c.c. D. Wood - Brussels
J.M.M. Thomson - London ✓
G.C.G. Alberini - Milan

31st October, 1968.

Dr. G. Maschio,
Pirelli General Cables Ltd.,
Eastleigh,
Hampshire.

Dear Dr. Maschio:

Aroclor 1242 : Quantity and Nature of Decomposition Products

It was a pleasure to meet you and Mr. Simmons on 16th October. I should now like to answer the questions that you raised during the meeting.

1) Theoretical calculation of the volume of hydrogen chloride produced by complete decomposition of Aroclor 1242

1 litre of Aroclor 1242 at 20°C weighs 1.38 kg and contains 0.58 kg of chlorine. Complete decomposition would produce 0.60 kg of hydrogen chloride which occupies a volume of 366 litres at a temperature of 0°C and a pressure of 760 torr. This is an extreme case assuming a sufficiently high input of energy. Since the Bunsen coefficient for the solution of hydrogen chloride in water is 412 at 30°C, at this temperature this volume of hydrogen chloride would be dissolved by 0.89 litres of water.

2) Volume of gases produced by decomposition of askarels in electric arcs

During 1954, one of our transformer customers carried out experiments on the volume of gases produced by powerful arcs in mineral oil and transformer askarels (Pyroclor). Records of the pressure and volume of gas produced and its composition were obtained together with oscillograph records of the arc conditions. Later, a second series of tests was made on Aroclor 1242, 1248 and 1254, but in this series the volume of gases was not measured. However, from the pressure data recorded for both series it is possible to estimate the volume of gases produced in the second series where these values were not measured directly. The arcs took place in a steel tank with a volume of about

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32 litres. The volume of liquid for each test was about 10 litres. The electrodes were of copper, arranged about 76 mm below the surface of the liquid. The gap was 12.7 mm and the arc was initiated by 2 strands of 40 S.W.G. (0.122 mm diameter) fuse wire. The free volume of the tank was evacuated before each test. The applied voltage was about 5 kV for all the tests.

The following table gives the results of the tests:-

Liquid	Symmetrical Breaking Current (kA RMS)	Arc duration (0.01 s)	Total Arc Energy(kJ)	Volume of gases at NTP (l)	Volume/ Energy (l/kJ)
Mineral oil	6.38	2.0	18.3	6.8	0.37
" "	10.4	3.0	64.7	13	0.20
" "	15.5	3.2	136.0	37	0.27
Pyroclor	5.94	3.0	95.8	122	1.27
"	6.13	3.1	130.0	178	1.37
"	6.06	3.0	71.2	54	0.76
"	10.4	3.0	329	496	1.51
Aroclor 1242	9.96	2.0	105	45	0.43
Aroclor 1248	10.1	3.9	319	235	0.74
"	9.4	1.9	86.2	73.5	0.85
Aroclor 1254	5.05	4.0	73.0	26.3	0.35
"	9.40	3.0	180	113	0.63
"	10.3	2.0	29.4	15	0.50
"	9.58	3.0	214	116	0.54

Although a total of 4 tests were made with Aroclor 1242, only in one case was the pressure recorded from which it is possible to estimate the volume of gases produced. We can summarize the previous table of results as follows:-

Liquid	No. of results	Volume of gas at NTP produced for unit arc energy (l/kJ)	
		Range	Average
Mineral oil	3	0.20 to 0.37	0.28
Pyroclor	4	0.76 to 1.51	1.23
Aroclor 1242	1	-	0.43
Aroclor 1248	2	0.74 to 0.85	0.80
Aroclor 1254	4	0.35 to 0.63	0.50

Although the amount of gas produced by arcing in insulating liquids depends upon the test conditions, these figures enable the order of magnitude to be calculated for a particular fault level.

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3) Information on the toxicity of hydrogen chloride and other gases

The following information has been summarized from N.I. Sax, "Dangerous Properties of Industrial Materials", 2nd edn., Reinhold Publishing Corporation, New York, 1963.

Hydrogen chloride: TLV (Threshold limiting value), ACGIH (accepted) : 5 ppm v/v in air, 7 mg/m^3 of air. A concentration of 35 ppm causes irritation of the throat after short exposure. Concentrations of 50 to 100 ppm are tolerable for 1 hour. Concentrations of 1000 to 2000 ppm are dangerous even for brief exposures. Mists of hydrogen chloride are considered less harmful than the anhydrous hydrogen chloride.

Chlorine: TLV ACGIH (accepted) : 1 ppm v/v in air, 3 mg/m^3 of air. A concentration of 3.5 ppm produces detectable odour. A concentration of 15 ppm causes immediate irritation of the throat. Concentrations of 50 ppm are dangerous even for short exposures. A concentration of 1000 ppm may be fatal even when exposure is brief.

Phosgene: TLV ACGIH (accepted) : 1 ppm v/v in air, 4 mg/m^3 of air. Concentrations of 3 to 5 ppm cause irritation of eyes and throat with coughing. A concentration of 25 ppm is dangerous for exposures lasting 30 to 60 minutes. A concentration of 50 ppm is rapidly fatal after even short exposure.

Carbon monoxide: TLV ACGIH (accepted) : 100 ppm v/v in air, 115 mg/m^3 of air. A concentration of 400 to 500 ppm in air can be inhaled without appreciable effect for 1 hour. One hour's exposure to a concentration of 600 to 700 ppm will cause barely appreciable effects. Exposure to 1000 to 1200 ppm is dangerous. Concentrations of 4000 ppm and over are fatal in less than an hour. Reported exposure to low concentrations up to 100 ppm is generally believed to cause no signs of poisoning or permanent damage.

The following additional information was summarized from F.A. Patty 'Industrial Hygene and Toxicology', 2nd edn., Interscience Publishers, New York, 1963.

Concentration of hydrogen chloride in air (ppm)	Effect
1 to 5	Most people can detect
5 to 10	disagreeable
10	work undisturbed
10 to 50	work difficult but possible
50 to 100	work impossible

Aroclor 1242 vapour in air TLV ACGIH (April 1969): 1.0 mg/m^3

4) Rate of decomposition of Aroclor 1242 at a temperature of about 1000°C

I regret that we do not have this information. We could make some estimates based on thermo dynamical reasoning but it would be necessary to make certain assumptions and the results would be of doubtful validity. Our only information of this type relates to the use of Aroclor in heat transfer

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systems operating at atmospheric pressure. Aroclor 1242 has a boiling point of about 310°C and a flash point by the method of ASTM D92-57 (Cleveland Open Cup) above 171°C : by the same test method, there is no fire point below the boiling point.

5) Tests for the presence of chlorine and phosgene in the gases resulting from the decomposition of Aroclor during arcing

a) I enclose a xerox copy of a paper by P. Jay 'Étude de la formation de phosgene par décomposition dans l'arc électrique des hydrocarbures chlorés', Chimie et Industrie, 92, No. 5 (Novembre 1964). I also enclose a copy of an English translation of this paper.

The Monsanto products equivalent to those mentioned in this paper are as follows:-

Pyralene 1499	-	Aroclor 1242
Pyralene 1476	-	Aroclor 1254
Pyralene 1467	-	Pyroclor (transformer askarel)

You will see that Jay was unable to detect the presence of either chlorine or phosgene during the tests on askarels.

b) In addition, I enclose an English translation of a report from the Chemisch-Technische Reichsanstalt, Berlin, Register No. 176/40C of 21st May 1940, 'Opinion on the behaviour of Clophens in thermal and electrical treatment'. We do not have the original version in the German language.

In this report, the Monsanto equivalents of those metnioned are as follows:-

Clophen T64	-	Pyroclor (transformer askarel)
Clophen A50	-	Aroclor 1254

At that time, trichlorodiphenyl was not widely used as a capacitor impregnant.

Again, the writer was unable to detect the presence of either chlorine or phosgene under a wide range of conditions.

I believe that I have now covered fully the questions that arose during our meeting, but please do not hesitate to let me know if you require further information.

Yours sincerely,

CRC

Colin R. Coleman
Research & Development Dept.

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