MEETINGS OF EIA PCB AD HOC COMMITTEE WITH VARIOUS ORGANIZATIONS TO DISCUSS FLAMMABILITY PROBLEMS IN CAPACITORS

Three meetings were held by the EIA PCB Ad Hoc Committee in Chicago on March 2 and 3, 1975 to discuss potential problems that may arise when Aroclor 1016 is replaced by other capacitor impregnants with less fire resistance. The three groups involved were Underwriters Laboratories (UL), U. S. Consumer Product Safety Commission (CPSC) and Association of Home Appliance Manufacturers (AHAM). The following were present for the EIA Committee - Cliff Tuttle - Aerovox, Richard Hauser - EUC, Richard Rollins - Jard, Bud Dibble and Bill Carrier of Mallory, Roger Wills - Westinghouse, Ray Clark - Universal Electric, Curt Lopes - Cornell Dubilier, Jim Flynn - GE, Dave Howe - Sprague, Tyler Nourse - EIA, David Wood and Roger Hatton - Monsanto.

Basically the same agenda was used for all three meetings. Major headings were:

I. Present Status of PCBs in Capacitors

II. What are the Alternates and Their Characteristics?

III. What are the Minimum Requirements for AC Capacitors?

IV. Where are non-PCBs now being used?

V. Specific Topics for Discussion with Each Group

UL Meeting

Those present for Underwriters Laboratory were R. W. Seelback, Harland Bratvold, James Duffy and Renee' Yerke.

The Monsanto phase-out of PCBs was reviewed by David Wood. There appeared to be no basic disagreement with our position; however, it was stated several times that the major reasons for urgency are governmental action and Monsanto's desire to cease making PCBs.

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Ray Clark of Universal presented a written statement on the present status of PCB impregnated capacitors pointing up the excellent reliability, safety and life characteristics of present units. A copy is attached.

Jim Flynn of G. E. reviewed government influences in terms of the Federal EPA actions, the Clean Water Act, the proposed Toxic Substances Act, and proposed EPA disposal guidelines. The overall intention appears to be to control the use and disposal of PCBs. He also reviewed the status of various state bills. Many of the state regulations are more stringent than those proposed by the Federal agencies. Roger Wills of Westinghouse indicated that OSHA and NIOSH are looking into the vapor concentration problems in the working space.

Rich Rollins of Jard reviewed the revision now underway on ANSI document C-107 to include more details on the handling of solid waste. Also labeling requirements and a spill handling plan will be added. The revision also involves the transformer area and, because of delay by this group, the revised document will not issue until later this year.

Cliff Tuttle of Aerovox summarized stating that there will be no PCB capacitors marketed after 24-36 months, the Federal Energy Act will require that capacitors be used in order to meet the necessary energy reductions, and that Monsanto and EPA actions are establishing the timing of the change.

Rich Rollins of Jard presented a paper on PCB alternatives and their characteristics for AC capacitors. A copy is attached. He emphasized the safety aspects stating that both the gases that can be formed and the liquid itself can be involved in fires. The problem can arise from case rupture, case burn out and leakage. He reviewed the relative size as related to impregnant capacitors. His calculations were theoretical using the same dielectric spacings. The consensus of those present was that the dielectric spacings would have to be increased with the fluids now under consideration due to lower stability. Such changes will make the capacitor larger and they are now indicating a 10-20% increase from the added paper.

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Non-PCB fluids are presently being used in primarily capacitors for export. This is required for Japan and Sweden but many users of capacitors are exporting their finished product with non-PCB containing units in order to lower inventory duplication. The two materials being used are phthalate esters and synthetic hydrocarbons, i.e., Monsanto products.

The UL representatives stated that they have no present requirements on capacitors since they consider them merely part of the total device which they approve. However, now that the capacitor flammability issue has been raised, they feel should investigate what is needed. They have no data on the number of capacitor failures or fires. They obviously cannot underwrite any fires. They are not sure how to approach the capacitor flammability problem in terms of specific tests or requirements. One is to look at fluid characteristics as a starting point. They also suggested that industry could supply life test data as well as failure modes.

UL would require contracts to study the area and is interested in approaching it. They used the general term, "burning intensity," but no methods of measuring it were detailed. However, they would evaluate ignition and propagation characteristics of multiple tests. They emphasized that fire point is not the sole criteria for capacitor fluid flammability.

Out of these discussions arose a need for understanding the failure modes of capacitors in order to evaluate fluid and sources of ignition. It was reported that 25-50% of the fluid in the capacitor is free fluid (not absorbed in the paper). Rich Rollins indicated that dielectric failure occurs in three places; first, where the two foils start; second, where the two tabs are put into the unit; and third, where the foil ends. The first failure phenomena is gasing plus heat plus circuit disruption (generally do not fail to ground not usually associated with case rupture). The second failure has no electrical resistance between tabs; therefore, there is rapid flow of electrical energy generating gas build-up and usually rupture of the case.* The third failure does not cause much difficulty (very similar to the first case).

*This is not a frequent occurrence but is violent when it happens.

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One other mode of failure is through the case when a short circuit to ground is formed causing the case to burn out and the fluid to escape. The fluid may be forcibly expelled through the hole, and, if on fire, act as a flame thrower. It is felt that case failures are probably less than 10% of the electrical failures. Total failures in the field are thought to be in the range of 0.02% of those in use. Venting of the case has not been used because of the problems with the nature of the vapors formed, requirements to operate at higher temperatures and mechanical deficiencies of the devices for venting. Under failure conditions temperatures probably reach 200°C with corona present and the pressure can reach 400 PSIG.

To summarize, the following points are important:

1) This was an initial meeting to present the flammability problem to Underwriters Laboratory; therefore, no official position was developed by UL on approving non-PCB capacitors. No consideration has been given by UL to the approval of units containing non-PCB capacitors since they do not test capacitors separately.

2) UL feel there should not be a change from the PCB fluids without good engineering reason and background and the hazards with non-PCB fluids should be compared to present units.

3) EIA does not want UL to set up electrical testing and criteria for the non-PCB capacitors. They want UL to look into flammability aspects only.

4) Some contract arrangement will be required for UL work which may be EIA sponsored, industry sponsored, or individually sponsored by each manufacturer.

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CPSC Meeting

The second meeting was held with representatives of the U. S. Consumer Product Safety Commission. Present were: Dr. Joseph McLaughlin, Jr. - Director, Div. of Biological Science, Bureau of Biomedical Science, and Mr. Wm. H. King, Jr., - Electrical Engineer, Bureau of Engineering Sciences.

The purpose of this meeting was to introduce to CPSC problems that might arise with non-PCB fluids in capacitors as it may affect consumer products. The agenda followed was similar to that of the UL meeting.

One particular area was discussion in answer to a question from Mr. King. This related to the possible replacement of fluid impregnated capacitors by metallized polypropylene film capacitors. It was indicated that present technology is based on European developments. One important characteristic of the metallized film capacitors is that they fail giving an open circuit as compared to failing in a shorting mode as with the impregnated types. Reasons for the interest in Europe are the differences in the type circuits used and the life expected. In Europe, capacitors are used in parallel circuits. For example, fluorescent lights do not have the quick start feature. The motors in common use are not the PSC type. Metallized film capacitors are used in power factor correction, but in parallel circuits where they see as a maximum line voltage. In series circuits as used in U. S., they see multiple of line voltage. Further, in the United States, major emphasis is on life and reliability. The life of metallized film units is somewhere in the range of 10% of U. S. standards. It appears that Japan follow European practice with parallel circuits and 220 volt systems instead of the three wire system we use. It was pointed out that metallized film capacitors generally fail by shorting across the film which reduces the capacitance of the unit slowly. This does not generally give complete failure but does reduce performance.

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Representatives from CPSC stated that at the present time they do not have any programs in this area but are responsible for building fire safety. Therefore, this could become an area of concern but it would have to fit into their priority system. The CPSC is a group of five commissioners who look into various areas as brought to their attention. It operates through a staff of experts such as those attending the meeting.

Dr. McLaughlin indicated that he was a member of a group looking into the problems with PCBs and PBBs which expected to issue a report by June, 1976 assessing the problems on PCBs. At the start of the work, there was no representative from the consumer side and Dr. McLaughlin was appointed. His assessment on acceptability of proposed PCB substitutes was that the phthalate esters have been shown not to be carcinogenic and are used in food packaging. In the mineral oil area, straight chain types appear to be very good, but other types are not. The silicones look fairly good. He made one comment that, since phthalates and silicones are not found in nature, they are easy to detect and therefore, any problems arising from their use can be traced. His conclusion is that the PCBs in open systems are gone, that PCBs in large industrial closed systems may stay and the task force will probably not distinguish between Aroclor 1016 and other PCBs.

Mr. King indicated that on the electrical side, they had not been aware of the potential problems. He reported that the National Bureau of Standards are doing work for ERDA on a program on test methods for properties of dielectrics. The report should be available around mid-year and is primarily on transformer fluids. The work is being led by a Purdue engineer, David Miller.

Possible actions were discussed. One approach would be to ask for a hearing before the Chairman of the CPSC to present the situation. Dr. McLaughlin will report back the concern of flammability of PCB replacements to his committee. It was indicated that this capacitor problem will undoubtedly be down the list of CPSC priorities but will be brought to the Commission's attention. Mr. King stated that they would need additional

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information on what is the probable incidence of problems, what are the specific problems and what data can be given. In response to this, Rollins reported a very bad fire in one of their test ovens. Tuttle reported one fire in their units, and Lopes indicated they are adding fire protection to their laboratory test facilities. It was agreed that these occurrences were all under test conditions but do give rise to worry concerning the eventual problem.

AHAM Meeting

The meeting was held March 3, 1976 and included 13 members from AHAM. These represented the air conditioning, freezer-refrigerator, dehumidifier and microwave producers as well as two from the AHAM technical staff. An attendance list is available. Official minutes will eventually be issued to all in attendance and to the total membership list of AHAM.

The discussions followed the previous agenda. Floor discussion on the various points gave some additional information. The question of chlorination of materials in the environment to show up as PCB-related product was raised and it was stated it would probably not go beyond the mono-chlorination stage. There was considerable interest in possible alternates such as metallized film. The differences were pointed out as before especially in terms of the 220 volt limit as compared to the 370 and 440 volt requirements in the U. S. and the failure mode of metallized film construction which does not interrupt the circuit. In Europe, there are presently approximately 100$\overline{M}$ capacitors of metallized film type in use. Eighty percent of these are in 250 volt maximum applications. The other 20$\overline{M}$ are on 440 volt circuits where they are used across the line and not in actual equipment. Based on present technology the capacitance maximum limit is 20 microfarads. Reliability is only 10,000 hours mean life as compared to the U. S. requirements of 95% survival after 60,000 hours for 70°C units and 100,000 hours with 70% survival for 90°C units. In Europe there is no or very limited warranty on units and therefore, it is difficult to get actual data on life of the unit. Further warranty does not seem to be as important as in the U. S.

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During the meeting, much information was provided by Tom Jacoby, Assistant Director of Engineering for Tecumseh Products Company. Their capacitor specification (H-115) is the most widely accepted by industry. He stated that no non-PCB fluid has yet passed their specification.

The effects of changes in capacitors on the equipment being built by members of AHAM was discussed in detail. On life and reliability, it was indicated that the development of heat pumps and larger compressor units are pushing the present limits for capacitors. In addition, temperatures might go somewhat higher. The general comment was that they cannot reduce the present requirements. Additional capacitors will be put on freezers and refrigerators because of the need for more efficient use of electricity in line with the government regulations. As fan motors, the present "shaded pole" types are on their way out and PSC (Permanent Split Capacitance) motors will be used in the future to get the desired energy improvements.

Capacitors are presently offered with 330, 370, and 440 volt maximum ratings. It was the consensus of opinion that there were very few applications for 300 volt limit capacitors (upper limit for metallized polypropylene). It was reported that "phthalate ester impregnants give lower voltage ratings because of potential problems with corona inception and extinction." With the new fluids, it was felt that the volt ampere ratings may be lower to handle the lower stability. This will decrease temperature generation in the unit.

The temperature problem was discussed primarily in terms of change in capacitor location. These locations involve efficiency considerations and there are not many tradeoffs available. The users want the temperature limits to remain as at present or go higher.

In the area of dissipation factor changes, it was felt that capacitor losses may be higher with the new fluids. Higher dissipation factors would increase temperatures. With metallized film, a greater than 5% drop in capacitance over the life of the unit is found as compared to the present 0.6% limit with impregnated capacitors. The differences are due to the mode of clearance of failures in the metallized film unit.

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In discussing physical size versus cost, real problems became apparent. In order to accommodate the differences due to use of the non-PCB impregnants, the case must change in height or diameter, usually in height. Manufacturers present indicated that they could see no way of introducing larger units into their present designs. Replacement in present units also represents a major problem.

There was considerable discussion on the failure modes and conditions in the environment around the capacitor. There can be a lot of dirt and dust present where these units are used, particularly in compressors. Further, capacitors are in the most vulnerable spot in the unit since arcing does occur in other electrical devices in the enclosure.

In summary of this meeting: the potential problems were recognized by AHAM and they appreciated being involved at an early stage; no resolution was developed nor expected during the first meeting; the problems would have to be studied and resolved; AHAM was willing to work with EIA and other groups to define and resolve the issue; additional contacts would be required.

Summary

This series of meetings outlined for three problems which may arise in replacement of PCB capacitor impregnant fluid by flammable materials in industrial capacitors. No resolution to the problem was developed but this was not expected since these were primarily information-type meetings. Without question, there is a potential flammability problem using non-PCB fluid in capacitors. The extent of the problem was not defined; there are no present test methods and no criteria available. Changes to non-PCB fluids give potential problems in size, life, reliability, temperature-rise, capacitor characteristics, and safety. Additional meetings are already planned with other users of capacitors to inform them of potential problems. All of these areas must be explored in detail for industry-wide use of non-PCB fluids to occur. This must be done as soon as possible because of government and Monsanto pressures to cease PCB production.

Roger E. Hatton

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