration of the askarel is very slight. However, improperly adjusted or defective switches in this type of apparatus can produce excessive and prolonged arcing with accelerated deterioration of the askarel. It is recommended that when askarel is used under these conditions checks of the liquid condition in conformance with manufacturers recommendations be made more frequently than when it is used only as a cooling and insulating fluid. Deterioration of this type is indicated by a blackening of the liquid. It can be reconditioned as previously described. Special attention should be given to maintaining the scavenger at the appropriate level.

B. Hazards

(a) Askarel Under Fault Conditions or Excessive Temperature

When askarel is subjected either to temperatures in excess of 200C or to an electric arc it distintegrates and hydrogen chloride gas is formed. During this disintegration process, portions of the liquid change into a gaseous state and abnormal pressures develop. Consequently it is recommended that, wherever possible, sealed askarel filled equipment be provided with pressure-relief devices. These devices must be large enough to provide immediate relief at a definite pressure and to prevent further build-up of pressure if decomposition continues. It must be remembered that the presence of devices of this sort does not necessarily preclude the rupturing of containing vessels since pressure build-up can be extremely rapid under violent arcing conditions.

Askarel in the uncontaminated state is, of course, non-flammable as is the hydrogen chloride gas that is generated during decomposition. However, if the askarel becomes contaminated with petroleum products flammable mixtures may result. Under these conditions secondary fires may result if relief devices or containing vessels rupture during fault. Consequently some thought should be given to location of askarel-filled equipment in order to minimize the hazard to person and property.

C. Personnel

It is generally accepted that exposure to askarel is not hazardous provided simple precautions are taken. Most people can handle askarel in the same manner as insulating oil without fear of toxic effects. As with insulating oil, some people are allergic to askarel and continued exposure may result in skin irritation, therefore, direct contact should be avoided where possible. Avoiding unnecessary contact with askarel and its vapor, particularly when it is hot, and cleanliness of workmen handling it should constitute adequate safeguards against such effects. Medicinal washes or detergents followed by an application of cold cream have been successfully used to eliminate irritation resulting from askarel coming into contact with an open cut or skin abrasion. A drop of castor oil has been found to neutralize, in most cases, irritation caused by contact of askarel with the eyes. It is recommended that small quantities of cold cream, castor oil, soap and clean water be readily available when askarel is being handled. There is no evidence that ordinary exposure to askarel vapors results in any ill effects. However, like other volatile materials, exposure to concentrated askarel vapors should be avoided, particularly in closed, unventilated rooms. As with many volatile liquids, the vaporization of askarel increases rapidly with temperature. Therefore, ventilation which is adequate for handling askarel at room temperature may not be adequate for handling askarel at elevated temperatures. The gases produced when askarel is disintegrated by very high temperatures or an electric arc in the presence of air or organic insulating materials contain a high percentage of hydrogen chloride and small percentages of carbon dioxide, carbon monoxide, oxygen and in some cases phosgene. Very small concentrations of this combination of gases are very unpleasant and irritating, thus giving ample warning of their presence. The all-purpose gas masks available for use around oil-filled devices are also used for protection from gases liberated from disintegrated askarel. Individual uses may require more detailed precautions in order to conform to local safety requirements pertaining to the specific operating conditions involved.

D. Storage and Handling of Askarel

Transformer askarel is a fluid and can be handled in much the same manner as transformer oil. Since askarel is somewhat more susceptible to contamination by moisture than transformer oil

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and also acts as a solvent on a large number of materials, considerable care must be exercised in its handling. The following general rules should be observed.

1. All necessary steps should be taken to maintain the askarel in a dry clean condition. This involves proper sealing, dryness and cleanliness of all storage containers and handling equipment.

2. Since askarel is a powerful solvent, care should be taken in the selection of materials to be used in contact with it. For example, consideration should be given to such things as the nature and compatibility of gasket materials, pipe-sealing compounds, container and tank linings (such as paints, varnishes, etc.) valve and pump packings and lubricants, the cleanliness and prior service of containers, storage tanks and transport lines. Only metal hoses should be used in handling since rubber and rubber-like compounds are attacked by askarel. It is important to avoid contamination of askarel with mineral oil and similar soluble organic materials. Therefore, handling equipment should be reserved solely for their use

3. In general care should be employed in the handling and processing of askarel to maintain it at or near room temperature to prevent undue volatilization of certain compounds and minimize removal of special scavenger additives due to solubility limitations or absorption on treating clays and to assure the most efficient removal of moisture by filtration or other means. All necessary precautions should be taken to provide adequate ventilation and other protective measures to properly protect those working with these materials.

4. Askarel weighs approximately twice as much as transformer oil, consequently thought should be given to size and structure of containing vessels.

5. More detailed information on various phases of these subjects, as generally treated above, is available in manufacturers' instructive pamphlets. These publications should be freely consulted when askarel-filled transformers are used.

E. Underwriters' Laboratories Reports

The Underwriters' Laboratories have exhaustively examined at the electrical manufacturers request the miscellaneous hazards involved in the use of askarel and askarel-filled apparatus. Reports have been issued to the respective manufacturer covering the tradenamed askarel being considered. It is suggested that interested users of transformer askarel contact the manufacturers for this information.

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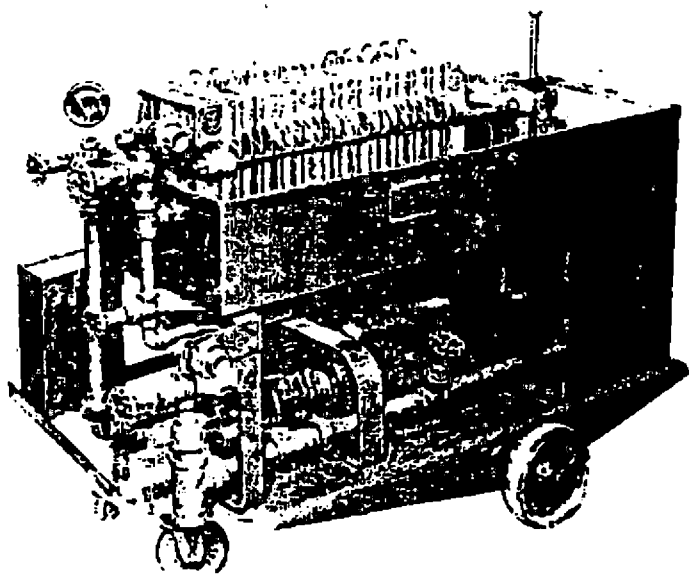


Figure 1
Askarel Filter Press

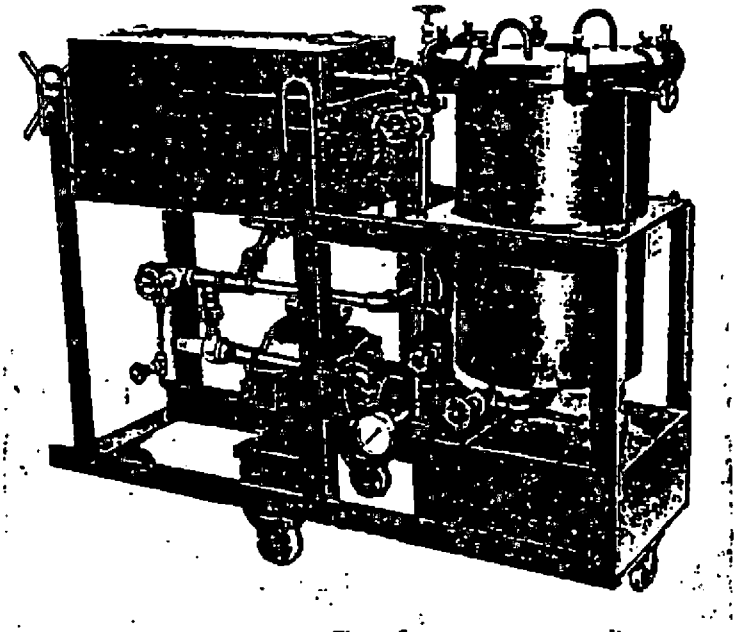


Figure 2
Askarel Filter Press with Auxiliary Clay Tank

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IEEE Guide for

Acceptance and Maintenance of

INSULATING OIL

IN EQUIPMENT

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IEEE Guide for Acceptance and Maintenance of

INSULATING OIL IN EQUIPMENT

1. INTRODUCTION

Insulating oil contained in equipment such as transformers, circuit-breaking devices, regulators, series and shunt reactors, as received from the manufacturer and as filled at the installation site but prior to service operation, should exhibit certain properties in order to insure satisfactory performance. It is expected that oil contained in equipment as received from the manufacturer when properly sampled from such equipment usually exhibits characteristics slightly different from those obtained from new oil, which has not been in contact with apparatus constructional materials.

Additionally, certain essential properties of insulating oil, used in transformers and circuit-breaking devices, must be retained in service if the oil is to perform its multiple role of electrical-insulating, arc-quenching, and heat-transferring agent reliably. It must have adequate dielectric strength to withstand the electric stresses imposed in service. It must retain a sufficiently low viscosity so that its ability to circulate and transfer heat is not impaired. It must pour readily at low temperatures and have high flash point and fire point for safety. Its dielectric losses should not become excessive. It should not be allowed to become so deteriorated or contaminated that it adversely affects other materials in the apparatus, nor should deterioration products sludge it sufficiently to impair its circulation through cooling ducts.

This Guide attempts to assist the power equipment operator in evaluating oil received in equipment and as filled at the installation site and to assist also in his efforts to maintain his oil in serviceable condition. It recommends and standardizes oil test and evaluation procedures, methods of reconditioning and reclaiming oil when necessary, and routines for restoring oxidation resistance by additions of inhibitors.

2. EVALUATION OF OIL RECEIVED IN NEW EQUIPMENT

Some users of power equipment find it desirable to make field screening tests while others find it more desirable to perform all tests on insulating oil in a laboratory. For those using field screening tests it is quite common to use such tests as dielectric breakdown voltage (most significant), neutralization number, color, and visual condition. Some operators with suitable equipment and trained personnel may wish to gain additional information by use of the interfacial tension test. If water-content or power-factor results are desired, such tests usually are performed in the laboratory.

In sampling oil contained in apparatus care must be used in order to obtain a representative sample. ASTM Method D923* should be followed.

Oil exhibiting the following characteristics is considered acceptable:

		ASTM Methods
Dielectric breakdown voltage	26 kV	D 877
Neutralization number	0.04 max	D 664, D 974
Color	1.0 max	D 1500
Condition—visual	clear	D 1524
Water content—parts per million	35 max	D 1533
Interfacial tension—dynes/cm (millinewtons/m)	35 min (0.35 min)	D 971
Power factor at 25°C	0.001 (0.1%) max	D 924
100°C	0.007 (0.7%) max	

3. EVALUATION OF OIL FOR USE IN FILLING APPARATUS AT THE INSTALLATION SITE AND AFTER FILLING SUCH APPARATUS**

(a) Oil in drums, tank trucks, or railroad tank cars received at an installation site must meet certain minimum characteristics in order to be suitable for field processing into equipment. This is currently under study with particular attention being given to those factors resulting in contamination of the oil by the transport container and to the limits of contamination allowable.

For circuit breakers filled at the installation site, it would be expected that the dielectric breakdown voltage of the oil at the time of filling should be a minimum of 30 kilovolts.

(b) The initial quality characteristics of oil in large apparatus filled at the installation site, particularly in the higher voltage classes, have not been firmly established as yet but are under study.

Oil taken from circuit breakers filled at the installation site should have a minimum dielectric breakdown voltage of 26 kilovolts.

4. CLASSIFICATION OF SERVICE-AGED INSULATING OIL

It is impossible to indicate the value of specific tests and recommended test limits for all possible existing applications of insulating oil in service. It should also be recognized that with the present state of knowledge

* ASTM methods referred to in this Guide are obtainable headquarters of the American Society for Testing and Materials, 1916 Race Street, Philadelphia 3, Pa.

** This is under study and material will be added here when study is complete.

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which the oil has been in contact, to reveal a tendency toward chemical change or deterioration, or to indicate chemical changes in additives. It may be used as a general guide for determining when an oil should be replaced or reclaimed, provided suitable rejection limits have been established and confirmation is received from other tests.

The tests for field use are not intended to replace standard laboratory tests, but rather are intended as screening tests to minimize the number of field samples submitted to the laboratory. They permit approximate evaluations of the amount of acid and polar constituents and hence of the degree of deterioration and/or contamination of the oil. However, they are only semi-quantitative and any decision to replace or reclaim an oil should be confirmed by laboratory tests.

2) Dielectric Breakdown Voltage—D 877, D 1816

The dielectric breakdown voltage of an insulating liquid is of importance as a measure of its ability to withstand electric stress without failure. It is the voltage at which breakdown occurs between two electrodes under prescribed test conditions. It also serves to indicate the presence of contaminating agents such as water, dirt, or conducting particles in the liquid, one or more of which may be present when low dielectric breakdown values are found by test. However, a high dielectric breakdown voltage does not indicate the absence of all contaminants.

Method D 1816 is a recently developed method that prescribes the use of spherically capped electrodes. It is sensitive to small amounts of contaminants and therefore is primarily suitable for use with new oils. Its significance for evaluating service-aged oils is being determined.

Method D 877 is generally considered to be more suitable for testing service-aged oils at this time.

3) Interfacial Tension—D 971 Field Test—D 2285

The interfacial tension between an electrical insulating oil and water is a measure of the molecular attractive force between their unlike molecules at the interface. It is expressed in dynes per centimeter (millinewtons per meter). This test provides a means of detecting soluble polar contaminants and products of deterioration. Soluble contaminants or oil-deterioration products generally decrease the interfacial tension value.

4) Power Factor—D 924

Power factor is the ratio of the power dissipated in the oil in watts to the product of the effective voltage and current in voltamperes, when tested with a sinusoidal field under prescribed conditions. A high value is an indication of the presence of contaminants or deterioration products such as water, oxidation products, metal soaps, charged colloids, etc.

5) Color—D 1500, D 1524

The color of an insulating oil is determined by means of transmitted light and is expressed by a numerical value based on comparison with a series of color standards. A rapidly increasing or high color number is an indication of oil deterioration or contamination or both. ASTM D 1524 includes a field test suitable for gauging color of service-aged electrical insulating oil.

6) Viscosity—D 88, D 445, D 2161

The viscosity of an oil is its resistance to uniformly continuous flow without turbulence, inertia or other forces. The viscosity of insulating oil is usually measured by the time of flow of a given quantity of oil under controlled conditions. Viscosity is not significantly affected by oil contamination or deterioration but may be useful for identifying certain types of service-aged insulating oils.

7) Flash Point—D 92

The flash point of oil is the temperature to which the material must be heated in order to give off sufficient vapor to form a flammable mixture with air under the conditions of the test.

The fire point of oil is the temperature to which the material must be heated in order to cause the oil to ignite and continue burning under the conditions of the test. This temperature is always higher than the flash-point temperature.

A low flash point indicates the presence of hazardous volatile combustible contaminants in the insulating oil. An acceptable flash point is always followed by an acceptable fire point at some higher temperature.

8) Steam Emulsion—D 1935

In the steam emulsion test, steam is passed into the oil under prescribed conditions, and the time in seconds required for separation of the oil and the condensed steam is recorded as the steam emulsion number (S. E. Number) of the oil.

The steam emulsion number may be of value in indicating the presence of certain undesirable impurities but has not been widely applied to service-aged oils.

9) Specific Gravity (Relative Density)—D 1298

The specific gravity (relative density) of an insulating oil is the ratio of the weights of equal volumes of oil and water at 15.56°C (60°F). Specific gravity (relative density) is not significant as such in determining the quality of an oil but may be pertinent in determining suitability for use in specific applications. In certain cold climates ice may form in equipment exposed to subzero (C) temperatures and may float in oil of high specific gravity (relative density).

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circumstances, it may be desirable to subject such residues to further laboratory examination and analysis.

21) Refractive Index and Specific Optical Dispersion—D 1807

The refractive index of an insulating oil varies with its composition and with the nature and amount of contaminants held in solution. Thus for service-aged oils, refractive index may be pertinent, if compared to the value for the new product, to detect and estimate any change in composition or degree of contamination.

Specific optical dispersion serves as a quick index for the amount of unsaturated compounds present in an oil; for insulating oils, values above a minimum of about 97 bear a direct relationship to the amount of aromatic compounds present.

These tests have not been widely applied to service-aged oils.

8. TESTING PROCEDURES

The procedure followed in applying tests to service-aged insulating oils depends to a great extent on the physical characteristics of the particular property involved and also on the economic considerations. Some users of power equipment find it desirable to make field screening tests while others find it desirable to perform all tests on service-aged insulating oil in a laboratory.

8.1 Field Screening. Several users of insulating oil use field screening to a great extent. Their experience in this matter indicates that visual condition, dielectric strength, neutralization number, and color will suffice for segregating oil in Groups I and II.

In addition to these tests, some operators with suitable field equipment and trained personnel may wish to gain additional information by use of such tests as interfacial tension and power factor. In interpreting results of these tests consideration must be given to other oil characteristics.

Portable dielectric test sets have been available for some time and have proved quite satisfactory. Several portable test kits are commercially available for testing oil color, acidity, and interfacial tension in the field. As listed and described above, the American Society for Testing and Materials has issued tentative standard field tests for Visual Condition and Color (D 1524), for Approximate Acidity (D 1534), for Approximate Acidity and Polar Contamination (D 1902), and for Interfacial Tension (D 1287).

8.2. Laboratory Screening. Oils requiring laboratory evaluation will vary widely in condition depending upon the amount of deterioration and the degree of contamination. There are many tests of a research nature that could be applied, but the general use of such tests would be impractical. The following tests, therefore, are believed to be adequate for classifying service-aged oil.

	ASTM Method
Visual condition	D 1524
Color	D 1500
Neutralization number	D 664, D 974
Dielectric breakdown voltage	D 877, D 1816
Interfacial tension	D 971
Water	D 1315, D 1533
Power factor	D 924
Sediment and oil-soluble sludge	D 1698
Inhibitor content	D 1698
Viscosity*	D 88, D 445, D 2161
Specific gravity*	D 1298
Pour point*	D 97
Corrosive sulfur	D 1275

* Not essential but can be used to establish type identification.

9. METHODS OF RECONDITIONING AND RECLAIMING SERVICE-AGED INSULATING OIL

When service-aged insulating oil is to be subjected to reconditioning and/or reclaiming processes it is very strongly recommended that every advantage possible be taken of natural precipitation. Considerable savings can frequently be realized in processing service-aged oil if it is allowed to remain in its container undisturbed for at least 24 hours so that water and suspended solids can settle out. The oil can then be removed without disturbing the residue in the bottom of the container, thus obviating the necessity of removing this residue from the processing machinery.

For purposes of this Guide, reconditioning is construed to be the removal of moisture and solid materials, by mechanical means while reclaiming is the removal of acidic and colloidal contaminants and products of oxidation by chemical and adsorbent means.

9.1. Reconditioning. The mechanical means that are used for removing water and solids from oil include several types of filters, centrifuges, and vacuum dehydrators. The extent of the usage of each is shown in the Appendix.

9.1.1. Filters. *Filter devices including the common filter* press vary somewhat in form but are based upon the principle of forcing oil under pressure through a series of absorbing materials such as paper. Filters of this type are capable of removing carbon, water, sludge, etc., when they are in suspension but, except for certain special arrangements, they cannot remove them effectively when they are dissolved or in colloidal form. These devices will not remove air and in fact tend to aerate the oil.

The water-removing ability of the filter is dependent upon the dryness of the filter media, and consequently suitable ovens should be provided to dry them before use. When filtering oil containing water, the filter media rapidly come into equilibrium with the water content of the oil and from that time on the filtered oil may contain water up to 100 percent of saturation at the temperature at which the filtering is done. Since the amount of dissolved water at saturation increases markedly with increasing temperature, filtering at low temperature is more effective in removing water. In the past there has been no satisfactory method of determining when the fil-

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IEEE Guide for Acceptance and Maintenance of

INSULATING OIL IN EQUIPMENT

1. INTRODUCTION

Insulating oil contained in equipment such as transformers, circuit-breaking devices, regulators, series and shunt reactors, as received from the manufacturer and as filled at the installation site but prior to service operation, should exhibit certain properties in order to insure satisfactory performance. It is expected that oil contained in equipment as received from the manufacturer when properly sampled from such equipment usually exhibits characteristics slightly different from those obtained from new oil, which has not been in contact with apparatus constructional materials.

Additionally, certain essential properties of insulating oil, used in transformers and circuit-breaking devices, must be retained in service if the oil is to perform its multiple role of electrical-insulating, arc-quenching, and heat-transferring agent reliably. It must have adequate dielectric strength to withstand the electric stresses imposed in service. It must retain a sufficiently low viscosity so that its ability to circulate and transfer heat is not impaired. It must pour readily at low temperatures and have high flash point and fire point for safety. Its dielectric losses should not become excessive. It should not be allowed to become so deteriorated or contaminated that it adversely affects other materials in the apparatus, nor should deterioration products sludge it sufficiently to impair its circulation through cooling ducts.

This Guide attempts to assist the power equipment operator in evaluating oil received in equipment and as filled at the installation site and to assist also in his efforts to maintain his oil in serviceable condition. It recommends and standardizes oil test and evaluation procedures, methods of reconditioning and reclaiming oil when necessary, and routines for restoring oxidation resistance by additions of inhibitors.

2. EVALUATION OF OIL RECEIVED IN NEW EQUIPMENT

Some users of power equipment find it desirable to make field screening tests while others find it more desirable to perform all tests on insulating oil in a laboratory. For those using field screening tests it is quite common to use such tests as dielectric breakdown voltage (most significant), neutralization number, color, and visual condition. Some operators with suitable equipment and trained personnel may wish to gain additional information by use of the interfacial tension test. If water-content or power-factor results are desired, such tests usually are performed in the laboratory.

In sampling oil contained in apparatus care must be used in order to obtain a representative sample. ASTM Method D923* should be followed.

Oil exhibiting the following characteristics is considered acceptable:

		ASTM Methods
Dielectric breakdown voltage	26 kV	D 877
Neutralization number	0.04 max	D 664, D 974
Color	1.0 max	D 1500
Condition—visual	clear	D 1524
Water content—parts per million	35 max	D 1533
Interfacial tension—dynes/cm (millinewtons/m)	35 min (0.35 min)	D 971
Power factor at 25°C	0.001 (0.1%) max	D 924
100°C	0.007 (0.7%) max	

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For circuit breakers filled at the installation site, it would be expected that the dielectric breakdown voltage of the oil at the time of filling should be a minimum of 30 kilovolts.

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The tests for field use are not intended to replace standard laboratory tests, but rather are intended as screening tests to minimize the number of field samples submitted to the laboratory. They permit approximate evaluations of the amount of acid and polar constituents and hence of the degree of deterioration and/or contamination of the oil. However, they are only semi-quantitative and any decision to replace or reclaim an oil should be confirmed by laboratory tests.

2) Dielectric Breakdown Voltage—D 877, D 1816

The dielectric breakdown voltage of an insulating liquid is of importance as a measure of its ability to withstand electric stress without failure. It is the voltage at which breakdown occurs between two electrodes under prescribed test conditions. It also serves to indicate the presence of contaminating agents such as water, dirt, or conducting particles in the liquid, one or more of which may be present when low dielectric breakdown values are found by test. However, a high dielectric breakdown voltage does not indicate the absence of all contaminants.

Method D 1816 is a recently developed method that prescribes the use of spherically capped electrodes. It is sensitive to small amounts of contaminants and therefore is primarily suitable for use with new oils. Its significance for evaluating service-aged oils is being determined.

Method D 877 is generally considered to be more suitable for testing service-aged oils at this time.

3) Interfacial Tension—D 971 Field Test—D 2285

The interfacial tension between an electrical insulating oil and water is a measure of the molecular attractive force between their unlike molecules at the interface. It is expressed in dynes per centimeter (millinewtons per meter). This test provides a means of detecting soluble polar contaminants and products of deterioration. Soluble-contamination or oil-deterioration products generally decrease the interfacial tension value.

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Power factor is the ratio of the power dissipated in the oil in watts to the product of the effective voltage and current in voltamperes, when tested with a sinusoidal field under prescribed conditions. A high value is an indication of the presence of contaminants or deterioration products such as water, oxidation products, metal soaps, charged colloids, etc.

5) Color—D 1500, D 1524

The color of an insulating oil is determined by means of transmitted light and is expressed by a numerical value based on comparison with a series of color standards. A rapidly increasing or high color number is an indication of oil deterioration or contamination or both. ASTM D 1524 includes a field test suitable for gauging color of service-aged electrical insulating oil.

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The flash point of oil is the temperature to which the material must be heated in order to give off sufficient vapor to form a flammable mixture with air under the conditions of the test.

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In the steam emulsion test, steam is passed into the oil under prescribed conditions, and the time in seconds required for separation of the oil and the condensed steam is recorded as the steam emulsion number (S. E. Number) of the oil.

The steam emulsion number may be of value in indicating the presence of certain undesirable impurities but has not been widely applied to service-aged oils.

9) Specific Gravity (Relative Density)—D 1298

The specific gravity (relative density) of an insulating oil is the ratio of the weights of equal volumes of oil and water at 15.56°C (60°F). Specific gravity (relative density) is not significant as such in determining the quality of an oil but may be pertinent in determining suitability for use in specific applications. In certain cold climates, ice may form in equipment exposed to subzero (C) temperatures and may float in oil of high specific gravity (relative density).

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circumstances, it may be desirable to subject such residues to further laboratory examination and analysis.

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The refractive index of an insulating oil varies with its composition and with the nature and amount of contaminants held in solution. Thus for service-aged oils, refractive index may be pertinent, if compared to the value for the new product, to detect and estimate any change in composition or degree of contamination.

Specific optical disperaion serves as a quick index for the amount of unsaturated compounds present in an oil; for insulating oils, values above a minimum of about 97 bear a direct relationship to the amount of aromatic compounds present.

These tests have not been widely applied to service-aged oils.

8. TESTING PROCEDURES

The procedure followed in applying tests to service-aged insulating oils depends to a great extent on the physical characteristics of the particular property involved and also on the economic considerations. Some users of power equipment find it desirable to make field screening tests while others find it desirable to perform all tests on service-aged insulating oil in a laboratory.

8.1 **Field Screening.** Several users of insulating oil use field screening to a great extent. Their experience in this matter indicates that visual condition, dielectric strength, neutralization number, and color will suffice for segregating oil in Groups I and II.

In addition to these tests, some operators with suitable field equipment and trained personnel may wish to gain additional information by use of such tests as interfacial tension and power factor. In interpreting results of these tests consideration must be given to other oil characteristics.

Portable dielectric test sets have been available for some time and have proved quite satisfactory. Several portable test kits are commercially available for testing oil color, acidity, and interfacial tension in the field. As listed and described above, the American Society for Testing and Materials has issued tentative standard field tests for Visual Condition and Color (D 1524), for Approximate Acidity (D 1534), for Approximate Acidity and Polar Contamination (D 1902), and for Interfacial Tension (D 1295)

8.2. **Laboratory Screening.** Oils requiring laboratory evaluation will vary widely in condition depending upon the amount of deterioration and the degree of contamination. There are many tests of a research nature that could be applied, but the general use of such tests would be impractical. The following tests, therefore, are believed to be adequate for classifying service-aged oil.

	ASTM Method
Visual condition	D 1524
Color	D 1500
Neutralization number	D 664, D 974
Dielectric breakdown voltage	D 877, D 1816
Interfacial tension	D 971
Water	D 1318, D 1533
Power factor	D 924
Sediment and oil-soluble sludge	D 1698
Inhibitor content	D 1698
Viscosity*	D 88, D 445, D 2161
Specific gravity*	D 1298
Pour point*	D 97
Corrosive sulfur	D 1275

* Not essential but can be used to establish type identification.

9. METHODS OF RECONDITIONING AND RECLAIMING SERVICE-AGED INSULATING OIL

When service-aged insulating oil is to be subjected to reconditioning and/or reclaiming processes it is very strongly recommended that every advantage possible be taken of natural precipitation. Considerable savings can frequently be realized in processing service-aged oil if it is allowed to remain in its container undisturbed for at least 24 hours so that water and suspended solids can settle out. The oil can then be removed without disturbing the residue in the bottom of the container, thus obviating the necessity of removing this residue from the processing machinery.

For purposes of this Guide, reconditioning is construed to be the removal of moisture and solid materials, by mechanical means while reclaiming is the removal of acidic and colloidal contaminants and products of oxidation by chemical and adsorbent means.

9.1. **Reconditioning.** The mechanical means that are used for removing water and solids from oil include several types of filters, centrifuges, and vacuum dehydrators. The extent of the usage of each is shown in the Appendix.

9.1.1. **Filters.** Filter devices including the common filter press vary somewhat in form but are based upon the principle of forcing oil under pressure through a series of absorbing materials such as paper. Filters of this type are capable of removing carbon, water, sludge, etc., when they are in suspension but, except for certain special arrangements, they cannot remove them effectively when they are dissolved or in colloidal form. These devices will not remove air and in fact tend to aerate the oil.

The water-removing ability of the filter is dependent upon the dryness of the filter media, and consequently suitable ovens should be provided to dry them before use. When filtering oil containing water, the filter media rapidly come into equilibrium with the water content of the oil and from that time on the filtered oil may contain water up to 100 percent of saturation at the temperature at which the filtering is done. Since the amount of dissolved water at saturation increases markedly with increasing temperature, filtering at low temperature is more effective in removing water. In the past there has been no satisfactory method of determining when the filter

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9.2.1.2. **Percolation by Gravity**—Gravity percolation makes use of gravity or the hydrostatic head of a column of oil to force the oil through a column of clay. A typical gravity system, shown schematically in Figure 1, consists of three tanks on different levels. The upper tank is used as a dirty-oil reservoir, the middle tank as the filter containing the fuller's earth, and the lower tank as a blending chamber for the filtered oil. The middle tank is equipped with a strainer-type bottom covered by canvas or filter cloth supporting a 6-foot (2-meter) bed of clay. A float valve controls the flow of oil from the dirty-oil storage tank above so that a constant head of about 15 feet (5 meters) to the filter plate is provided. Once the process is started it continues in operation with very little attention other than periodic sampling. Tests for interfacial tension or acidity are used to control the process.

The output of gravity percolation is a graded one starting with water-white overtreated oil and ending with oil in approximately the same condition as before treatment. To obtain a uniform product, blending is necessary in the third tank in the series. Some convenient mechanical means of agitating the oil in this tank is essential.

It has been assumed that the undesirable characteristics of the overtreated oil that first comes through the earth are offset in the blending process.

By this method the oil can be treated to any desired degree. The flow rate of such a method is slow, being about 10 gallons per hour per square foot (400 liters per hour per square meter) of filter bed area for an installation such as the one described above. This slow flow rate results in a relatively long contact time which makes for efficient use of the clay.

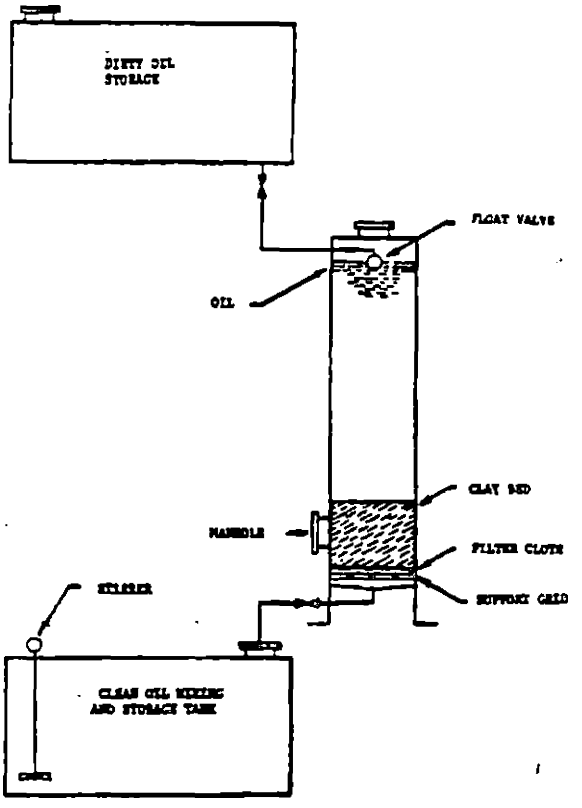


Figure 1. Schematic diagram of gravity-percolation refining apparatus.

9.2.1.3. **Contact Process**—The contact process for reclaiming oil makes use of 200-mesh (77 mesh per centimeter) fuller's earth and relatively high operating temperatures. This process makes the most efficient use of the earth and produces a uniform product. The degree of reclaiming depends on the amount of earth used which is determined by an analysis of the deteriorated oil.

In a typical commercial apparatus, oil is introduced into a heated mixing chamber as a measured amount of earth is fed in through a hopper. The mixture is stirred as heat is applied, and the process continues until the desired temperature is reached. This operation requires about half an hour. The oil is then dropped into a tank before it is pumped through a filter especially built to accommodate the earth. Much of the oil ordinarily retained in the earth is extracted by the application of compressed air to the filter. A semiautomatic type of apparatus is on the market which recharges itself and operates until the filter becomes filled with clay.

This type of apparatus does not lend itself to the treatment of oil in transformers under load, as, operating on the batch principle, it withdraws oil from the apparatus and does not return the oil for 45 minutes. Also it should not be used to process oil containing DBPC if it is desired to retain the inhibitor in the oil, as this material, when catalyzed by clay, begins to decompose at 100°C.

9.2.2. **Choice of Methods.** The choice of reclamation methods that will prove the most practical and economical for a given system depends upon the geographical characteristics of the power system, the existing facilities available for application to such work, and the facts concerning the various types of refining equipment and methods previously described.

For example, on a compact system with large quantities of damaged oil or on a system where oil reconditioning has been done in the past at a central location, the gravity-percolation method of reclaiming has many advantages in requiring a minimum amount of new equipment, attention, and labor. On a system where the oils requiring attention are widely scattered in location, service outages are difficult to obtain, and spare equipment is at a premium, some type of portable pressure percolator may be indicated for reclaiming in the field by recirculating the oil in the equipment. The possibility of recirculation

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9.2.3.3. **Percolation by Thermo-Siphon Bypass**—Good oil which is deteriorating slowly may be held in safe operating condition by applying a special bypass earth filter to the individual transformer. The oil is forced through the filter by the action of the heat generated by the apparatus and the heat dissipated by the filter. As the actuating force is small, the filters must be loosely packed. Coarse activated alumina or ¼-inch-mesh (0.66 centimeter-mesh) fuller's earth is employed, and the apparatus operates without attention during the active life of the adsorbent.

The bypass method of maintaining oil in usable condition has certain definite limitations. On standby transformers or on circuit breakers it is inoperative as the heat necessary to its operation is not constantly available. The operation of bypass filters might also be termed very "gentle" as little force is available to drive the oil through even a coarse filter bed. There is also the possibility that fine particles of the earth may leak through the system into the processed oil.

10. ADDITION OF INHIBITORS

New insulating oil, as normally refined, contains small amounts of certain chemical compounds that act as oxidation inhibitors. These natural-occurring materials retard oil oxidation until such time as they are consumed. The rate at which the inhibitors in oil are used up is dependent upon such things as the amount of oxygen available, soluble contaminants in the oil, catalytic agents in the oil, and the temperature of the oil. In modern transformers, either sealed to exclude air and moisture or protected by an inert atmosphere, the benefits of the inhibitors can be extended over many years. Once the inhibitor is exhausted, the rate of the oxidation and deterioration of the oil increases. Reclaiming processes, such as acid refining or clay treating, can restore the oil so that it has most of its original characteristics, but this has no effect upon restoring the usefulness of the natural inhibitors occurring in the oil. To overcome this undesirable condition, certain synthetic oxidation inhibitors may be used to extend the life of the reclaimed oil.

A search for suitable oxidation inhibitors has been carried on in many laboratories, and research in this field has been very extensive. These studies have shown not only the benefits of stabilizing reclaimed oil, but also the desirability of fortifying the natural inhibitors in new oil for some applications. Typical types of material which have been studied are sulfides, aromatic amines, phenols, and phosphates. Of the many materials studied, there is one which has been outstanding and has found almost universal approval as an inhibitor. It has been prepared in highly purified form and in sufficient quantities to fill the requirements of the industry. Chemically it is known as 2, 6-ditertiary-butyl-para-cresol, but generally it is referred to as DBPC. Some of the outstanding properties that make this material a desirable inhibitor are:

(a) DBPC is a stable and effective oil antioxidant in small concentrations;
(b) DBPC is commercially available from at least two sources in a highly purified form;
(c) DBPC is readily soluble in oil but insoluble in water;
(d) The oxidation products of DBPC are soluble in transformer oil and therefore will not precipitate out as sediment;
(e) The oil solutions of the inhibitor are not materially affected by exposure to light;
(f) DBPC is insoluble in aqueous alkalis and it is not easily removed from oil by use of the usual reclamation methods of filtration through activated materials if the temperature is maintained below 60°C.

Since in most cases the natural inhibitors are consumed by oil in service, it is important that, following the reclaiming process, an inhibitor such as DBPC should be added to the oil. This can be accomplished either by adding a concentrated solution of the inhibitor to the oil or by the introduction of a dry solid with subsequent heating and agitation of the oil. A concentrated solution of DBPC may be prepared by adding the solid to the oil while gently heating with mechanical agitation. Before the temperature of the oil reaches 50°C, the inhibitor should be in complete solution. Since the solubility of DBPC in insulating oil at usual temperatures is about 30 percent by weight, this figure should not be exceeded. If the solution is to be stored at winter temperatures, a concentrate of 20 percent by weight should be used for temperatures of 10°C or higher or 10 percent by weight for temperatures of −30°C to +10°C.

It is undesirable to add more than a small quantity of crystalline material at one time to the oil of an energized transformer. If crystals are added to the oil of an energized transformer, they should be put in slowly and with sufficient time allowed for solution. This can be accelerated by having the oil at a temperature of at least 50°C when the crystals are added. A concentrated solution of an inhibitor should not be added to the oil of an energized transformer since it has appreciably lower breakdown strength than the oil itself. After adding a concentrated solution of an inhibitor to a transformer with the oil at a minimum temperature of 50°C, allow a period of 4 to 6 hours for solution before energizing the transformer. Complete solution is dependent upon the temperature, circulation, and the amount of oil involved. DBPC is stable and soluble in concentrations as high as 20 percent in insulating oil. However, use of concentrations as high as 20 percent may give some difficulty due to separation at low temperatures. Solutions of 10 percent, however, can be handled quite readily. As a general rule, when an inhibitor is added to the reclaimed oil in service, the amount is approximately 0.3 percent by weight.

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12. APPENDIX—RESULTS OF SURVEY OF UNITED STATES AND CANADIAN USERS OF INSULATING OIL

12.1. General. On the basis of a survey made in 1958 of United States and Canadian users of transformer oil, it is possible to give an indication of practices followed by users of insulating oil at that time according to their procedures of testing, classifying, reconditioning, reclaiming, and addition of inhibitors. The results contained in this Appendix are the results of replies from 96 users. All values are reported on a percentage basis of the 96 making reports. It should be recognized that since 1958 when this survey was taken, additional users may well have adopted the procedures and test methods cited. Additionally, newer methods and procedures are being tried by some users.

The detailed results of the survey have been reported by the American Society for Testing and Materials who were cosponsors with IEEE. It should be emphasized that the values and procedures indicated in this Appendix are not necessarily applicable to any specific user, since the size and type of the system, available testing, reclaiming, and reconditioning facilities have a major bearing on the exact procedure to be used.

All of the users make some type of test on insulating oil contained in electric equipment in operation. Nearly all have a fixed testing schedule with the greatest number testing at yearly intervals. This schedule varies in many cases between transformers of different voltage classes, with the higher voltage class of equipment being tested in some cases as often as every six months. The oil in circuit breakers may be tested at more frequent intervals either based on the number of operations or as frequently as monthly intervals. The oil in low-voltage transformers is tested at very infrequent intervals and, in some cases, only when the equipment is removed from service.

The survey asked for information regarding the number and types of tests used in the field and in the laboratory. The following data give some indication as to general practices and tests most frequently used.

1) Transformer Oil—Field Tests

While 84 percent of the users do some type of field testing

30 percent make at least three field tests:

dielectric breakdown voltage,
neutralization number,
power factor.

Other tests used in decreasing order of frequency are color, visual inspection, and interfacial tension.

29 percent make only two field tests:

dielectric breakdown voltage,
neutralization number.

25 percent make only a single field test:

dielectric breakdown voltage.

2) Circuit-Breaker Oil—Field Tests

While 83 percent of the users do some type of field testing,

19 percent make at least three field tests:

dielectric breakdown voltage,
color,
either power factor or neutralization number.

Other tests used in decreasing order of frequency are visual inspection and interfacial tension.

34 percent make only two field tests:

dielectric breakdown voltage,
either visual inspection, power factor, color, or neutralization number.

30 percent make only a single field test:

dielectric breakdown voltage.

3) Transformer Oil—Laboratory Tests

While 78 percent of the users do some type of laboratory testing,

48 percent make at least three laboratory tests:

neutralization number,
dielectric breakdown voltage,
interfacial tension.

Other tests used in decreasing order of frequency are color, power factor, pour point, viscosity, and visual inspection.

22 percent make only two laboratory tests:

dielectric breakdown voltage,
either neutralization number or interfacial tension.

8 percent make only a single laboratory test:

either neutralization number or dielectric breakdown voltage.

4) Circuit-Breaker Oil—Laboratory Tests

While 63 percent of the users do some type of laboratory testing,

29 percent make at least three laboratory tests:

dielectric breakdown voltage,
neutralization number,
interfacial tension.

Other tests used in decreasing order of frequency are color, power factor, visual inspection, pour point, and viscosity.

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12.3.3. Quality control of end product (average of all companies reporting. These are not necessarily improved by reconditioning process).

Test (in order of relative importance)	*Transformer Oil (column 1)*	*Circuit-Breaker Oil (column 2)*
Dielectric breakdown voltage	27 kV min*	26 kV min*
Neutralization number	0.3 max	0.3 max
Visual condition	clear	clear
Interfacial tension	20 min dynes/cm (0.20 millinewton/m)	23 min dynes/cm (0.23 millinewton/m)
Power factor %—20°C	1.6 max	1.5 max
Color—ASTM (Union)	2½ max	3 max

* Most widely used single criterion in designated category.
Note 1: It should not be implied that these values are accepted standard values.
Note 2: One or more tests normally required by users for classifying reconditioned oil.

12.4. Reclaiming (any method or process such as clay or alkali treatment resulting in a beneficial change in the oil)

12.4.1. 60 percent reclaim oil from transformers:

32 percent at central location only,
13 percent in the field only, with portable equipment,
15 percent in both field and central location,
55 percent use fuller's earth type of clay,
5 percent use activated alumina,
3 percent use alkali wash.

12.4.2. 41 percent reclaim oil from circuit breakers:

39 percent use fuller's earth type of clay,
2 percent use activated alumina,
3 percent use alkali wash.

12.4.3. Quality control of end product (average of all companies reporting).

Test (in order of relative importance)	*Transformer Oil (column 1)*	*Circuit-Breaker Oil (column 2)*
Neutralization number	0.16 max*	0.17 max*
Dielectric breakdown voltage	27 kV min*	26 kV min*
Interfacial tension	25 min dynes/cm (0.25 millinewton/m)	28 min dynes/cm (0.28 millinewton/m)
Color—ASTM (Union)	1½ max	1½ max
Power factor %—20°C	0.8 max	0.9 max

* Two most widely used criteria in designated category.
Note 1: It should not be implied that these values are accepted standard values.
Note 2: Two or three tests normally required by users for classifying reclaimed oil.

12.5. Addition of Inhibitors

12.5.1. Percentage of those surveyed adding inhibitor to reconditioned or reclaimed oil:

10 percent add to reconditioned transformer oil,
3 percent add to reconditioned circuit-breaker oil,
35 percent add to reclaimed transformer oil,
17 percent add to reclaimed circuit-breaker oil.

12.5.2. Type of inhibitors used.

DBPC (2, 6-ditertiary-butyl-para-cresol) is the inhibitor regularly used, predominately 0.3 percent addition, by weight.

No other inhibitor type used except experimentally.

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23 percent make only two laboratory tests:

dielectric breakdown voltage,
either neutralization number or color.

11 percent make only a single laboratory test:

either dielectric breakdown voltage or neutralization number.

The survey asked for information regarding tests for oxidation stability, inhibitor presence, and inhibitor response. The answers to these questions were inconclusive since only about 5 percent of the users make any of these tests. In some few cases, the tests were made on an experimental basis.

The users were asked if they used reconditioned or reclaimed circuit-breaker oil in transformers and vice versa. The results showed that 53 percent used reconditioned or reclaimed circuit-breaker oil in transformers. (Most transformer manufacturers do not recommend this practice because of the possibility of admitting carbon particles to the transformer.) 58 percent of the users used reconditioned or reclaimed transformer oil in circuit breakers.

Concerning the importance attached by users to sludge and acidity in transformer oil, 71 percent of the users consider the presence of sludge very important; 56 percent of the users consider acidity important and have definite limits that are considered satisfactory for continued use.

12.2. Testing

12.2.1. 100 percent of companies reporting test service-aged insulating oil;

85 percent use field tests,
80 percent use laboratory tests,
80 percent use both field and laboratory tests.

12.2.2. Test limits of oil from transformers (average of all companies reporting)

Test (in order of relative importance)	*Satisfactory for Use (column 1)*	*To Be Reconditioned (column 2)*	*To Be Reclaimed (column 3)*	*To Be Discarded (column 4)*
Dielectric breakdown voltage	23 kV min	Less than 22 kV	—	Less than 14 kV
Neutralization number	0.4 max	—	Greater than 0.4	Greater than 1.0*
Interfacial tension	19 min dynes/cm (0.19 millinewton/m)	—	Less than 18 dynes/cm (0.18 millinewton/m)	Less than 14 dynes/cm (0.14 millinewton/m)
Power factor %—20°C	1.4 max	Greater than 1.8	Greater than 1.4	—
Color—ASTM (Union)	3½ max	—	—	—
Visual condition	Clear	Cloudy, dirty, or visible water	—	—

* Most widely used single criterion in designated category.
Note: Number of tests normally required by users for classifying oil from transformers: column 1—3 or more; column 2—1 or 2; column 3—2 or 3; column 4—1 or 2.

12.2.3. Test limits of oil from circuit breakers (average of all companies reporting)

Test (in order of relative importance)	*Satisfactory for Use (column 1)*	*To Be Reconditioned (column 2)*	*To Be Reclaimed (column 3)*	*To Be Discarded (column 4)*
Dielectric breakdown voltage	24 kV min	Less than 22 kV*	Less than 20 kV	Less than 15 kV
Neutralization number	0.5 max	—	Greater than 0.5*	Greater than 1.0*
Color—ASTM (Union)	3½ max	—	—	—
Interfacial tension	18 min dynes/cm (0.18 millinewton/m)	—	Less than 18 dynes/cm (0.18 millinewton/m)	—
Power factor %—20°C	1.4 max	Greater than 1.7	—	—
Visual condition	Clear	Cloudy, dirty excess carbon, or visible water	—	Dirty, heavy carbon

* Most widely used single criterion in designated category.
Note: Number of tests normally required by users for classifying oil from circuit breakers: column 1—3 or more; columns 2, 3 and 4—1 or 2.

12.3. Reconditioning (the mechanical removal of moisture and insoluble contaminants by such means as filtration and centrifuging)

12.3.1. 99 percent recondition oil from transformers:

46 percent use filtering only,
32 percent use centrifuge with a filter,
14 percent use a filter with vacuum dehydrator,
6 percent use centrifuge, filter, and vacuum dehydrator.

12.3.2. 97 percent recondition oil from circuit breakers:

57 percent use filtering only,
39 percent use centrifuge with a filter,
1 percent use a filter with vacuum dehydrator.

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11. SPECIAL CONSIDERATIONS

11.1. Insulating Oil for Circuit Breakers

11.1.1. General. The characteristics of insulating oil used in oil circuit breakers, henceforth referred to as circuit-breaker oil, as distinguished from insulating oil for transformers, henceforth referred to as transformer oil, are tabulated below in the table. Most modern circuit breakers require a low viscosity, low pour-point oil since a large percentage of them are used outdoors and in many cases at low temperatures. It should be noted that all circuit breakers are free breathers (open to the atmosphere through a breathing device). This does not prevent the admittance of humid air to the device. There are, however, a number of oil circuit breakers still in use in which it is deemed desirable to use higher viscosity oil. This high-viscosity oil is considered obsolete by most manufacturers and is becoming increasingly difficult to obtain. Although this oil is given the same general tests and treatment as modern oil, caution must be exercised in its usage. Effects which would result from addition of inhibitor, for example, have not as yet been established with certainty. This oil should not be mixed with modern oil except where detrimental effects on cooling effectiveness, freezing temperatures, and other characteristics can be tolerated.

Type	*Color Number*	*Viscosity 37.8°C (100°F), seconds*	*Pour Point, °C*	*Flash Point, °C*
Modern	½ to 1	57	−40	133
Obsolete Outdoor	2 to 3	90	−40	155
Obsolete Indoor	3 to 5	105	−10	185

Although it has been customary to recondition circuit-breaker oil in much the same manner as transformer oil, the problem is somewhat different. Whereas sludging is, or may be, the principal problem in a transformer oil, such is not the case with circuit-breaker oil. Conditions conducive to sludge formation as well as the deleterious effects that are obtained in transformers do not normally apply in the case of circuit breakers. Aside from its dielectric service, the chief function of the transformer oil is to dissipate heat. In a circuit breaker, on the other hand, the chief function of the insulating oil is to quench the arc. In so doing thermal cracking can occur and minute particles of carbon can form. These particles coupled with moisture can lower the dielectric breakdown voltage of the oil. If sufficient quantities of carbon are deposited on the surface of insulating members, a flashover may occur.

11.1.2. Testing. Testing methods for circuit-breaker oils are the same as those used for transformer oils. Samples are taken in the same manner as for transformer oil at specified intervals, varying from a few months to a year or more. Most users make one or more of the following listed tests on used circuit-breaker oil. Each user includes at least the dielectric breakdown voltage test.

(a) dielectric breakdown voltage
(b) neutralization number
(c) interfacial tension
(d) color
(e) power factor
(f) visual examination

Typical minimum values for oil to be left in service without reconditioning or reclaiming are given in the Appendix.

If it is desired to make additional tests, they should be made in a manner outlined previously for insulating oil. Some users of circuit-breaker oils change or recondition without testing the oil after an agreed-upon number of operations.

Viscosity is checked where deemed advisable to verify the type of oil. This characteristic is highly important in determining the speed of operation of circuit breakers at low temperatures.

11.1.3. Reconditioning. The chief problem in circuit-breaker oil maintenance is to keep it free of water, arcing products, and other contaminants. If visual examination shows the presence of these materials and if the dielectric strength drops below an acceptable value, the oil can be reconditioned provided the acidity, power factor, etc., are good. The accepted method of reconditioning oil is by means of a filter. However, the filter media commonly used are not dense enough to remove all of the colloidal contaminants in the oil. A method being used to some extent to remove colloidal and other contaminants completely is to use a small amount of activated clay with the filter medium. This is accomplished very simply by mixing 1 to 2 cups (one-quarter to one-half liter) of clay with 2½ to 5 gallons (1 to 2 dekaliters) of the oil and then passing it through the filter prior to the main filtering operations. The clay is removed from the oil and deposited on the filter medium thus producing, in effect, a much denser filtering medium. No reduction in acidity of the oil is to be expected since the amount of clay used is extremely small. Typical values to permit reconditioned oil to be put back in service in circuit breakers are given in the Appendix.

In some cases, an oxidation inhibitor is added to the reconditioned oil.

11.1.4. Reclaiming. In some cases it may be economical to reclaim circuit-breaker oil that has undergone extensive contamination or oxidation. This oil may be reclaimed by one of the processes described previously. To be suitable for circuit-breaker use reclaimed oil must meet certain minimum values. Typical minimum values are given in the Appendix.

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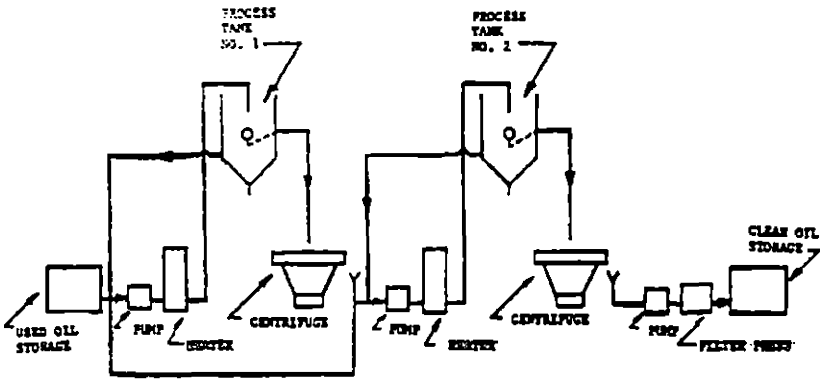


Figure 2. Schematic diagram of trisodium phosphate/fuller's earth refining apparatus.

with the equipment alive should be considered in such cases, with due regard to safety measures.

Irrespective of the type of clay treater used, two adjuncts should also be incorporated with the treater. a) The oil should be put through some device for removing free water before it contacts the clay in order to prevent water from wetting the clay. Water will cause at least partial and possibly complete blocking of the clay, thus making it necessary to discard that batch of clay. b) The oil coming out of the clay treater should be put through some kind of foolproof, completely automatic dehydrator equipped with positive means and safeguards for preventing any water from being present in the finished product. This is particularly true when recirculating the oil in a transformer and absolutely essential if the reclaiming is done when the transformer is energized.

9.2.3. Other Reclaiming Methods Not Widely Used. (See Appendix for extent of usage of each process.)

9.2.3.1. Reclaiming by Trisodium Phosphate—The trisodium phosphate/activated fuller's earth method (see Figure 2) consists in agitating a mixture of oil and trisodium phosphate solution maintained at 80°C for an hour and then allowing the mixture to separate. Most of the spent phosphate solution is drained from the tank, the balance is washed from the oil with a water spray, and the oil is then decanted through a centrifuge and a heater to another tank where 200-mesh (77 mesh per centimeter) activated fuller's earth is added and the mixture agitated. This agitation with clay is maintained for 15 minutes and the clay is allowed to settle out over night. The oil is again washed with hot water, decanted through a centrifuge, and then dehydrated by passage through a dehydrator or filter.

The process is described as economical and capable of yielding a uniform product by varying the amounts of reclaiming agents as determined by the analysis of the deteriorated oil. The method may be more economical than reclaiming with clay alone for large quantities of badly deteriorated oil.

9.2.3.2. Reclaiming by Activated Carbon–Sodium Silicate—This method is capable of variation to meet the requirements of different grades of service-aged oil. Under favorable conditions, this process is a continuous one. The method consists of the following basic treatments:

(a) an activated-carbon treatment in which 2 percent by weight of activated carbon is used,
(b) a treatment involving 30 percent by volume of a 2 percent sodium silicate solution,
(c) a clay treatment in which 2 percent by weight of activated fuller's earth is used.

The oil is heated to 85°C and is maintained at this temperature until the final filtering operation is reached. The first step consists of a treatment by agitation with activated carbon in cases where the acid rating of the oil is 0.5 milligram of potassium hydroxide per gram or over. This step is necessary to prevent subsequent emulsification of acid oil with the sodium silicate solution. Where the acid value is low, this process may be omitted.

The oil is next decanted through a filter to a second tank where it is paddle-stirred with the sodium silicate solution. It is then run through a centrifuge and the silicate solution discarded.

The oil is now run into a reaction tank with clay added through a hopper. The resulting mixture is agitated allowed to settle, and then cleaned by passing through a second centrifuge. The oil is then run into a receiving tank and allowed to cool. Finally, it is filtered and run into storage tanks.

When used without activated carbon, the process is continuous with an output of 150 gallons per hour (570 liters per hour). When the activated-carbon treatment is necessary, the process becomes a batch process with an output of 500 gallons per day (1900 liters per day). As both clay and carbon retain about 60 percent of their weight of oil, the process should be run with a minimum of these materials. Oil in fair condition shows satisfactory characteristics when treated with 1 percent carbon and 1 clay.

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media are too wet for further use. Chief reliance has been placed upon inspection of the media, an increase in input pressure, or a lowering in dielectric strength of the filtered oil. Means are available that permit a continuous indication of the water content of the outgoing oil.

When the oil being processed contains much contamination, it is necessary to change the filter media at frequent intervals. In some cases, the use of a pre-coat applied to the filter medium increases both the efficiency of operation and the length of time that the filter media may be used. Some filters are designed so that small beds of earth or clay may be built up in the press to facilitate the removal of colloids.

9.1.2. **Centrifuges.** Another means for separating free and suspended contaminants such as carbon, water, sludge, etc., from oil is the continuous centrifuge. In general, the centrifuge can handle a much greater concentration of contamination than can the conventional filter but cannot remove some of the contaminants as completely as a filter. Consequently the centrifuge is generally found in use for rough bulk cleaning where large amounts of contaminated oil are to be handled. Frequently the output of the centrifuge is put through a filter for the final cleanup. Figure 2 shows such an application.

The centrifuge cannot remove dissolved water from the oil, and since the centrifuge is sealed with water, the oil leaving the centrifuge may be saturated at the temperature of operation and may contain more dissolved water than when it entered. Neither the centrifuge nor the filter is designed to treat the oil chemically. However, some types of centrifuges have been operated in conjunction with auxiliary tanks containing chemicals such as activated carbon or sodium silicate in order to facilitate the overall results.

9.1.3. **Vacuum Dehydrators.** The vacuum dehydrator is an efficient means of reducing the gas and water content of an insulating oil to a very low value. There are two types of vacuum dehydrators in general use today. The guiding principle of both is the same: that is, the oil is exposed to a high vacuum and heat for a short interval of time. In one method the exposure of the oil is accomplished by spraying the oil through a nozzle into a vacuum chamber. In another type of vacuum dehydrator the oil is allowed to flow over a series of baffles inside a vacuum chamber thus forming thin films so that a large surface is exposed to the vacuum. If the oil contains solid matter, it is advisable to pass it through some kind of a filter before processing it in the vacuum dehydrator, since solid contaminants may plug the nozzle of one type of dehydrator or pass through either type without being removed from the oil.

The operation of vacuum dehydrators is continuous. In addition to removing water, vacuum dehydrators will degas the oil and remove the more volatile acids. The other acids, however, will be relatively unaffected and it is doubtful whether the overall acidity of an oil will be much improved by the vacuum dehydration method. In either type of dehydrator some means of automatically recirculating a very wet oil should be provided as a safety device to prevent an excessive water content in the outgoing oil.

9.2. **Reclaiming.** The removal of deterioration products is usually accomplished by the use of reclaiming processes involving fuller's earth alone or in combination with certain chemicals. A number of these processes are outlined below.

9.2.1. **Adsorbent Means.** Fuller's earth, a naturally occurring clay with a fairly high surface activity, is the material most frequently used for reclaiming oils and is the least expensive. It may be used in its original state, except for drying, crushing, and sizing, or it may be burned, water-washed, steam-treated, or acid-treated. The processed clays are more active but also more expensive. Activated alumina is an efficient adsorbent for impurities found in oil; it is mechanically more stable, and may be reactivated. Oil treated with activated alumina shows a marked rise in steam emulsion number.

In general, reclaiming is done in accordance with one of two methods: a) percolation through coarse clay using either gravity or pressure to force the oil through the clay, or b) contact at an elevated temperature with finely divided clay. Almost any desired degree of reclaiming may be accomplished by either of the above methods.

9.2.1.1. **Percolation by Pressure**—Pressure percolation is similar to gravity percolation in general principle except that the oil is forced through the clay by a pump. Pressure percolators are commercially available and vary in mechanical detail, but all have a chamber to hold a container such as a bag or cartridge filled with clay. The chamber is so designed that oil is admitted around the outside of the clay pack and must pass through a certain amount of clay before leaving the chamber.

These machines are capable of processing large volumes of oil in a relatively short time. They accomplish this by forcing the oil through a comparatively shallow depth of clay at a pressure of about 60 pounds per square inch (400 kilonewtons per square meter) resulting in a short contact time. Since the amount of clay is relatively small with respect to the amount of oil, frequent changes of clay are required.

Specially treated clays are sometimes used for increased efficiency. The output is a graded one for the same reasons that apply to the gravity percolation output, and the same control tests are used.

An advantage of such machines is that they may be brought to the job and used directly on the apparatus whose oil is to be reclaimed. They have been used on energized equipment to a limited extent, and such use will increase when proper safety procedures have been developed.

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10) Pour Point—D 97

The temperature at which insulating oil will just flow under the prescribed conditions is known as the pour point.

The pour point has little significance as far as contamination or deterioration is concerned but may be useful for type identification and for determining the type of equipment in which it can be used.

11) Resistivity—D 1169

The resistivity (specific resistance) in ohm-centimeters of an oil is the ratio of the direct potential gradient in volts per centimeter paralleling the current flow within the sample to the current density in amperes per square centimeter, at a given instant of time and under prescribed conditions. A low resistivity normally indicates the presence of conductive contaminants, but the test has not been widely applied to service-aged oils.

12) Saponification Number—D 94

The saponification number of an oil is the number of milligrams of potassium hydroxide which react with one gram of oil under prescribed conditions. A high saponification number normally indicates the presence of compounds resulting from the oxidation of the oil, added compounds, or contaminants, but the test has not been widely applied to service-aged insulating oils

13) Gas Content—D 831, D 1827

The gas content of an insulating oil may be defined as the volume of gas per 100 volumes of oil. In evaluating service-aged oil, this test normally has little significance in determining quality or serviceability of the oil. It will have significance to the operator of apparatus where low gas content is required.

14) Inorganic Chlorides and Sulfates—D 878

This test indicates the presence of inorganic chlorides and sulfates by precipitation of insoluble salts by means of the usual analytical procedures. The presence of inorganic chlorides or sulfates is an indication of corrosivity of the oil and of the presence of contaminants.

15) Corrosive Sulfur—D 1275

This test is designed to detect the presence of free sulfur and combined corrosive sulfur by subjecting copper to contact with oil under prescribed conditions. This test indicates the possibility of corrosion resulting from the presence of either free sulfur or unstable sulfur compounds.

16) Sludge—D 1313, D 1904, D 2112, D 2440

The sludge value for mineral insulating oil is an indication of its oxidation characteristics. It may be reported as:

(a) the percentage of insoluble matter formed in a prescribed length of time, or
(b) the length of time required before the appearance of insoluble matter or excess acidity, or
(c) the length of time required for the oil to react with a given volume of oxygen

when a sample of oil is heated and oxidized under prescribed conditions.

These tests are generally applicable to new and/or reclaimed insulating oils, and D 2112 is intended specifically for inhibited oils.

Numerical correlation between results from these laboratory tests and years of service or sludge accumulation in transformers has yet to be established.

17) Water in Insulating Oil:
Extraction Method—D 1315
Karl Fischer Method—D 1533

Water may be present in insulating oil in several forms. The presence of free water may be disclosed by visual examination in the form of separated droplets or as a cloud dispersed throughout the oil. This type of water invariably results in decreased dielectric strength, which may be restored by filtration or other suitable means. Water in solution cannot be detected visually and is normally determined by either physical or chemical means. Both methods cited are suitable for the determination of water in insulating oil and, depending upon conditions of sample handling and method of analysis, can be used to estimate total-water as well as soluble-water content of oil. The unit of measure of the water is in parts per million. These tests are significant in that they will show the presence of water which may not be evident from electrical tests.

18) DBPC Inhibitor in Electrical Insulating Oil—D 1473

DBPC (i.e., 2, 6-ditertiary-butyl-para-cresol) is an oxidation inhibitor commonly used in insulating oil to provide added protection against oil oxidation in insulation systems partially or freely exposed to air during service life. Inhibitor effectiveness is a function of base oil type, freedom from contamination, and concentration. Consequently, a method is provided to assay concentration of this inhibitor in insulating oil.

19) Visual Examination Field Test—D 1524

This test gauges color and turbidity or cloudiness of an oil, which may indicate the presence of free water or sediment such as metal particles, insoluble sludge, carbon fibers, dirt, etc. If insoluble contaminants are present valuable information may be obtained by filtering the oil and identifying the residue.

20) Sediment and Soluble Sludge in Service-Aged Oil—D 1698

This test distinguishes between miscellaneous insoluble matter and oil-insoluble sludge and also signals the presence of oil-soluble sludge. Under certain

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no one test can be used as the sole criterion of the condition of oil in service. It is possible, however, to summarize the value and importance of the current tests and to suggest methods of treatment for the oil being examined, such methods being based on current industry experience. Oils in service may be placed in the following classifications based upon the composite evaluation of significant characteristics.

Group I: This group contains oils that are in satisfactory conditions for continued use.

Group II: This group contains oils that require only minor reconditioning for further service. (Reconditioning is the mechanical removal of moisture and insoluble contaminants. Typical means employed are filtering and centrifuging.)

Group III: This group contains oils in poor condition. They should be reclaimed or disposed of depending upon economic considerations. (Reclamation involves the use of methods and processes which result in a beneficial chemical change in the oil. Typical means employed are treatments with adsorption agents, acid refining, alkali treatment, etc.)

Group IV: This group contains those oils in such poor condition that it is technically advisable to dispose of them.

5. ECONOMIC FACTORS

A review of experience and cost data obtained from many operators and users of transformers reveals a wide variation of practices and cost data involved in the reconditioning and reclaiming of oil. These differences are mostly attributable to the type of system, field inspection operations, and available laboratory and shop facilities. For example, an operator having a large number of pole-type transformers installed over a large area may follow a different practice than one having large transformers in stations in a metropolitan area.

In determining whether or not reconditioning and/or reclaiming or insulating oil is economically justifiable, a number of factors must be considered. Some of these factors are as follows:

1) cost of materials,
2) disposition of service-aged materials,
3) total cost of process versus quality of end product,
4) equipment maintenance and amortization,
5) cost of collection and storage of oil,
6) labor and transportation costs,
7) laboratory costs,
8) cost of new oil versus cost of reprocessed oil,
9) loss of oil during reprocessing,
10) cost of inhibitors and blending process,
11) value of service-aged oil when used for some other purpose. (One user reports that they utilize certain amounts of this oil for fuel purposes with a value of between 7 and 10 cents per gallon.)

The economic justification of whether reconditioning and/or reclamation work is performed by company personnel or contractors must be resolved on the basis of factors applicable in each particular case.

6. SAMPLING

Accurate sampling, whether of the complete contents or only parts thereof, is extremely important from the standpoint of evaluation of the quality of the product sampled. Obviously, careless sampling procedures or contamination in the sampling equipment will result in a sample that is not truly representative. This generally leads to erroneous conclusions concerning quality and incurs extra time, effort, and expense involved in securing, transporting, and testing the sample. It is very strongly recommended that all of the procedures and precautions outlined in the latest revision of ASTM D923 (Sampling Electrical Insulating Liquids) be followed.

7. OIL TESTS AND THEIR SIGNIFICANCE

There are many tests that can be applied to insulating oil for classification purposes. It is recommended that tests be the latest revisions accepted as standards or tentative standards by ASTM. These tests and their significance are as follows:

		ASTM Methods
1)	Neutralization Number	D 664, D 974
	Approximate Acidity Field Test	D 1534
	Approximate Acidity and Polar Contamination Spot Test	D 1902
2)	Dielectric Breakdown Voltage	D 877, D 1816
3)	Interfacial Tension	D 971
	Interfacial Tension Field Test	D 2285
4)	Power Factor	D 924
5)	Color	D 1500, D 1524
6)	Viscosity	D 88, D 445 D 2161
7)	Flash Point	D 92
8)	Steam Emulsion	D 1935
9)	Specific Gravity (Relative Density)	D 1298
10)	Pour Point	D 97
11)	Resistivity	D 1169
12)	Saponification Number	D 94
13)	Gas Content	D 831, D 1827
14)	Inorganic Chlorides and Sulfates	D 878
15)	Corrosive Sulfur	D 1275
16)	Sludge	D 1313, D 1904 D 2112, D 2440
17)	Water in Insulating Oil:	
	Extraction Method	D 1315
	Karl Fischer Method	D 1533
18)	DBPC Inhibitor in Electrical Insulating Oil	D 1473
19)	Visual Examination Field Test	D 1524
20)	Sediment and Soluble Sludge in Service-Aged Oil	D 1698
21)	Refractive Index and Specific Optical Dispersion	D 1807

1) Neutralization Number—D 664, D 974
Approximate Acidity Field Test—D 1534
Approximate Acidity and Polar Contamination Spot Test—D 1902

The neutralization number for service-aged oils is in general a measure of the acidic constituents of the oil and may be pertinent, if compared to the value for the new product, to detect contamination by substances with

NPC00024002

770818

SPECIFICATION

FOR

NEW, UNUSED TRANSFORMER-TYPE ASKARELS

FEBRUARY, 1975

PREPARED BY THE INSULATING FLUIDS SUBCOMMITTEE OF THE

IEEE TRANSFORMERS COMMITTEE

NPC00024004

770820

1. SCOPE AND INTRODUCTION

1.1 - This specification covers bulk shipment in tank cars and drums of new, synthetic, nonflammable electrical insulating liquids of the chlorinated aromatic type known as askarels which are used as insulating and cooling media in liquid-filled transformers. While this specification is intended to cover the composition and characteristics of askarels for purchase only and does not apply to liquids in apparatus, a number of discontinued types are included for purposes of identification and historical significance.

2. DEFINITION

2.1 - Askarel is a generic term describing a widely used broad class of nonflammable synthetic halogenated hydrocarbon insulating liquids. Askarels of various compositional types are used. Under arcing conditions the gases produced, while consisting of predominantly noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

3. CAUTION

3.1 - Transformer askarels contain polychlorinated biphenyls (PCB's) considered by many to be an environmental contaminant. Proper handling and disposal procedures should be exercised to prevent their entry into the environment. Such procedures are covered in the IEEE Guide for Acceptance and Maintenance of Transformer Askarel in Equipment, Std. 71-1974, and in the American National Standard, Guidelines for Handling and Disposal of Capacitor - and Transformer - Grade Askarels Containing Polychlorinated Biphenyls, C107.1 (1974).

4. SAMPLING AND METHODS OF TEST

4.1 - The material shall be sampled in accordance with ASTM Method D923, Sampling Electrical Insulating Liquids, and tests shall be conducted in accordance with the methods of test listed in Table II.

5. COMPOSITION

5.1 - Askarels covered by this specification are of several types which are mixtures having the approximate compositions in weight per cent as shown in Table I. Some types of askarels are included for identification and historical significance. The components and respective percentages are descriptive of the materials in common use and are not intended as part of this specification which is based on the physical, chemical and electrical properties given in Table II.

NPC00024005

TABLE I

ASKAREL COMPONENTS IN WEIGHT PER CENT

COMPONENTS	Type A	Type B	Type C	Type D	Type E	Type F	Type G
Commercially available as of 1974	No	No	No	Yes	Yes	No	Yes
Hexachlorobiphenyl (1)	60	45					
Pentachlorobiphenyl (2)				70		45	60
Trichlorobiphenyl (3)			80		100		
Trichlorobenzene (4)	40			30			40
Tri-tetrachlorobenzene (5)		55	20			55	
Phenoxypropene oxide (6)	0.18 to 0.22			0.18 to 0.22	0.18 to 0.22		
Diepoxide-type compound (7)		0.115 to 0.135	0.115 to 0.135			0.115 to 0.135	0.115 to 0.135

Note (1): Biphenyl chlorinated to a chlorine content of 60 weight per cent -- predominantly hexachlorobiphenyl but containing significant amounts of higher and lower chlorinated biphenyls.

Note (2): Biphenyl chlorinated to a chlorine content of 54 weight per cent -- predominantly pentachlorobiphenyl but containing significant amounts of higher and lower chlorinated biphenyls.

Note (3): Biphenyl chlorinated to a chlorine content of 42 weight per cent -- predominantly trichlorobiphenyl but containing significant amounts of higher and lower chlorinated biphenyls.

Note (4): Basically a mixture of isomers of trichlorobenzene but with smaller amounts of benzene chlorinated to other degrees.

Note (5): Approximately a mixture of the isomers of trichlorobenzene (73% by weight) and tetrachlorobenzene (27% by weight) but with smaller amounts of benzene chlorinated to other degrees.

Note (6): Glycidyl-phenyl ether.

Note (7): 3,4-Epoxycyclohexylmethyl-3,4-Epoxycyclohexanecarboxylate

6. DETAIL REQUIREMENTS

Askarels for use in transformers shall conform to the requirements prescribed in Table II.

NPC00024006

TABLE II

DETAIL REQUIREMENTS FOR ASKARELS FOR TRANSFORMERS

PROPERTY	Type A	Type B	Type C	Type D	ASTM Test Method (4)
Acidity, mgKOH/g, max.	0.014	0.014	0.014	0.014	D974, D664
Color, APHA, max.	150	150	150	150	D2129
Condition	Clear	Clear	Clear	Clear	(Visual)
Chlorides, inorganic, ppm, max.	0.1	0.1	0.1	0.1	D1821
Dielectric Constant @ 100C and 1 kHz	3.7 to 4.0	3.8 to 4.3	4.4 to 4.9	4.3 to 4.6	D924
Dielectric breakdown voltage, kV, min.	35	35	35	35	D877
Fire point(1)	None to Boiling	None to Boiling	None to Boiling	None to Boiling	D92
Pour point, °C, max.	-32	-44	-30	-30	D97
Refractive Index @25°C	1.6130 to 1.6154	1.6068 to 1.6088	1.6146 to 1.6166	1.6163 to 1.6193	D1807 to
Resistivity at 100C, 500 Vd-c, ohm-cm, min. (2)	100×10^9	100×10^9	100×10^9	100×10^9	D1169
Scavenger content, per cent					
Phenoxypropene oxide	0.18 to 0.22			0.18 to 0.22	D1701
Diepoxide-type compound		0.115 to 0.135	0.115 to 0.135		D1701
Specific Gravity @15.56°C	1.560 to 1.568	1.560 to 1.571	1.412 to 1.425	1.518 to 1.528	D1810
Viscosity, Saybolt Universal, s at 37.8C	52 to 56	41 to 45	50 to 55	56 to 61	D88
Viscosity, kinematic cSt at 37.8C	8.0 to 9.2	4.6 to 5.8	7.4 to 8.9	9.2 to 10.6	D445
Coefficient of thermal expansion(3), $Cm^3/Cm^3/°C$	0.0007	0.0007	0.0007	0.0007	D1903
Water content, ppm, max.	30	30	30	30	D1533

	Type E	Type F	Type G	ASTM Test Method (4)
Acidity, mgKOH/g, max.	.014	.014	.014	D974, D664
Color, APHA, max.	150	150	150	D2129
Condition	Clear	Clear	Clear	(Visual)
Chlorides, inorganic, ppm, max.	0.1	0.1	0.1	D1821
Dielectric constant at 100C and 1 kHz	4.7 to 4.9	4.5 to 4.9	4.3 to 4.6	D924
Dielectric breakdown voltage, kV, min.	35	35	35	D877
Fire Point(1)	None to Boiling	None to Boiling	None to Boiling	D92

NPC00024007

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TABLE II - (Cont'd)

PROPERTY	Type E	Type F	Type G	ASTM Test Method (4)
Pour Point, °C, max.	-14	-42	-38	D97
Refractive Index @ 25°C	1.6240 to 1.6260	1.6060 to 1.6070	1.6110 to 1.6120	D1807
Resistivity at 100C, 500 V d-c. ohms-cm, min.(2)	100×10^9	100×10^9	100×10^9	D1169
Scavenger content, per cent				
Phenoxypropane oxide	0.18 to 0.22			D1701
Diepoxide type compound		0.115 to 0.135	0.115 to 0.135	D1701
Specific Gravity @ 15.56°C	1.381 to 1.392	1.522 to 1.532	1.502 to 1.517	D1810
Viscosity, Saybolt Universal, s at 37.8C	82 to 92	39 to 43	44 to 48	D88
Viscosity, kinematic, cST at 37.8C	16.2 to 18.6	4.0 to 5.3	5.5 to 6.8	D445
Coefficient of thermal expansion(3) $cm^3/cm^3/°C$	0.0007	0.0007	0.0007	D1903
Water content, ppm, max.	30	30	30	D1533

Note (1): When testing for fire point, a pseudo-flash may be observed; it differs noticeably from the flash obtained on combustible materials and is not indicative of a fire hazard.

Note (2): If more convenient, a measurement of power factor may be made by ASTM Method D924, Test for Power Factor and Dielectric Constant of Electrical Insulating Liquids, in place of the resistivity measurement. Theoretical considerations indicate and experiment confirms that a strong statistical correlation exists between power factor and resistivity; however, other factors modify in practice the precise relationship predicted by theory. A power factor at 60 Hz and 100C that is not in excess of 15 per cent shall be considered satisfactory.

Note (3): These are approximate values included for information only.

Note (4): These designations refer to test methods under the jurisdiction of Committee D27 on Electrical Insulating Liquids and Gases of the American Society for Testing and Materials.

NPC00024008

12/15/71
C – 107
O'Hare Inn

① Papageorge – Recap:
C 107 Dg
Topic Subject – next session of Congress (Hart Bill)
Ryans Bill (3rd) 72 others co-sponsors [in committee]
EPA – 2 reg
② Alabama → Monsanto contract effluent to zero → impossible. Zeolite dropping – 50 to 100 ppB in water ok for now. [0.3 lb/day] in 200 gpm flow
[long term performance will have to be better]
[EPA Chi → no action on St Louis]
[EPA – Dallas → asking questions of offshore drilling re heat xfer fluids, Monsanto has stopped sale → bootleg?]
③ Mich: with resources commit: active against major in Detroit area. Except PCB effluents (from hydraulic fluids in bottle plants) may result in plant closings. Stop immediately – 300 PCB's. FDA method from detect ½ ppm. Monsanto: 2 ppB
Range of resp. of detection 2 ppB – 100 ppB

NPC00024009

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(Criteria for air effluent: none)

600 ppB detected in aqueous (re. hydraulic fluid) — casting plants
treatment in settling basin (But
Solubility = (50 ppb to 100 ppb) —?

Pepperose will talk in Mich & plans for improvement

(C) Dutton N.F. — meeting Mon & Tues Dec 20.
NIOHS — National Inst. of Envr. (Health) Research
Gov. agencies — meeting on PCBs (3 fr. Monsanto
no more allowed) (150 total) [20 on wait list]
Health Inst. Research
Halocarbon
Japanese (Rice oil)
Steps Bird/seminal fox. — related to Human
Toxicity RQR (PCB, specifically.)
Expert panel — Sent to Edwards Commission — reason for
Concern & move to control —
no panic
Will Hunt Cres exempt from control —?
Mallory will be summing up "chronic" testing.

NPC00024010

Pepperose: data insufficient to set regulation on
concentration that can be tolerated.
FDA has more data than for any other reg. matl
but unwilling to sit down & make decision.

— 2 —

770826

Dec 10 issue "Science": writeup on DDT.
Ruckelshaus will state gov. position re DDT
on Dec 1, so Sec will not go to bfd. Con.

(D) World — Germany — (Bayer — say they will use "Penta" & higher Chlorinated Cyclodiene materials from open systems. Bromide to be sold for paint) Monsanto trying to keep them from short-sighted approach

France — Prodelic — don't think there is a problem.

Italy — don't agree either, but will refrain fr. U.S., UK views.

Japan — Excited, Rice Oil, 1968; no coverage then, Dec 1970 meeting in Rome. Japanese paper resurrected incident. Japan may move quickly to gov. control

Sweden — gov. ban + except Cap & Xplosives which are assessed licenses (Parallels U.S. Monsanto action, Home control)

Lili Holjimans can use 1254 if they want (they use 1242),

Importers of Human Caps must have license — ?

More effect: elim. use in paints etc.

— 3 —

— NPC00024011 —

Also English license protect Swedish
confirm? Arb mtl. Some help — no
guarantee. Does not relieve mfr
of responsibility.

1971
Nov 80, Hansard

(E) Release of production records, 1960 to present
(longer period back to 1930's, denied)

Reduced exports activity [redacted] reduced by
about 1/2 from 1970 to 1971,

[redacted] activity
[redacted] trip

1970 — 20,268 T
1971 — 14,417 T

Note: sum of Domestic Sales + US export Sales do
not add to US production. Reasons —
intervening fluctuations, mult. sources of
data.

NPC00024012

770828

Sorgazorgi — Wegeray → workable → improve Peter

Kanawha 68 000 000 at Monsanto Farm Co. — based on fictional Contamination.
+ other units pending.

9 mill lines in St Louis

Solids & disposal

Liquid waste

Raab:

"Fact sheet" in Wire — 7

Monsanto will prepare sheet for ABC sponsorship

PCB's in Farmers — # transformers

Size

Failure rate

Total in service

NPC00024013

3

770829

[Don't list ANSI Steering Comm. Fact Sheet
Use as committee guide]

Capacitor Welding Grp

11:40

NPC00024014

6

770830

11/15/71

C-107

Cap. Working Grp.

11:40 AM

Al Pezeshky — Biodegradability: what is the rate of disappearance, there is need for answer. Clean land fill disposal depends on answer to "rate" question

Bill Engineering — 46 members for all 1220 — 490 T. in 7 days

Benzene — ① If buried does it migrate. Some data shows it stays put, [But when same material formed after burial time — does it biodegrade?]

② Biodegrading teats: sludge teat have not given direct answer. "Most of non-degrading mater... being removed."

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— 4 —

770831

Profsky — In the end a standard test of [illegible] biodegradability required.

Propagation — Mr. Berger asked for "half life."
Moore to Labs working on this.

Bergen — Morris now reaching point of writing their interpretation of [illegible] results, to date.

Stafford — nuclear waste disposal —
[illegible] Corps Labs — no chance of loss to
[illegible] surface water.
[illegible] acceptance for
[illegible] disposal.

LUNCH

[illegible] — Regents (re Profsky)
Salt Slide disposal — approved landfills?

Water on load unload spill report
[illegible] Fire response (Sue Jennings)
Occupational Safety & Health Act — may control
[illegible] problems & safe levels = ?
Employee Safety

→ Release (W) SPDS on Arvelors to W Orleans Group.

NPC00024016

Coming agenda: (A) IN House (B) Plant load to environment,
(C) Disposal — ?

770832

McClam — Comprehensive Industrial Safety

(1) (a) accumulate ref. matl & circulate for comment
(b) after draft by committee
(2) to committee
recommending good practice by
incorporate SPDs if possible,
comparable statements
Disposal of waste
Warnings
Cartons — Bozefsky
Booklet on Vapor concentration
Bulletin 10-ET-1 (skin contact?
Eye contact?
Engineering
Personnel
Ventilation, conc. controls
Exposure controls
Storage
Handling

NPC00024017

Test Methods — See Monsanto Spectroscopy Method 70-1 Job No. 16303"
+
Limits

Hygienic Series from - - - - (All Bozefsky)
— C —

770833

(Check with transformer grp. before starting)

T.K. Sloat

(2) Factory Locations

Pozefsky air effluents - Roof air vents, Stacks

water effluent -

Bulk solid - Liquid - Solid

Sanitary -

Pozefsky - short for zero.

Pozefsky - Samples, test methods of trapping PCB

Pozefsky - Spill control, isolate drains. Recycle water (River cooling water - in & out - no PCB)

Pozefsky - Identify pts effluents leave plant - test method required to determine levels

Levels permitted - experts will be set by regulatory bodies

(2) (3) Pozefsky will write up methods for test, water trap (more pollutants technology)

NPC00024018

[Post Mortem looking at Monsanto procedures]

Dr. Moore - E.H.C. sends samples to Carus Chemical Water Analysis Lab, La Salle Ill 61301, (also Milwaukee)

- D -

770834

[Will be received Monsanto test methods for water analysis, etc — see a Lab in Charge — Ck. Sawyer, Scraft]

Vapor effluent potentially most difficult to control, Monsanto loses low (not open system) 5 lbs/day,

Ref. Ck. [illegible] Water fluid 60°C under vacuum in boiler — vapors go out pump [illegible]

[Ballast cap. supposed greater than pwr. caps.]

(Positive Crankcase Ventilation principle used by Monsanto)

Use of 1242 in diffusion pumps added to problem. Monsanto has no substitute. Exhausts must be trapped

NPC00024019

E

770835

more meaningful guide than "PPM"

Transport Storage Later

Disposal Production feature: landfill

(4) (5) (6) + Ray Clark + Elmer Hammer

+ Power Capacitors

+ Labelling

+ EE → landfill (concrete encasement)

+ EM drums come before going to landfill. (Recapsulate or 1/3 → incinerate)

↓

Salazar: Users collect recond. cause, sell to Junk dealer → strips coins & sells, dumps wiring

↓

ΣWC → Private Gov. disposal site approved by state for radioactive waste

(W) landfill

Line Material →

Mr. Clarkson (5) (6)

NPC00024020

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(5) Cont
Field Failure

labelling? Power unit, maybe

Ballast — ? e.g. prefers to live with out labelling until forced

Pesticide
- Not toxic.
- Dispersed
- Degree of bio degradability
- Does not migrate
- Min Hazard

Pesticide Container

Packaging
Landfill and regulation: no scavenging
Fenced
Open & closed Perms set
Site review & approval

States are reviewing. (Penna. toughest)

G

NPC00024021

770837

(7) Paul Benignus

~~Ask for specs on askarel~~

Benignus: PCB for caps —

Mon 9-10 Lynnfield High PCB use

(former 7% — up to 50%)

Benignus 350,000 # 1254 being used in caps

(Aerovox — increased)

Interonics, Darling MC,

Tele Communications etc.)

Some AC diffusion pumps

Can Monsanto stop 1254?

Polyglycol, Fomblin

(8) Solid Disposal Service

Dr. Morris

(National Disposal SD
NDS
Private landfill
Incineration
(Rollins Park)

NPC00024022

~~(2) (3) Polyglycol~~

+ (9) Standardized Analytical procedures

Ask Dr Morris and method to Pozefsky

770838

Have reports ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

to Pozefsky in 1 mo. (cc to others)
(By JAN 17)

Minute of task force ASP — incl cc to Salazar,

Will [illegible] in diffusion pump?
(or [illegible])

Next meeting in End of Jan - early Feb → Chicago
(Marriott)

I

NPC00024023

770839

Transformer

100,000 to 125,000 transformers with PCB in existence

Failure rate: < .5%

Leak: ~ 1%

350 - 5 companies present production

Average fill ~ 235 gal to 400 gal / transformer

GE Moloney

Disposal Solid + liquid - on agenda

NPC00024024

Regulations - 3 E (Real) + Disposal facilities & procedures

Short → Guidelines transformer mfg and service shops

Retrofit - users.

Program - water treatment effluent

- Disposal equip.

770840

american national standards institute, inc.

Address Secretary at:
National Electrical Manufacturers Association
155 East 44th St., New York, N. Y. 10017
Telephone: 212-682-1500

MINUTES: MEETINGS OF CAPACITOR AND TRANSFORMER WORKING GROUPS; OF THE ANSI COMMITTEE, C107, ON USE AND DISPOSAL OF ASKAREL AND ASKAREL-SOAKED MATERIALS

PLACE OF MEETING: O'HARE INN
DES PLAINES, ILL.

DATE AND TIME: WEDNESDAY, DECEMBER 15, 1971

JOINT SESSIONS
10:15 A.M. - 11:30 A.M.
3:30 P.M. - 4:30 P.M.

SEPARATE SESSIONS OF THE WORKING GROUPS
11:45 A.M. - 3:30 P.M.

MEMBERS PRESENT:

Capacitor Working Group

N. R. Clark	Universal Manufacturing Co.
E. G. Hammer	McGraw-Edison Power Systems Div.
J. F. Kuzela	Sangamo Electric Company
R. D. McClain	Westinghouse Electric Corporation
E. M. Moore	Electrical Utilities Company
A. Pozefsky (CHAIRMAN)	General Electric Company

Transformer Working Group

W. S. Grogan	Allis-Chalmers Corporation
F. R. Lengefeld	Union Electric Co.
E. L. Raab (CHAIRMAN)	General Electric Company
W. C. Reinhardt	Central Moloney Transformer Div. Colt Industries
A. L. Rickley	Doble Engineering Company
T. K. Sloat	Westinghouse Electric Corporation

MEMBERS ABSENT:

Capacitor Working Group

NONE

Transformer Working Group

D. M. Crabtree	Department of the Army

NPC00024025

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OTHERS PRESENT:

*A. Barbaro	CDC International Inc.
**P. G. Benignus	Monsanto Company
**W. P. Papageorge	Monsanto Company
A. M. Salazar	NEMA Staff

PRESIDING OFFICER: W. P. Papageorge, Chairman
ANSI C107 Committee

*Attended the Joint and Capacitor Working Group sessions only.

**Attendance shared between all three sessions.

I. APPROVAL OF PREVIOUS MINUTES

This being the first meeting of these Working Groups, no previous minutes were submitted for approval.

II. PURPOSES OF THIS MEETING

It was noted that the background leading to the appointment of these two Working Groups and the purpose of this meeting was given in the Secretary's letter of November 18, 1971 (EXHIBIT "A"). The two Chairmen's agenda for the Capacitor and Transformer Working Group meetings are attached as EXHIBITS "B" and "C", respectively.

It was also noted that a brief outline of the Environmental Protection Agency's (EPA) National Disposal Site (NDS) Study, was distributed prior to this meeting. A copy of the outline, which was prepared by Mr. Henry Johnson, Acting Project Manager, Hazardous Wastes Project, of the National Environmental Research Center, is attached as EXHIBIT "D".

JOINT SESSIONS

III. BRIEF REVIEW OF DEVELOPMENTS OF INTEREST, SINCE THE SEPTEMBER 14, 1971 MEETING OF THE FULL ANSI C107 COMMITTEE

Mr. W. P. Papageorge briefed the members on the subject. A copy of Monsanto's recent press release on production figures, which was referred to during this briefing, is attached as EXHIBIT "E".

Mr. Papageorge also conducted a general review of bases that should be used in developing proposals for the Capacitor and Transformer guidelines, for the members' information in proceeding with the separate Working Group meetings.

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Another joint session was held after adjournment of the separate Working Group meetings, to compare the progress made at each meeting and arrive at a time and place for the next meetings.

SEPARATE SESSIONS OF THE WORKING GROUPS

IV. CAPACITOR WORKING GROUP
Dr. A. Pozefsky, Chairman

SECRETARY'S NOTE

The record of the results of the discussions at this meeting is recorded in Mr. R. D. McClain's letter of December 31, 1971, attached as EXHIBIT "F".

V. TRANSFORMER WORKING GROUP
E. L. Raab, Chairman

The record of the results of the discussions at this meeting were excerpted from the Chairman's notes, as follows:

1. Raab called attention to EEI Publication 6371 w/o "A-C Network Operations, 1959-1961". Page 4 lists Failure rates for Area Surveyed.

2. Answers to five questions:

No.	Raab	Reinhardt
1	5000	3500
2	235 avg. (40-500) Range)	400
3	1 to 1.3%	1%
4	0.2%	Less than 0.5%
5	100,000	125,000 - 150,000

Allis-Chalmers (Grogan) & Westinghouse (Sloat) will check above figures with their records.

First units were built in 1932

3. Discussion held on disposal of solids and liquid scrap:

a. GE has done some study on vapor phase cleaning and results show 85-93% efficiency.

NPC00024027

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b. Flushing method of cleaning has proved less efficient.

c. Firms identified for liquid and software disposal were Rollins Perle, Chem-Trol and Globe Metals.

E. Raab will take responsibility to write-up. This will include list of companies that handle waste plus a list of disposal methods, backed by efficiency of result. (Items 4 and 6 on agenda).

4. Transformer General, Manufacturing and Repair Guidelines, should cover both manufacturing plants and service facilities, from receipt of liquid to installation.

T. Sloat will be responsible for investigation and recommendations. Some items to be covered are:

a. Mixture of fluid

b. Disposal of non-returnable drums

c. Treatment facilities employed in handling askarel.

d. Handling of spills.

e. Filling process

(Item 2 of agenda)

5. Operating guidelines for transformer users will be proposed by W. Reinhardt. This will include such things as normal make-up, dealing with failures involving ruptured tank leaks, spills and inspection. Main concern is environment. Special recognition should be given to submersible type units in vaults. (Item 5 of agenda).

6. Control of water and vapor effluents including recommended limits for water effluents, as well as identification of analytical procedures.

To be reported on by W. S. Grogan (Items 3 and 7 of agenda).

7. Liquid and solid disposal services including identification of existing facilities and possible development of new facilities will be handled by A. Rickley (Item 8 of agenda)

8. Whether or not warning labels should be put on. Transformers and the wording will be investigated and recommended by F. Lengefeld. (Item 9 of agenda).

9. Comments should be mailed to the Chairman for distribution before next meeting, if possible.

10. Standardization of liquid not desirable for power transformers since the range of application is wide and what is best for one application is not necessarily the best for another.

11. The question of available substitutes will not be treated separately but should be covered in the "Fact Sheet".

VI. TIME AND PLACE OF THE NEXT MEETING

The Working Groups concurred that the next meeting should be at 8:30 A.M., on February 8-9, 1972, at the Marriott Motor Hotel, Chicago, Ill.

VII. ADJOURNMENT

There being no further business before the Working Groups, the meetings were adjourned at 4:30 P.M., having recessed for lunch between the hours of 12:00 P.M. - 1:00 P.M.

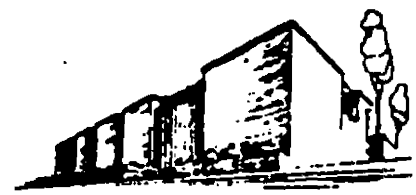
A. M. Salazar, Secretary
ANSI C107 Committee

AMS:dk
ATTS: EXHIBITS "A" - "F"

NPC00024029

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GENERAL ELECTRIC
COMPANY
POWER DELIVERY GROUP
Group Technical Resources Operation
100 WOODLAWN AVE., PITTSFIELD, MASS. 01201 . . . TEL AREA CODE 413, 443-3511



PITTSFIELD
MATERIALS AND TECHNOLOGY
LABORATORY

Subject: ANSI WORKING GROUP ON TRANSFORMERS

Pittsfield, Mass.
December 9, 1971

Messrs.	D. M. Crabtree,	Dept. of the Army
	W. S. Grogan,	Allis-Chalmers
	F. R. Lengefeld,	Union Electric
	W. C. Reinhardt,	Central Moloney
	A. L. Rickley,	Doble Engineering
	T. K. Sloat,	Westinghouse
	P. G. Benignus,	Monsanto
	W. P. Papageorge,	Monsanto
	A. M. Salazar,	N.E.M.A.
	A. Pozefsky,	General Electric

Gentlemen:

It has been suggested that our working group on transformers should be prepared to discuss the following items during our scheduled meeting in Chicago on December 15. Should any additional items occur to you, please let me know. My phone is 413-443-3511 extension 2275.

1. A "fact" sheet for distribution to apparatus users, legislative bodies, the public, etc.
2. Transformer manufacturing and repair guidelines for effective plant housekeeping and employee safety.
3. Control of water and vapor effluents.
4. Disposal of manufacturing solid and liquid scrap from production failures and/or contamination.
5. Guidelines for transformer users.
6. Disposal of field failure solid and liquid scrap.
7. Standardized analytical procedures.
8. Liquid and solid disposal services.

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EXHIBIT (1) 8

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Undoubtedly, we will have to decide what is needed, establish an order of priority, and initiate steps to draft recommendations for consideration by the full Transformer Subcommittee.

In addition to the above items at our meeting on November 11, Messrs. W. C. Reinhardt and E. L. Raab agreed to obtain the following information from their companies if possible:

1. An industry estimate of the number of askarel transformers made each year.
2. The average liquid volume in an askarel transformer.
3. An estimate of the production failure rate.
4. An estimate of the failure rate of transformers in service.
5. An estimate of the total number of askarel transformers in service (cumulative).

Should this information be available, we should also decide what, if anything, to do with it.

Very truly yours,

ELR:ml

E. L. Raab
Chairman-Transformer Working Group

EXHIBIT C (2)

NPC00024031

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NATIONAL ENVIRONMENTAL RESEARCH CENTER
CINCINNATI, OHIO 45268
December 6, 1971

Mr. P. G. Benignus, Chairman
ANSI C107 Steering Committee
Monsanto Company
800 North Lindbergh Boulevard
O-2 South
St. Louis, Missouri 63166

Dear Mr. Benignus:

Mr. Al Salazar has asked that I prepare a brief outline of the Environmental Protection Agency's (EPA) National Disposal Site (NDS) study so that this information will be available for the December 15 meeting of the two working groups. As I stated at the November 11 C107 meeting, the project deals with the problems of disposing of hazardous waste materials. Congress has mandated this work in Section 212 of the Resource Recovery Act of 1970 (enclosed).

In-house efforts, interagency agreements, and contracts will be used to accomplish the six enumerated goals in Section 212 of the Act. The following are tasks that will have to be performed in order to complete this project:

1. Hazardous Waste Survey

A contract was let July 1, 1971 to Booz-Allen Research, Inc. to prepare a list of hazardous wastes which should be subject to special disposal techniques. The locations, quantities, and generation rates of these materials will be included as part of the listing.

2. Recommended Methods of Disposal

Final steps are being taken to award a contract for this task. Methods of reduction, neutralization, recovery, or disposal of the materials listed in task 1 will be recommended.

POOR QUALITY ORIGINAL

3. Inventory of Potential Sites

The physical, hydrological, chemical, climatological, demographical, etc., requirements necessary for various acceptable methods

EXHIBIT D

will be listed and an inventory made of those available sites satisfying these requirements.

4. Functional Makeup

Based upon the recommended disposal methods, the functional make-up designs for model disposal sites will be developed inclusive of necessary equipment, physical layout, safety requirements, and costs on a unit basis.

5. Cost-Sharing Plan

Using the projected unit costs from the functional design, an investigation will be made of equitable cost-sharing programs, incentives, tax shelters, subsidies, loans, etc.

6. Public Acceptance Plan

Attitudinal research will be conducted to develop a public awareness program for the dissemination of information on hazardous wastes, their undesirable effects, and the necessity of a system of sites to properly handle these wastes.

7. Required Legislation

An investigation will be made of the existing legal bases and additional legislation necessary to implement the proposed system of sites.

8. Computer Model

A mathematical model will be developed to optimize the location of NDS based upon quantities, locations, generation rates, transportation distances, etc.

9. Report to Congress

All the information generated in the above listed tasks will be used to prepare a final report to Congress. The report will deal with the feasibility of National Disposal Sites and will outline research needed to develop techniques for handling those wastes for which we presently have no adequate means of disposal.

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If you need any further information, please feel free to contact me.

Sincerely yours,

Henry Johnson
Acting Project Manager
Hazardous Wastes Project

Enclosure

cc:
Mr. Al Salazar
Mr. W. P. Papageorge

(3)

EKH:b

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of this Act in the operation or administration of such property or facility, or the performance of such contract, as the case may be.

(2) Each Executive agency which conducts any activity—

(A) which generates solid waste, and

(B) which, if conducted by a person other than such agency, would require a permit or license from such agency in order to dispose of such solid waste,

shall insure compliance with such guidelines and the purposes of this Act in conducting such activity.

(3) Each Executive agency which permits the use of Federal property for purposes of disposal of solid waste shall insure compliance with such guidelines and the purposes of this Act in the disposal of such waste.

(4) The President shall prescribe regulations to carry out this subsection.

Presidential regulations.

(b) Each Executive agency which issues any license or permit for disposal of solid waste shall, prior to the issuance of such license or permit, consult with the Secretary to insure compliance with guidelines recommended under section 209 and the purposes of this Act.

NATIONAL DISPOSAL SITES STUDY

Report to Congress.

SEC. 212.[14] The Secretary shall submit to the Congress no later than two years after the date of enactment of the Resource Recovery Act of 1970, a comprehensive report and plan for the creation of a system of national disposal sites for the storage and disposal of hazardous wastes, including radioactive, toxic chemical, biological, and other wastes which may endanger public health or welfare. Such report shall include: (1) a list of materials which should be subject to disposal in any such site; (2) current methods of disposal of such materials; (3) recommended methods of reduction, neutralization, recovery, or disposal of such materials; (4) an inventory of possible sites including existing land or water disposal sites operated or licensed by Federal agencies; (5) an estimate of the cost of developing and maintaining sites including consideration of means for distributing the short- and long-term costs of operating such sites among the users thereof; and (6) such other information as may be appropriate.

LABOR STANDARDS

40 U.S.C. 461

SEC. 213.[15] No grant for a project of construction under this Act shall be made unless the Secretary finds that the application contains or is supported by reason-

[14] Sec. 212 added by sec. 104(b) of P.L. 91-512.
[15] Former sect. 207 through 210 redesignated as sects. 213 through 216 by sec. 104(b) of P.L. 91-512.

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EXHIBIT D

770851

Westinghouse Electric Corporation

Box 341, Bloomington, Ind 47401

December 31, 1971

Dr. A. Pozefsky, Chairman
C-107 Capacitor Working Group
General Electric Company
Engineering Department
Hudson Falls, New York 12839

Dear Dr. Pozefsky:

Attached is a copy of my notes from the ANSI C-107 Capacitor Working Group meeting held at the O'Hare Inn, Chicago, on December 14, 1971.

Mr. R. J. Boudreau of your Advanced Development Laboratory has sent me a copy of the Hygienic Guide Series on Chlorodiphenyls. By copy of this letter to other members of our Working Group, I am soliciting any similar material they may wish to submit for use in preparing the first draft of Capacitor Plant Housekeeping and Employee Safety. It is still my intent to submit this by January 17, 1972.

Sincerely,

Robert D. McClain, Manager
Capacitor Unit Engineering

RDMcC:kb

cc: A. M. Salazar, NEMA Headquarters
N. R. Clark, Universal Manufacturing Company
E. G. Hammer, McGraw Edison
J. F. Kuzela, Sangamo Electric
Dr. E. M. Moore, Electric Utilities
F. R. Lengefeld, Union Electric
P. G. Benignus, Monsanto
W. P. Papageorge, Monsanto

EXHIBIT

Minutes of Meeting, O'Hare Inn, Chicago, Illinois, December 15, 1971, ANSI C-107 Committee on Use and Disposal of Askarel and Askarel-Soaked Materials, Working Group on Capacitors:

Meeting called to order by Dr. A. Pozefsky, Chairman.

1. In a brief, preliminary discussion, three aspects of the problem were discussed:

   A. Biodegradeability. Attempts to establish degradeability and degradation rates for the different homologues and isomers of polychlorinated biphenyl have been attempted by several different methods. Statements of "half life" cannot be made at this time.

   B. Landfills. Migration of buried material through sand has been indicated as being very slow. Disposal sites, used for radio active wastes, have been used on the basis of no surface or subsurface runoff.

   C. National Disposal Sites. Mr. Henry Johnson, Acting Project Manager, Hazardous Wastes Project, National Environmental Research Center, Cincinnatio, Ohio, has pointed out the study being conducted under Section 212 of the Resource Racovery Act of 1970.

2. Following a recess for lunch, the group considered the agenda proposed by Dr. Pozefsky (December 3, 1971). It was generally accepted that the outline would serve as a basis for generating a first draft of proposed procedures and standards for the use and disposal of PCB's in capacitors. Assignments for first drafts by mid January were made by the Chairman:

   A. Capacitor Plant Housekeeping and Employee Safety - Westinghouse, R. D. McClain.

   B. Control of Water Effluents, and

   C. Control of Vapor Effluents - General Electric Company, Dr. A. Pozefsky.

   D. Disposal of Production Failures

   E. Disposal of Field Failures

   F. Disposal of Liquid and Solid Scrap

      1. Power Capacitors - Line Material, Elmer Hammer

      2. Small Capacitors - Universal Manufacturing Company, Ray Clark
         Electric Utilities Company, Dr. E. M. Moore

      Consideration will also be given to possible labelling procedures.

   G. Industry Standard on Askarel Composition - Monsanto Company, P. G. Benignus.

(2)

EXHIBIT

NPC00024037

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Minutes of Meeting, O'Hare Inn, Chicago, Illinois, December 15, 1971, ANSI C-107 Committee on Use and Disposal of Askarel and Askarel-Soaked Materials, Working Group on Capacitors:

Meeting called to order by Dr. A. Pozefsky, Chairman.

1. In a brief, preliminary discussion, three aspects of the problem were discussed:

   A. Biodegradeability. Attempts to establish degradeability and degradation rates for the different homologues and isomers of polychlorinated biphenyl have been attempted by several different methods. Statements of "half life" cannot be made at this time.

   B. Landfills. Migration of buried material through sand has been indicated as being very slow. Disposal sites, used for radio active wastes, have been used on the basis of no surface or subsurface runoff.

   C. National Disposal Sites. Mr. Henry Johnson, Acting Project Manager, Hazardous Wastes Project, National Environmental Research Center, Cincinnatio, Ohio, has pointed out the study being conducted under Section 212 of the Resource Recovery Act of 1970.

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   B. Control of Water Effluents, and

   C. Control of Vapor Effluents - General Electric Company, Dr. A. Pozefsky.

   D. Disposal of Production Failures

   E. Disposal of Field Failures

   F. Disposal of Liquid and Solid Scrap

      1. Power Capacitors - Line Material, Elmer Hammer

      2. Small Capacitors - Universal Manufacturing Company, Ray Clark
         Electric Utilities Company, Dr. E. M. Moore

      Consideration will also be given to possible labelling procedures.

   G. Industry Standard on Askarel Composition - Monsanto Company, P. G. Benignus.

H. Solid Disposal Services - Electric Utilities Company, Dr. E. M. Moore.

I. Standardized Analytical Procedures - Electric Utilities Company, Dr. E. M. Moore and General Electric Company, Dr. A. Pozefsky.

The Chairman requested that first drafts and reports be submitted to him by January 17, 1972, with copies distributed to other members of the group, in order to expedite reviews prior to the next meeting in Chicago at the Mariott Hotel, February 8 and 9, 1972.

Robert D. McClain
Acting Secretary

GENERAL ELECTRIC COMPANY

JOHN STREET, HUDSON FALLS, NEW YORK 12839 . . . AREA CODE 518, TELEPHONE 747-3341

INDUSTRIAL AND POWER

CAPACITOR DEPARTMENT

December 3, 1971

ANSI WORKING GROUP ON CAPACITORS

Messrs: N. R. Clark, Universal Mfg. Co.
E. G. Hammer, McGraw-Edison
J. F. Kuzela, Sangamo Electric
R. D. McClain, Westinghouse
E. M. Moore, Electric Utilities
P. G. Benignus, Monsanto
W. P. Papageorge, Monsanto
A. M. Salazar
E. L. Raab

The following is the agenda of items I feel we should be prepared to discuss during our meeting in Chicago on December 15.

1. Capacitor Plant Housekeeping and Employee Safety.
2. Control of Water Effluents.
3. Control of Vapor Effluents
4. Disposal of Production Failures.
5. Disposal of Field Failures.
6. Disposal of liquid and Solid Scrap.
7. Need for Industry Standard on Askarel Composition.
8. Solid Disposal Services.
9. Standardized Analytical Procedures.

I anticipate that we will want to first decide which of these areas are in need of national control standards and procedures and to initiate steps to formulate the appropriate recommendations of this Committee.

Please let me know of there are any other items you feel should be added to this Agenda. My phone is 518-747-3341.

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A. Pozefsky
Chairman-Capacitor Working Group

/kw

EXHIBIT B

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National Institute Environmental Health Sciences

Meetings on PCB's, Week of 12/20/71, Quail Roost, N.C.

Report in A W N, Dec. 27, 1971, p 5, by
Wil Lepkowski (biochemist), McGraw Hill publication

100 attendees: List available?
Prisons disobeying for FDA release, list of users, by Monsanto
Corporate accountability disclosed

→ Dr. Morton Nelson, "chief of environmental medicine"
New York University

Reference to H.E.W. Dept. Occupational Safety & Health
Institute

Interagency ad hoc PCB Committee; Terry Davies
Co-Chairman

E. P. Lichtenstein, U of Wisc.
Dr. Arie Sarofim M.I.T.
Dr. I.C.T. Nisbet Mass. Audubon Society
Dr. Charles Edwards, FDA

Time Carpet the Washington Post (Sect F, Sunday Jan 2 1972 issue Louisville Courier-Journal & Times)

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ENGINEER'S TRIP REPORT
WESTINGHOUSE FORM 3811 G

FILE
[illegible]

NO[illegible] 1 - The Engineer reporting is responsible for [illegible]prompt delivery of his reports to all interested persons and for seeing that all points requiring action are cleared up without delay.
2 - For long reports give a summary of important points and recommendations.

For Westinghouse Representatives only.

DATE December 21, 1971

ORIGINAL TO ISSUING DEPARTMENT'S FILE NO.	DATE OF ARRIVAL AT PROPERTY	DATE OF LEAVING PROPERTY

COPY TO: (FOR REPORT DISTRIBUTION GUIDE - REFER TO REVERSE SIDE OF THIS SHEET)

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☐	Sharon Works, ML-381	MR. R. L. Schwab
☐	Sharon Works, ML-015	MR. J. Riesinger
☐	Bloomington Works	MR. R. D. McClain
☐	South Boston Works	MR. G. C. Wilburn
☐	Sharon Works, ML-024	MR. R. L. Rademacher
☐	Sharon Works, ML-082	MR. C. E. Hutchison
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☐		MR.

VISIT - NAME _____ NEG. _____

LOCATION _____ G.O. _____ S.O. _____ SER. O. _____

PURPOSE OF TRIP ANSI C-107 Meeting

CONFERENCE HELD AT Chicago, Ill. DATE Dec. 15, 1971

THOSE PRESENT _____

SUMMARY:

A meeting of the transformer and capacitor working groups of ANSI C-107 was held to delegate work assignment to the various members. The purpose of the work is to provide industry guide for the proper and safe handling of Askarels to prevent environmental pollution.

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SIGNED (ENGINEER)	APPROVED		
DEPARTMENT: Fluid Insulation Section	DIVISION: Transformer Division	LOCATION: Sharon Works	PAGE: 1

[redacted]

770858

Chicago, December 15, 1971

MEETING ANSI C-107
USE AND DISPOSAL OF ASKARELS AND
ASKAREL SOAKED MATERIALS

PRESENT:

Transformer Group

E. L. Raab, General Electric
W. S. Grogan, Allis-Chalmers
F. R. Lengefeld, Union Electric
W. C. Reinhardt, Central Moloney
A.C. Rickley, Doble Eng.
T. K. Sloat, Westinghouse

Capacitor Group

A. Pozefsky, General Electric
N. R. Clark, Universal Mfg. Co.
E. G. Hammer, McGraw Edison
R. D. McClain, Westinghouse
E. M. Moore, Electric Utilities

P. G. Benignus, Monsanto, Ex. Officer
W. P. Papageorge, Monsanto, Ex. Officer
A. M. Salazer, ANSI

The meeting opened with Mr. Papageorge presenting the lastest information on the government status on the PCB's.

1. The Toxic Chemical Act will probably not be passed by the present congress but it appears fairly certain it will be handled under this act, that is, the controls on PCB's.

2. 22 Other Congressmen have now co-sponsored a third bill of Congressmen Ryan banning all PCB's. It does not appear as though this bill will get out of committee.

3. The EPA has been active in Alabama at the Monsanto plant. The effluent from the plant contained about 50-100 ppb. and based on the flow represented about 0.3#/day. This is not acceptable on a long term basis.

4. The state of Michigan's Water Resource Commission has been attacking big industry for PCB's in water effluent coming from hydraulic systems. A zero level is required.

5. Several groups have raised the question of air contamination by PCB's but no studies are underway.

6. A meeting is to be held in Durham, N. C., December 20 and 21 ?? sponsored by the National Institutes of Health to hear a group of papers by domestic and foreign scientists on their studies of PCB's and effects on human biology. Approximately 100 people will attend. Documents will be made available of this meeting.

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7. In spite of the vast amount of data available to the FDA they have not made a ruling or regulation on the PCB's.

8. Mr. Papageorge distributed to the members present production figures for the Aroclors from 1960 to date.

It was decided that Monsanto would prepare a fact sheet of the question and answer type for distribution to all interested parties. This fact sheet will be ready for review at the next committee meeting.

The committee then broke into the transformer and capacitor groups for work assignments.

Transformer Group

The following assignments were made to provide information to be made into an ANSI document.

1. Transformer manufacturing and repair guidelines for effective plant housekeeping and employee safety. - T. K. Sloat

2. Guide line limits for control of water and vapor effluents. - W. S. Grogan

3. Disposal of manufacturing solid and liquid scrap from production failures and/or contamination. - E. L. Raab

4. Guidelines for transformer users. - W. C. Reinhardt

5. Disposal of field failure solid and liquid scrap. - E. L. Raab

6. Standardized analytical procedures for water and air. - W. S. Grogan

7. Liquid and Solid disposal services. - A. L. Rickley

8. Warning Labels and disposal. - F. R. Lengefeld

Each person is to submit drafts of his assignment to the chairman prior to next meeting for distribution to other members.

The following questions were proposed and answers by GE and Central Moloney given. Westinghouse and Allis Chalmers were asked to also respond.

1. An industry estimate of the number of askarel transformers are made each year.
   GE 5000 Moloney 3500

2. The average volume of liquid in an askarel transformer.
   GE 235 gal. Moloney 400 gal.

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3. An estimate of production failure rate.
   GE 1-1.3% Moloney 1.0%

4. An estimate of the failure rate of transformers in service.
   GE 0.2% Moloney 0.5%

5. An estimate of the total number of askarel transformers in service (cumulative).
   GE 100,000 Moloney 125,000

The following items were of interest:

1. The General Electric Company has on order an incinerator for April startup which will destroy liquids and solids soaked with askarel. They are considering making this service available to customers.

2. The General Electric Company is considering a vapotherm type of treatment of core and coil assemblies to wash out PCB's prior to scrapping the assemblies. It has been shown to be an efficient way to clean the askarel from the core and coil.

3. The General Electric Company at Pittsfield and Rome use Aroclor 1254, 85%, and tri-tetra chlorobenzene, 15% for all transformers.

The transformer and capacitor groups met again for final information. The assignments of the capacitor group were as follows.

1. Housekeeping and plant safety. - R. D. McClain

2. Guidelines for handling water and vapor effluents. - A. Pozefsky

3. A.S.T.M. will be asked to provide methods for determination of Askarels in materials and air.

The next meeting will be held February 8 and 9 at the Marriott Hotel in Chicago. Individual assignment drafts to be sent out by January 26.

T. K. Sloat

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