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# A CONTROLLED THERMAL ENVIRONMENT FOR DIELECTRIC BREAKDOWN STRENGTH STUDIES

by

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## DISCLAIMER

# A CONTROLLED THERMAL ENVIRONMENT FOR DIELECTRIC BREAKDOWN STRENGTH STUDIES

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A small automatic temperature chamber has been developed in which it is possible to conduct dielectric breakdown strength tests and similar studies over the range of -10°C to + 210°C with ±0.1°C stability. The chamber is of the fluid immersion type and was designed around a 220 kv pulse generator, although it is readily adaptable to most other types of high voltage generating equipment. Made of Pyrex, it is composed of two cylindrical vessels stacked vertically: the upper, called the test chamber, contains the specimen and the circulating temperature bath while the lower merely surrounds the high voltage bus bar with a room temperature fluid and reduces the flow of heat through this bus to the high voltage generator which has been calibrated at room temperature.

The dielectric fluid, having passed through a heat exchanger, enters the four-gallon test chamber from beneath and is forced to assume a circular flow pattern by three input tubes which protrude tangentially into the chamber. Thus as the fluid level rises, a selective heat field is developed; the outer, rapidly-rotating layers exchanging their heat with the chamber walls, the core rotating very little and retaining its temperature and that of the dielectric specimen within it.

In the system (Figure 1), the temperature chamber is supplied with a silicone dielectric fluid by a pump/heat-exchanger unit through three metal hoses, and exhausts to this unit in the same way. An auxiliary 430 W heater is shown wrapped around the set of input hoses and augments the two 500 W and 700 W submersible heaters in the heat exchanger. All heaters are singly controlled and may be operated in combination. (With all heaters on, the chamber temperature will reach +210°C in about 5 hours.) When a desired temperature has been achieved in the chamber, an immersed contact thermometer actuates a relay which de-energizes the heaters in use. While this thermostatic action provides gross temperature pulsations at the pump, the combination of its diffusive mixing action, the selective rotary flow pattern and glass wool insulation (not shown) serves to maintain the temperature at the dielectric specimen ±0.1°C.

Temperatures below ambient are achieved by passing a fluid heat sink through a submerged cooling coil within the heat exchanger. Control is provided by one heater with the contact thermometer. With the same silicone dielectric fluid, temperatures of -10°C have been reached but at the expense of bubbles and moisture condensation in the oil and of sluggish fluid flow. A dry atmosphere and a less viscous fluid would correct the latter two defects. However, the bubbling occurs at all temperatures and is a characteristic of the pump in this system.

To avoid long delay in bringing chamber and specimen to a high temperature, an automatic warmup system has been devised which starts pump and heaters at some early hour and ensures their safe operation. Should the hot fluid threaten to overfill the test chamber, for example, a floating switch shuts the entire system off, permitting the fluid to re-establish a safe level at which time normal operation resumes.

The tests performed in this environment have thus far been tests of dielectric strength, with electrodes of two types (Figure 2): an ASTM electrode combination of nickel-plated brass, and an imbedded $y = 0.4\pi$

Rogowski[1] contour coated with metallic paint to which the ASTM electrodes merely provide electrical contact. In both cases, positive voltage pulses of about 20 μs duration (Figure 3) were applied once per second, each successive pulse increasing in amplitude by 2.5 kv until breakdown occurred.

Using the first of these electrode configurations, Hysol epoxy 13-009[2] in flat sheets 4 x 4 square inches in area and having various thicknesses was tested to determine its dielectric strength versus thickness and temperature. The resulting surface (Figure 4) represents the mean of some 330 data and displays the expected decrease[3,4] of dielectric strength with increasing thickness and temperature in this range.

In the second group, three materials were tested with the y = 0.4 π electrode: Diall 52-20-30 (diallyl phthalate with kaolinite filler and reinforced with long glass fiber), Diall FS-4 (diallyl isophthalate with kaolinite filler and reinforced with long glass fiber), and Plaskon 422 (a mineral-filled alkyd molding compound). The data averaged for these tests appear in Figure 5.

1. O. Milton, "A Rogowski Surface for Dielectric Strength Tests," 33rd Conference on Electrical Insulation, NAS-NRC, October 1964.

2. B. Carroll and J. Smatana, "Transparent Cold-Shock-Resistant Epoxy Casting Resin," SCR-173, Sandia Corporation, Albuquerque, April 1960.

3. J. H. Mason, "Electrical Insulation (Part I): Dielectric Breakdown," Electrical Energy, p. 68, November 1956.

4. S. Whitehead, Dielectric Breakdown of Solids, (Oxford, London, 1953), p. 39 ff.

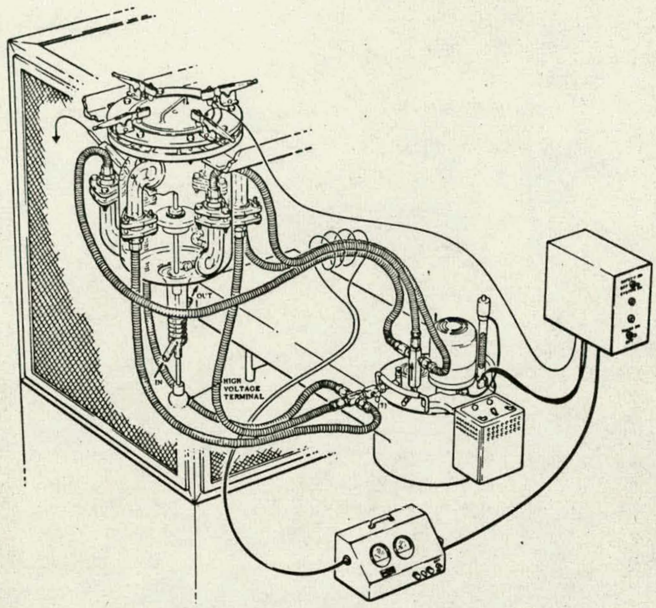



Fig. 1: Thermal environmental apparatus, showing temperature chamber, heat exchanger, and control box.

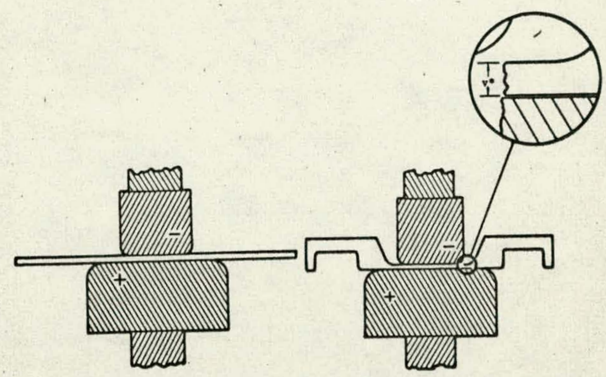


Fig. 2: Electrodes for sheet-cast and recess-molded dielectrics. Top electrode diameter is one inch.

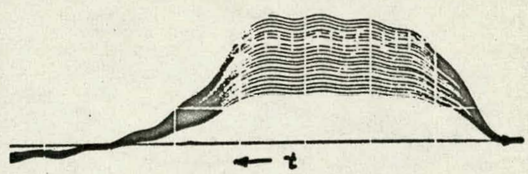



Fig. 3: Pulse shape: 2.5 kv increment each second, 5 $\mu$sec per division. 89 kv breakdown.

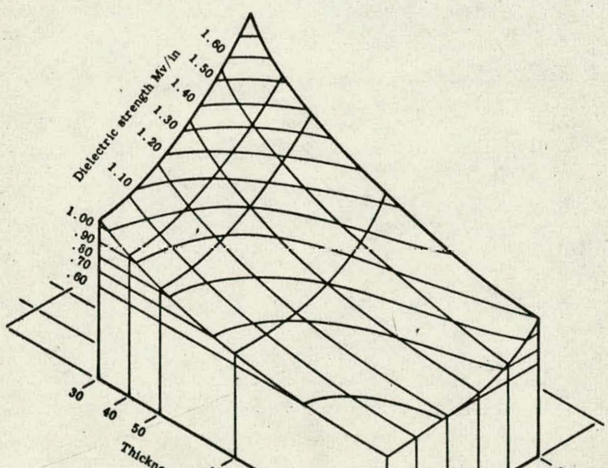
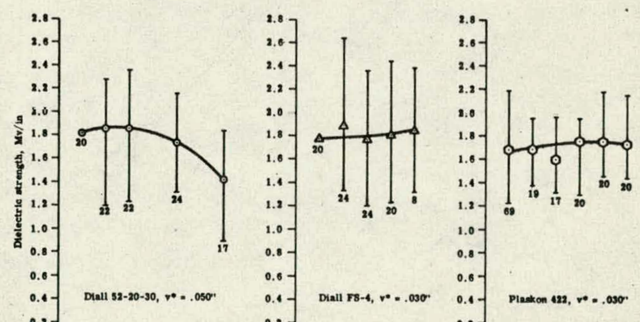



Fig. 4: Dielectric strength of SRIR epoxy sheets versus temperature and thickness.




Numbers beneath data average indicate quantity of samples in each test. v* is breakdown thickness.

Fig. 5: Dielectric strength versus temperature of three molded resins with imbedded Rogowski contour.

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