Dielectric Strength Notes
Note 5

Spring 1966

Revision of Breakdown Data Concerning Mylar

by
Ian D. Smith
Atomic Weapons Research Establishment

First Printed as SSWA/IDS/6610/102

A previous note on solid breakdown described the decrease of the mean single shot impulse breakdown field E(Mv/cm) with increase of the volume V (cc) of solid stressed, and related the rate of decrease to the intrinsic scatter of the results obtained when a number of samples of the same volume are tested. The experimental results yielded straight lines when log E was plotted against log V over a range of volumes from less than a tenth of a cc up to 10 litres, the constancy of slope of such a plot corresponding to the observation of a standard deviation which is a constant fraction of the mean, independent of V.

This fraction was 14% and E changed by a factor of 1·32 for every factor of 10 in volume, ($E \propto V^{-1/8}$), in all the four materials checked, which therefore plotted as four parallel straight lines. In increasing order of strength the materials were polyethylene, polypropylene, mylar (or Melinex) and lucite (Perspex). Of these, polyethylene and lucite were quite thoroughly investigated and subsequent results tend to confirm the original data. A reasonably accurate determination was made from a limited sample of polypropylene and there is no reason to doubt these results. Mylar was not investigated thoroughly, since the application which led to the experiment was the construction of generators using large volumes and large thicknesses, and mylar, besides being expensive was only available in thin sheets. The mylar used in most of the tests was in fact a commercially available bonded sheet made from two 14 mils sheets. Three series of experiments with this yielded three points indicating a line parallel to that obtained for the other plastics. However, one point (the largest volume) is now found to be invalid, since the breakdown mechanism in most cases involved tracking near edges.

Accumulated data now indicates a line of distinctly less slope, crossing the perspex line to become, at large volumes, the best of the insulators studied, though data at the larger volumes is now lacking somewhat. The slope may be as low as 1·22 per decade ($E \approx V^{1/12}$).

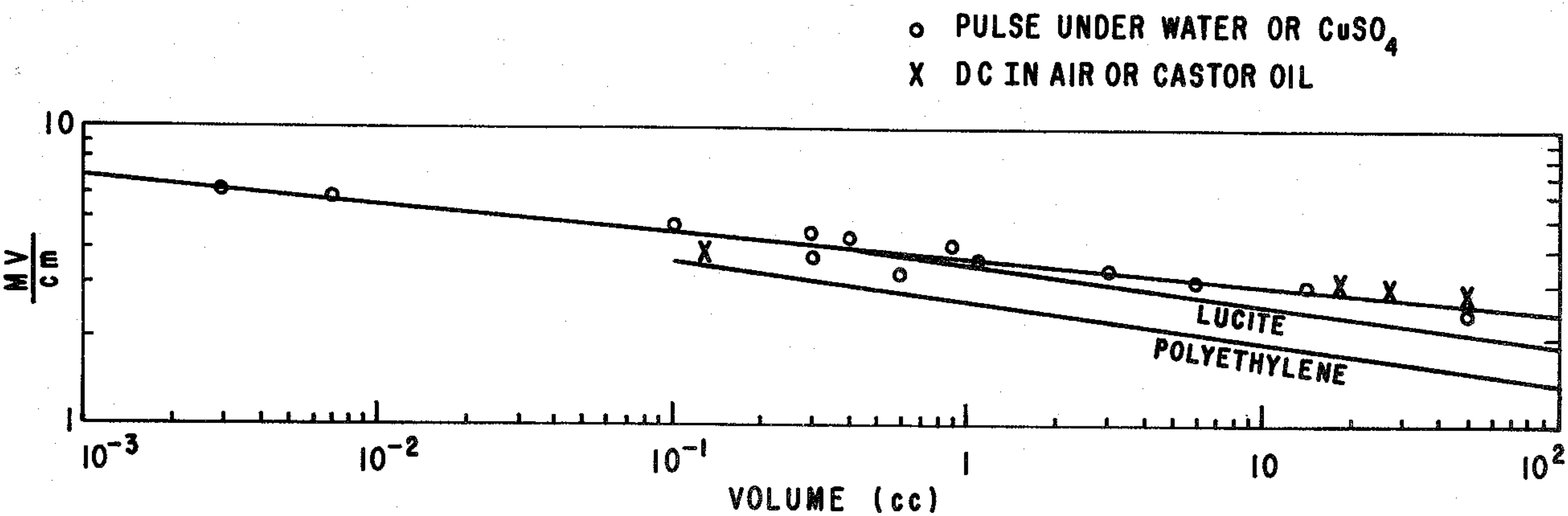
As before, impulse voltages have mostly been applied, rising in a microsecond or less, to samples immersed in water or copper sulphate solution. In one case the mylar sample with the copper electrodes was vacuum impregnated with copper sulphate. Also, some points have been obtained for D.C., using both air and castor oil as the ambient medium, and in one case castor oil was combined with vacuum impregnation. None of the above variants yielded significantly different results and we feel confident that the results indicate a property of the material and not of any particular test method.

We have not detected, for mylar, the conditioning effect which Cooper at Manchester has shown in the case of polyethylene to give higher strengths for D.C. than for microsecond like impulses, and which also leads to failure when D.C. charge to near breaking point is followed by a moderate impulse reversal of voltage. We still know of no region where uniform field breakdown of solids shows a time dependency.

One slight inconsistency is that the standard deviations in the case of mylar (12-13%) is not so much lower than for other materials as one might anticipate from the smaller slope of the E - V plot. This could be due to a contribution to scatter in some experiments from significant percentage variations in the thickness of the thin films used.

In addition, a piece of plastic (thickness 30 mils) of the same composition as Melinex but before strain orientation, was tested and gave results a little below, but probably not significantly, the present plot.

	Thickness d (cm)	Mean Voltage V (kV)	Field (MV/cm)	Area (cm^2)	Volume (cc)	No. of Shots N	Standard Deviation (%)	Method
1	0.142	434	3.05	45	6.0	5	7	Pulse, CuSo4 solution
2	0.142	462	3.26	4.5	0.6	5	8	" "
3.	0.071	244	3.44	45	3.0	4	1	" "
4.	0.071	257	3.63	4.5	0.3	8	5	" "
5.	0.071	256	3.62	16	1.1	10	11	" Water
6.	0.0198	89	4.47	16	0.30	10	16	" "
7.	0.059	248	4.18	16	0.90	6	12	" "
8.	0.0198	63	3.15	700	14	10	19	" "
9.	0.026	112	4.33	16	0.4	30	12	" "
10.	0.026	124	4.75	5	0.1	-	-	" "
11.	0.0028	16.8	6.10	1	0.003	75	15	" "
12.	0.0060	33.8	5.63	1	0.007	60	15	" "
13.	0.0076	19	2.45	6300	50	9	20	" CuSo4 vacuum impregnated
14.	0.057	16.8	2.94	3200	18	3	3	D.C. in air
15.	0.086	24.6	2.85	3200	27	2	3	" " "
16.	0.076	20.3	2.70	3200	26	5	20	" " "
17.	0.076	30	3.9	15	.13	6	15	D.C. castor oil
18.	0.076	20.3	2.65	6300	50	3	15	D.C. castor oil vacuum impregnated


o PULSE UNDER WATER OR $CuSO_4$
X DC IN AIR OR CASTOR OIL
10
1
MV/cm
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
VOLUME (cc)
LUCITE
POLYETHYLENE