Report on the Twenty-fourth Annual Meeting of the Conference on Electrical Insulation of the National Academy of Sciences and National Research Council of America: October 17-19, 1955 at Pocono Manor, Pennsylvania, U.S.A

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NATIONAL RESEARCH COUNCIL OF CANADA
RADIO AND ELECTRICAL ENGINEERING DIVISION

TWENTY-FOURTH ANNUAL MEETING OF THE CONFERENCE ON ELECTRICAL INSULATION OF THE NATIONAL ACADEMY OF SCIENCES AND NATIONAL RESEARCH COUNCIL OF AMERICA

OCTOBER 17-19, 1955

OTTAWA

NOVEMBER 1955

REPORT ON THE TWENTY-FOURTH ANNUAL MEETING
OF THE CONFERENCE ON ELECTRICAL INSULATION OF
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by

P. K. Watson

Twenty-seven papers were presented at this year's Conference on Electrical Insulation, and abstracts of the papers will be published in due course in the Annual Report on the Conference. This report describes a selection of the papers which were presented, and some of the ideas put forward in discussion which were of interest to the writer.

1. THE ELECTRICAL BREAKDOWN OF DIELECTRICS

In the session on Electrical Breakdown there were two papers dealing with the statistical theory of the breakdown of liquids, and its application in the interpretation of results.

Weber and Endicott presented a paper on the Effect of Electrode Area on the Electrical Breakdown of Liquid Dielectrics, in which they showed results from a large number of tests on insulating oil under A.S.T.M. conditions but using Rogowski profiles instead of sharp edged discs for the electrodes. The results were found to conform to a pronounced skew distribution, contrary to the findings of many previous workers, who, with fewer results to guide them, obtained distributions of breakdown voltage that were essentially Gaussian.

The mean breakdown voltage itself was found to vary with electrode area in accordance with the relationship,

$$V_1 - V_2 = \frac{S_v}{\sigma_n} \log \frac{A_2}{A_1},$$

where V_1 and V_2 are the mean breakdown voltages obtained using electrodes of area A_1 and A_2, respectively, and S_v and σ_n are parameters describing the frequency-distribution of the breakdown voltages.

This relationship was used by Sharbaugh, Cox, Crowe, and Auer, to interpret their results on the breakdown strength of pure Hexane; it was found possible to condense results from a number of tests, each carried out using a different size of electrodes, into one curve of Breakdown Strength against electrode spacing.

2. MATERIALS AND APPLICATIONS

In the second session, on Materials and Applications, an interesting "commercial" was presented by Norman, Pfunter and Kessel, in which non-tracking organic insulations were described.

The mechanism of tracking in organic insulation is fairly well understood; localized arcing takes place across surfaces adjacent to the high voltage terminals, particularly under severe weather conditions, and carbon particles are formed by the resulting thermal deterioration of the insulation: arcing proceeds along the localized track of carbon, and eventually bridges the surface of the insulation with consequent failure of the apparatus.

The paper described the use of an oxidizing agent as a filler in a number of compounds, which included butyl rubber and an epoxy resin. This filler was capable of oxidizing the carbon as soon as it was formed, giving carbon monoxide as the electrically innocuous end product, and so preventing the formation of a carbon track.

This technique gave considerably improved arc resistance to all compounds tested, and this was particularly true of the butyl rubber derivative which is now in commercial use. This has been used for the insulation of outdoor current transformers, which are giving good service in regions such as the west coast of the U.S.A., where sea fogs with a high saline content have long been a source of arcing troubles.

Unfortunately, the authors of the paper omitted to mention the name of the oxidizing material they had used, and declined to amend their omission during the discussion afterwards.

3. THERMAL AND CHEMICAL DETERIORATION OF DIELECTRICS

An interesting part of these conferences are the Round Table Sessions, in which no formal papers are presented, but topics are open to group discussion — this ofter leads to an interesting exchange of ideas between engineers, physicists and chemists.

This year, one of the topics presented was, "The Thermal and Chemical Deterioration of Dielectrics", which led to a discussion on Rate Processes.

It has been evident for some time that the idea of Rate Process, widely used in physical chemistry, can be used with profit in the testing of electrical insulation. The influence of temperature upon the rate constant (k) of a chemical reaction of a given order is shown by the Arrhenius equation:

$$k = A\exp(-E/RT),$$

where E = activation energy of the reaction,
R = universal gas constant,
T = absolute temperature,
and A = a constant of the reaction

Thus, by measuring the accelerated rate of a process — say the deterioration of insulation as measured by insulation resistance — at a series of elevated temperatures, and extrapolating these results in accordance with the straight line relationship of log k against 1/T, it is possible to deduce the life expectancy of the insulation at its working temperature (see figure). This is a technique which has been used implicitly by engineers for decades — the rule of thumb which states that the life of insulation is halved for every 10°C rise in working temperature is a typical instance — however, the recent 'discovery' of the basic theoretical work has served to put these empirical rules on a more dignified footing.

At this point a controversy arises as to how far one is at liberty to assume a constant order of reaction, and whether it is as safe as it would seem at first sight to extrapolate to temperatures outside the range at which the test measurements were made. If, in fact, a transition takes place below the range of temperatures at which the tests were carried out, and a different order of reaction, or even a totally different reaction, with a different activation energy, takes over, then the true life expectancy may be very different from the calculated one, and in some cases, the insulation may fail in a far shorter time than would be supposed from the test results.

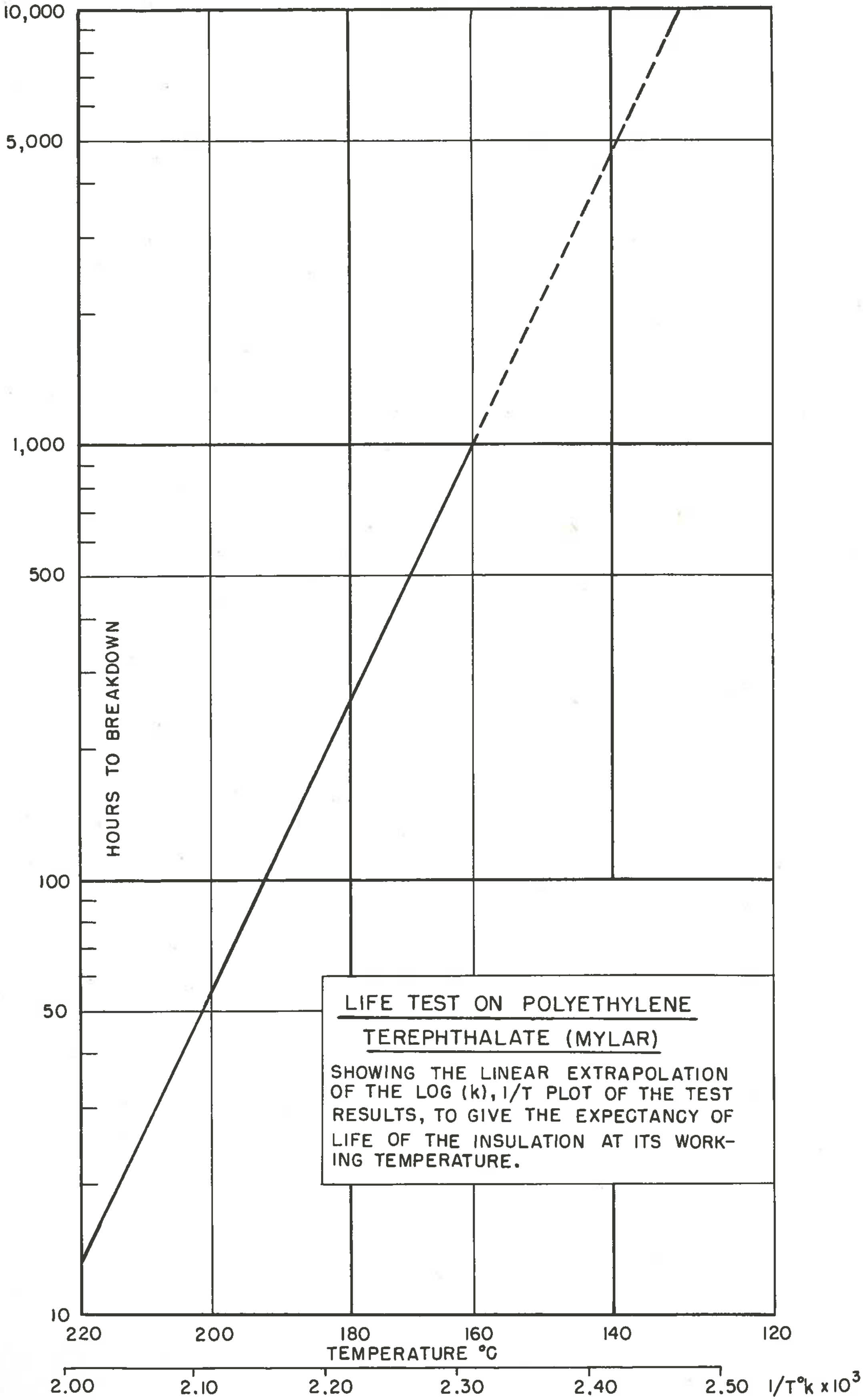
Thus, although the Arrhenius equation is a valuable tool, it has decided limitations; it is particularly useful for the correlation of data from life tests on insulation at elevated temperatures, but its use in the design of insulation can lead to trouble.

4. MISCELLANEA

A paper in the session on the General Properties of Dielectrics described an interesting new ferroelectric material, Guanidine Aluminum Sulfate Hexahydrate. This material has a remarkably low dielectric constant for a ferroelectric (approximately 6); its Curie point cannot be measured because the material loses its water of crystalization in heating above 100°C, but it is thought to lie between 200° and 300°C. The material has very high stability when used in switching circuits, a feature which the most widely used ferroelectric, barium titanate, does not possess. The latter tends to age, after a few million switching cycles.

An innovation at the conference this year was the J.B. Whitehead Memorial Lecture. This was given by Dr. John G. Kirkwood, Professor of Physical Chemistry at Yale University. His lecture traced the development of the concepts of dielectric constant in polar liquids from Debye and Onsager to the statistical mechanical models of Kirkwood and Leonard Jones.

Professor A. von Hippel of M.I.T. gave a lecture on his concept of the so called Molecular Engineer, a man trained in Engineering and in the basic sciences, well versed in the laws governing the intrinsic properties of matter, and as a consequence, capable of finding the new materials constantly demanded by industry, without resort to the wasteful cut and try technique so much in evidence to-day. A great deal of interest has been expressed in this idea and it is proposed to run a summer school in 1956 at M.I.T. as an experiment in this direction.


10,000
5,000
1,000
500
100
50
10
HOURS TO BREAKDOWN
220
200
180
160
140
120
TEMPERATURE °C
2.00
2.10
2.20
2.30
2.40
2.50
1/T°k x 10³
LIFE TEST ON POLYETHYLENE TEREPHTHALATE (MYLAR)
SHOWING THE LINEAR EXTRAPOLATION OF THE LOG (k), 1/T PLOT OF THE TEST RESULTS, TO GIVE THE EXPECTANCY OF LIFE OF THE INSULATION AT ITS WORKING TEMPERATURE.