

a thermocouple and bridge, and a Bunsen burner. The thermocouple lead wires were fastened to the cup handle, and its sensing head was located inside the cup, about 1/32 in from the bottom. A small piece of Teflon was attached to the head to weigh it down and to keep it from touching the heated metal. The hot plate and the aluminum block were next to each other with their surfaces at about the same level, so that the cup could be easily moved from the hot plate onto the aluminum block. They were located in a draft-free enclosure. For any test, the hot plate was always at its highest temperature, and the aluminum block was initially at room temperature.

In a typical test, a sample of fluid in the cup was ignited with the burner to continuous burning while heated on the hot plate, and then moved onto the surface of the aluminum block and cooled until the flame extinguished, temperature being recorded throughout, and also time during the cooling. At the time of ignition the fluid was checked visually if it was boiling. The cup was cleaned carefully before each test, removing any soot, and was filled with fluid to the designated level. A specimen was assumed to be burning continuously when the flame persisted for 10 seconds. When a fluid was tested for the first time, the burner flame was applied for about one second every 5-10 C rise. In subsequent test the flame might be kept on the surface for several seconds at a lower bulk fluid temperature to affect forced ignition. Or, the sample was ignited at a higher temperature than in the first test. This was the most meaningful test, particularly when the specimen was ignited at or near boiling.

The following fluids were tested: pentachlorobiphenyl (Aroclor 1254), trichlorobiphenyl (MKS 1016), mineral oil, various solutions of trichlorobiphenyl and mineral oil, tricresyl and tributyl phosphates, diisononyl phthalate, and polydimethyl and polymethylphenyl silicone (Dow Corning 200, 30 cc, and DC 550). The trichlorobiphenyl fluid and mineral oil served as representative "markers" of non-fire hazardous and fire hazardous fluids, respectively. The fluids were tested in the same manner as described above, and the results are shown in Figs. 1, 2 and 3. The fluids were tested in the same manner as described above, and the results are shown in Figs. 1, 2 and 3. The fluids were tested in the same manner as described above, and the results are shown in Figs. 1, 2 and 3.

Results of these tests are shown in Figs. 1, 2 and 3 where the temperature of the fluid is plotted as a function of time, from the ignition to a continuous, 10 second, flame to extinction of the flame while cooling. The criteria for a fluid to be non-fire hazardous in power equipment are satisfied by only pentachlorobiphenyl, and by trichlorobiphenyl and its solutions of up to 10% mineral oil, Fig. 1. In fact, pentachlorobiphenyl did not even burn for 10 seconds when ignited at its boiling point. A solution of 20% mineral oil in trichlorobiphenyl could be ignited well below its boiling point, and then continued to burn until the temperature decreased by about 50°C. Mineral oil itself continued to burn for some time during cooling until the flame extinguished. The temperature of the fluid increasing during the ignition period and during the initial cooling period, Fig. 2. This effect was observed in none of the other tests here. Tributyl phosphate, Fig. 2, showed this effect of continuing to burn during cooling. The sample was heated to boiling, and then moved to the hot plate, and the flame continued to burn continuously for 10 seconds, and then the flame extinguished. When it was ignited at 100°C, still below boiling, its flame extinguished only after it reached

about 35 C. Both silicone oils required relatively high temperatures to be ignited to continuous burning, Figs. 2 and 3. But once this occurred, they continued to burn during cooling. In fact, polydimethyl silicone continued to burn from about 290 C to less than 80 C without its flame extinguishing. It should be noted that the ignition temperatures of the silicone oils and tricresyl phosphate are about as high or higher than that of trichlorobiphenyl, but they are more flammable by the criteria presented here.

It was observed that the chlorinated biphenyl fluids produced considerable soot and flashes of flame at considerable distances from the specimen in this test, as well as in the Cleveland Open Cup Test, when exposed to a flame at or near boiling. The soot and flashes of flame seem to be associated. Some fluid may be sorbed on the soot, and, perhaps by catalysis, may burn even at a relatively low temperature. The possibility of a fire spreading this way should be considered. But it is not as dangerous as when a fluid like mineral oil is ignited, where the bulk fluid burns continuously, while here only very small amounts are involved.

Discussion

The results of this test are quite reasonable. It is significant that positive flammability results, indicating fire hazard, were obtained with polymethylphenyl silicone (DC 500), polydimethyl silicone and tricresyl phosphate whose Cleveland Open Cup Test fire points are either about the same as, or higher than trichlorobiphenyl. These fluids burn freely, after being ignited at atmospheric conditions, because of their relatively high hydrogen contents.

However, the magnitude of the Cleveland Open Cup test fire point, or the ignition temperature in its modification here, is significant when considered in conjunction with the non-flammability criteria that separate fluids that are non-fire hazardous from those that are fire hazardous. The magnitude of the fire point, or the ignition temperature, is a significant factor in determining the fire hazard of a fluid. The magnitude of the fire point, or the ignition temperature, is a significant factor in determining the fire hazard of a fluid. The magnitude of the fire point, or the ignition temperature, is a significant factor in determining the fire hazard of a fluid.

Acknowledgement

The authors wish to thank Dr. J. W. Dakin, Westinghouse Research Laboratories, for his suggestions and work with the Cleveland Open Cup test procedure, and to follow the temperature of the burning fluid, in this investigation.

References

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Fig. 2—Flammability temperature relationships for electric fluids in a modified Cleveland Open Cup test. Subscripts refer to different tests on the same fluid.

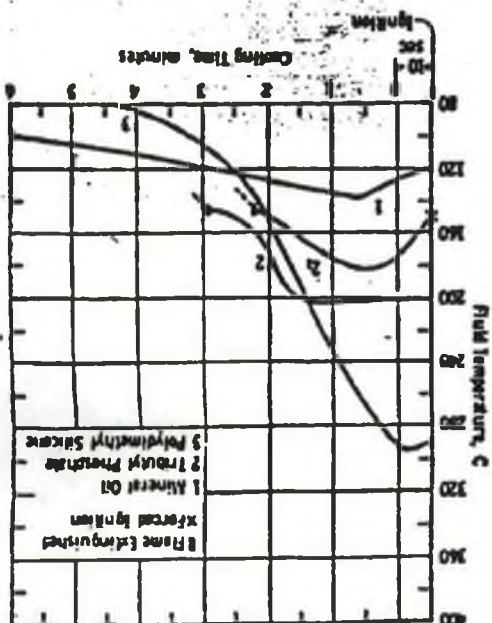


Fig. 1—Flammability temperature relationships for electric fluids in a modified Cleveland Open Cup test. Subscripts refer to different tests on the same fluid.

