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CLASS 1

THE USE AND MISUSE OF MULTIPLE REGRESSION
IN IDENTIFYING IMPORTANT PROCESS VARIABLES

by

G. J. Hahn and S. S. Shapiro

Report No. 66-C-178

May 1966

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CLASS 1

THE JOINT ASSESSMENT OF NORMALITY
OF SEVERAL INDEPENDENT SAMPLES

by

S. S. Shapiro and M. B. Wilk*
Information Sciences Laboratory

Report No. 67-C-322

August 1967

*Bell Telephone Laboratories, Inc.

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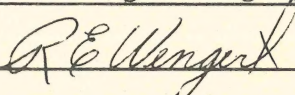
AUTHORS C.E. Pangburn C. Arabadjis	SUBJECT Statistics	NO. R67SIPD12 DATE 18 April 1967
TITLE The Log-Normal Distribution		GE CLASS 1 GOVT. CLASS. Unclassified
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SUMMARY This report provides engineers and technicians with tools by which they can determine whether data is log-normally distributed, and if it is so distributed, provides a means by which they can best find the estimator of the mean and variance of the distribution. In providing these tools, the log-normal distribution was first analyzed and such expressions as those for moments and cumulative probabilities were derived. Estimation techniques are discussed, and a comparison of errors is graphically presented. Four time-sharing BASIC programs have been written, and these are discussed fully. The programs are used to: describe log-normal distributions, estimate the mean and variance of log-normally distributed data, and test data for log-normality, using a chi-squared goodness-of-fit test.		
KEY WORDS Estimation, time sharing, probability density function, confidence limits, reliability, mean-squared error.		

INFORMATION PREPARED FOR _____

TESTS MADE BY _____

AUTHORS C.E. Pangburn and C. Arabadjis

COMPONENT Systems Development Engineering

APPROVED R.E. Wengert 

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Report No. RL-332

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TITLE PREPARATION AND TESTING OF IN-
ORGANIC SEMI-CONDUCTING COMPOUNDS--
PROGRESS REPORT

AUTHOR G.S. GORDON
J.A. PARODI
R.R. RALSTON

SEPTEMBER 20, 1949

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SOME PROPERTIES AND APPLICATIONS OF EPOXY RESINS

by

C. D. DOYLE

SCHENECTADY, NEW YORK

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Plastics

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Electrophoretic Deposition
of
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W. G. Morrison, Jr.

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E. S. WHEELER

ELECTRICAL INSULATION CONFERENCE 1967

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RESINS & PLASTICS - "Epoxide resins-applications
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G. Walton,
R.E. Stolton,
"Shell" Research Ltd.

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BAYESIAN AND CLASSICAL UPPER ONE-SIDED CONFIDENCE LIMITS
ON FAILURE RATE

by

J. J. Fleck, Information Sciences Laboratory

Report No. 69-C-150

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CONFIDENCE LIMITS AND DEMONSTRATION TESTS
FOR PRODUCT FAILURE RATES

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W. B. Nelson
Information Science & Engineering

Report No. 71-C-042

January 1971

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ENGINEERING AND STATISTICAL PROBLEMS ASSOCIATED
WITH THE INSPECTION OF MOLDS

by

George J. Hurwitz

Army Chemical Center

In the past the members of the Baltimore Section have been treated to talks by personnel from the Quality Assurance Division, Chemical Corps Materiel Command on the need for coordination between the statistician and the engineer and the benefits which can result from such a coordinated effort. The problem to be discussed aptly illustrates this team work which resulted in a substantial dollar and manpower saving, and the resolution of a difficult although very interesting problem. All of the statistics shown were prepared by Quality Assurance Division statisticians and will illustrate the F Test, "t" Test, Analysis of Variance and Wilcoxon Ranking Method.

The problem involved the dimensional inspection of vacuum forming molds used in the fabrication of a certain type of gas mask. A vacuum forming mold is a metallic device shaped in the form that will cure the rubber into the shape it will ultimately assume. Chemical Corps specifications require that the molds used by the fabricator be approved by the Chemical Corps prior to use. In addition, since the molds become Government property at termination of the contract, inspection is also required prior to placing in storage for subsequent use on another contract.

The usual procedure is to mount the mold on a flat plate, rule off lines 1/2" apart in both the horizontal and vertical directions and then determine the distance of the intersections from the base line. By this procedure approximately 500 individual points on the mold are determined and compared with the drawing. Set up time was approximately 7 hours and an equal time was required to make the measurements. Total cost in labor to inspect one mold was \$42.00. Although the cost of the mold is not a factor since the mold can be used to produce a large quantity of masks, it is interesting to note that the cost of initial inspection was 21% of the cost of the mold. Since another inspection would be required at the end of the contract, it can be seen that the cost of mold inspection could become a sizeable sum, particularly as in this case about fifty molds were involved. The problem therefore was to determine what savings could be accomplished in inspection cost and still have sufficient information upon which to base a decision with respect to the following:

INTRODUCTION TO WORK SAMPLING

Stanley R. Kalin
Chief Industrial Engineer

The National Plastics Products Company
Odenton, Maryland

The p, or percent defective chart is a device well known in the quality field for its ability to provide an estimate of percent defective in a run. It owes its utility to the basic statistical truth that a sample taken in a random manner from a universe will tend to reflect the characteristics of that universe. Ordinarily the characteristics are length, diameter, tensile strength or other quality features. But if we were to consider a universe consisting of all the minutes in the day of a production machine at random minutes and noting if it were productive or idle, we should then be able to estimate how the day was divided into productive and idle time.

The eminent British Statistician L. H. C. Tippett first used this technique, which was later to become known as Ratio Delay Study, when he applied statistical sampling to the problem of predicting loom breakdown in a textile mill in England. (1) The first appearance in this country was in 1940. (2) The term "work sampling" is currently used to describe an expanded concept in which the technique is used to gather facts not only about machines but about men as well. (3)

As an example of how Work Sampling might apply to an actual case, let us assume Department X of our plant has submitted a request for an additional bench grinder on the ground that the one in the department cannot keep up with the amount of grinding to be done. To check this allegation we might elect to use work sampling techniques, in which case we would proceed as follows: Mark a piece of paper productive and idle, in two columns, and wander through department X at random intervals observing the grinder. If the grinder is operating when observed, place a tally mark in the Productive column, and if idle, place a tally mark in the Idle column. Do this at random throughout the day, and repeat until somewhere between 500 and 3000 observations are recorded. Take the number of tallies in the Idle column and divide by the total number of observations made. This fraction times 480, the number of minutes in an 8 hour working shift, gives the total minutes the grinder is idle per day on the average. If the amount of idle time is sufficient to care of the excess work load complained of, the new machine is probably not justified.

Work Sampling is based on the binomial distribution. Confidence limits are easily computed by means of the following:

$$\sigma = \sqrt{\frac{p q}{n}}$$

Transactions Paper

(Reviewed and Accepted for Publication)



Healey

FACTORS AFFECTING THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES

J. H. Hagenguth
Fellow AIEE

J. G. Anderson
Member AIEE

Both of:
General Electric Co.
Pittsfield, Mass.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 7-11, 1957. Manuscript submitted May 31, 1957; made available for printing August 20, 1957.

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A
E E
I

THE PRESTRIKE THEORY AND OTHER EFFECTS IN THE LIGHTNING STROKE

Theory

S. B. Griscom
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

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H. A. FREY

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Theory

THE LIGHTNING STROKE

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Both of:
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East Pittsburgh, Pa.

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Lightning Theory

ARC DROP DURING TRANSITION FROM SPARK DISCHARGE TO ARC

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C. M. Lane
Associate Member AIEE

C. M. Lear
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Lightning Theory

ANOMALOUS FLASHOVERS ON TRANSMISSION LINES -- PART II

Charles J. Miller, Jr.
Fellow AIEE
The Ohio Brass Company
Barberton, Ohio

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THE TEINOGRAPH - A NEW HIGH-VOLTAGE SURGE RECORDER

J. G. Anderson
Member - AIEE

R. U. Giacomoni
Associate Member - AIEE

Both of:
General Electric Co.
Pittsfield, Mass.

To be presented at the AIEE Middle Eastern District Meeting,
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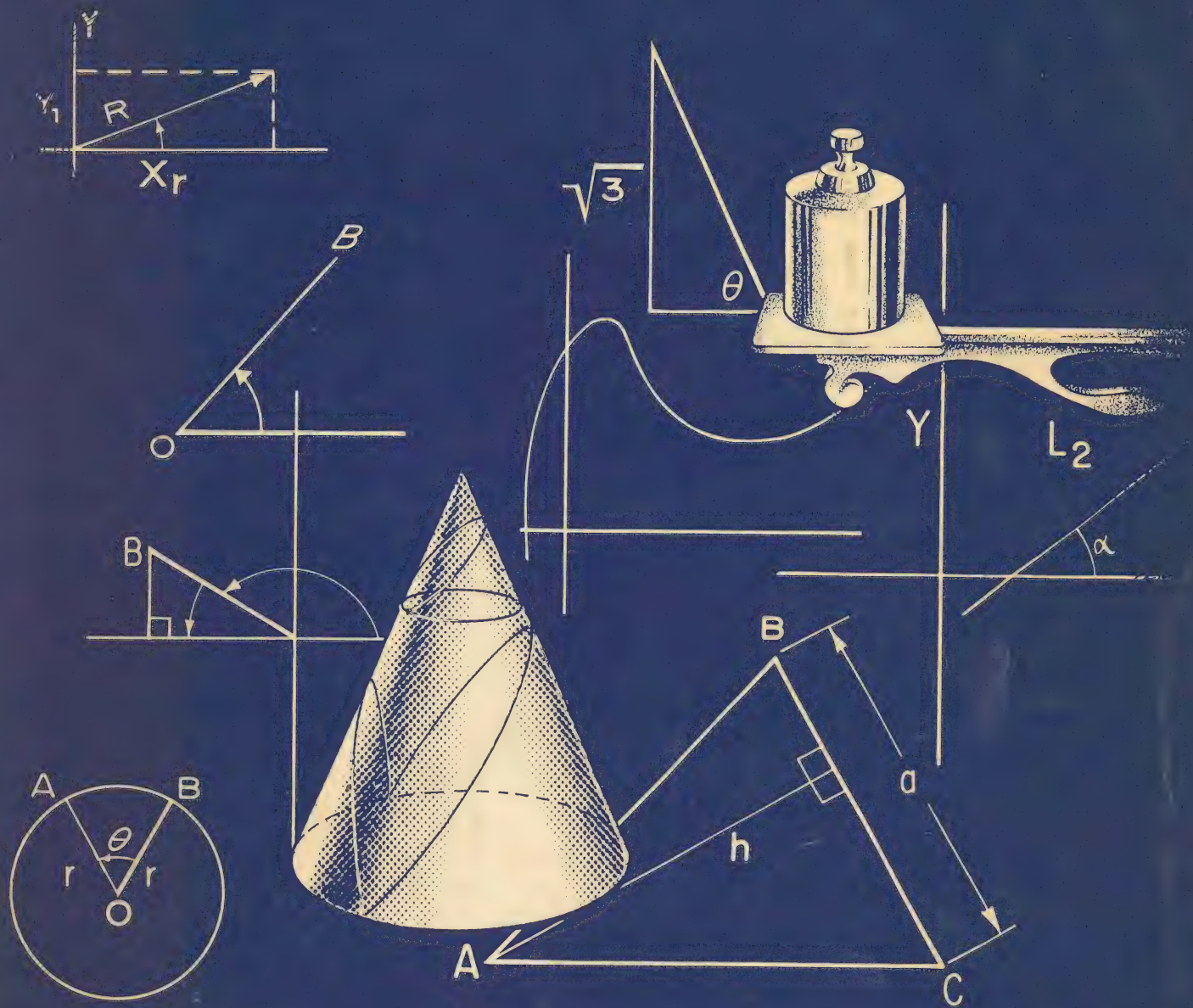
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MATHEMATICS, VOL. 2

224

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ARCS AND ARCING CONTACTS

by

J.D. Cobine

SCHENECTADY, NEW YORK

GENERAL ELECTRIC
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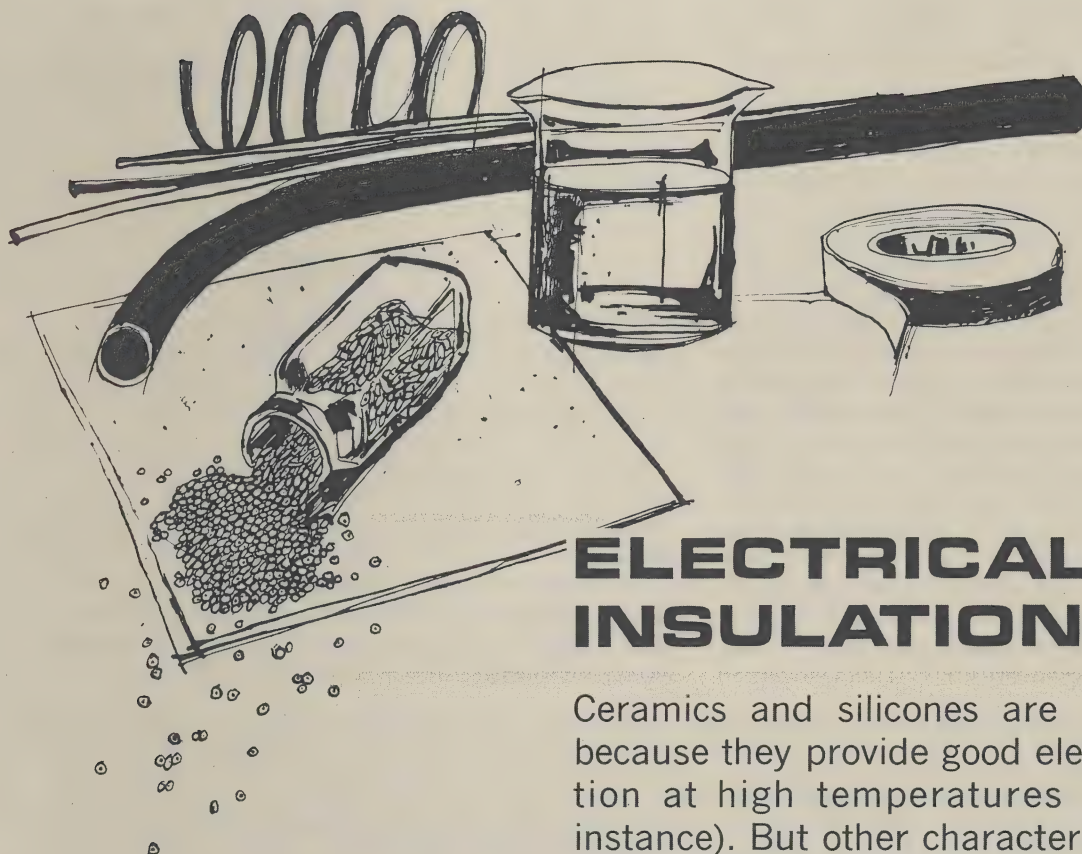
ARC RECOVERY AND PASCHEN'S LAW

by

G. A. Farrall and J. D. Cobine

SCHENECTADY, NEW YORK

A.L.2 36y



ELECTRICAL INSULATION: 1966

Ceramics and silicones are making news because they provide good electrical insulation at high temperatures (700°C , for instance). But other characteristics—formability, weight, moisture resistance—make epoxy resins and polyurethane foams equally important. New techniques, such as transfer molding, permit substantial cost reductions in semiconductor components. Here are some of the latest advances in insulation materials and forming processes—with data for comparing them.

Mr. Kaminski

" Kingsbury

" Vohr

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SURFACES, STRESS-DEPENDENT REACTIONS, AND STRENGTH

by

W. B. Hillig and R. J. Charles

Report No. 64-RL-3756 M

October 1964

CLASS 1

SCHENECTADY, NEW YORK

A High-Voltage Pulse Generator and Tests on an Improved Deflecting System of a Cold-Cathode Oscillograph

Harold N. Cones

An improved deflecting system for a cold-cathode oscillograph is described. This deflecting system reduces transit-time errors and eliminates errors due to impedance mismatch between the signal coaxial cable and the deflector.

A high-voltage pulse generator for producing single pulses in the millimicrosecond range was devised, and its use in testing the improved deflecting system is explained.

1. Introduction

The cathode-ray oscillograph (CRO) is an indispensable tool in high-voltage surge testing and research. However, the requirements of an oscillograph for his work are somewhat different from the requirements of the usual laboratory oscillograph. Sensitivity is not an important factor, as ample signal voltage is available. In fact, the available voltage is usually limited only by the flashover voltage of the fittings on the coaxial cable between the source of voltage to be measured and the oscillograph.

High writing speed is essential, as it is necessary to record on film single transients of a few millimicroseconds duration. This high writing speed is attained by the use of high accelerating voltages for the electron beam, and in many cases by allowing the beam to impinge directly on the photographic emulsion instead of photographing a trace on a fluorescent screen.

Cold-cathode oscillographs of the type described by Ackermann [1]¹ are used in the Bureau's high-voltage laboratory and are entirely adequate for ordinary surge work.

However, with increasing interest in studies of steep-front voltage surges, the ability to faithfully record single transients of approximately 50-m μ sec duration is essential. A resolution of time intervals of the order of 1 m μ sec for the current and voltage records is highly desirable in making a detailed study of the mechanism of spark breakdown.

To record such rapid transient variations, a very high writing speed is necessary. Also, recording errors in the oscillograph, as well as those arising from its connections, which are not significant at lower recording speeds, become important and must be reduced or eliminated. Actually, a sufficiently high writing speed was insured by using Park's method of beam intensification [2]. Therefore, the recording errors introduced by the oscillograph itself and the means adopted for their elimination form the basis of the present study.

2. Cathode-Ray Oscillograph Recording Errors

Two sources of error of the CRO are of concern when very short transients are to be recorded. One is the error due to the transit time of the electrons in passing from one end to the other of the deflecting plates. The other error is caused by impedance mismatch in connecting the deflecting-plate circuit to a coaxial cable.

A typical cold-cathode oscillograph uses an accelerating voltage of 50 kv and has deflecting plates 3 cm long. The velocity of 50-kv electrons is 1.23×10^{10} cm/sec, and the corresponding transit time is 2.44×10^{-10} sec. The error arising from transit time will be 5 percent at 600 Mc for a pure sine wave.² For a steeply rising pulse the error will be 5 percent for a pulse with a rise time of 2.4 m μ sec.³ Although, in general, for steep-front surge work, errors due to transit time can be neglected, pulses with rise times of this order occur and are important in studies of spark breakdown.

The errors arising from impedance mismatch are more serious. The capacitance of the deflecting plates in the typical cold-cathode oscillograph is about 15×10^{-12} f, and the associated lead inductance is about 2 or 3×10^{-8} h, giving rise to a resonance frequency of 200 to 300 Mc. Hence, for all but somewhat lower frequencies, disturbing reflections will occur, giving rise to a voltage at the deflecting plates that may be quite different from the voltage at the input end of the cable. Furthermore, steeply rising pulses will force the deflecting-plate system into oscillation. The modification of an oscillograph to reduce these errors and the testing of the modified oscillograph are now described.

3. Redesign of Deflecting Plate System

One method of reducing the above errors is to drastically reduce the size of the deflecting plates. The transit time can in this way be reduced by the

² See the appendix, which is a discussion by J. H. Park of transit-time errors. This discussion is an excerpt from an unpublished informal communication.

³ These values do not take into account the effect of fringing field at the ends of the plates. This increases the effective length of the plates and increases the error due to transit time.

¹ Figures in brackets indicate the literature references at the end of this paper.



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Transactions Paper

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Discussion in Duplicate Due July 5, 1963.



SPARKOVER CHARACTERISTICS OF LARGE GAP SPACES AND LONG INSULATION STRINGS

T. Udo

Central Research Institute of Electric Power Industry
Tokyo, Japan

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63-1040

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Transactions Paper

(Reviewed and Accepted for Publication)



THE INFLUENCE OF WATER RESISTIVITY AND PRECIPITATION RATE UPON SIXTY-CYCLE WET FLASHOVER VOLTAGE

AIEE Working Group on Rain Tests
of the
AIEE Subcommittee on Techniques for Dielectric Tests

A paper recommended by the AIEE Special Instruments and Auxiliary Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 15, 1957; made available for printing October 31, 1957.

For personnel of AIEE Working Group on Rain Tests, see page 1 of text.

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EEI No. TDJ-52
NEMA No. 140-1952

ASA
Reg. U. S. Pat. Off.
C29.2-1955
UDC 621.315.624

American Standard

Wet-Process Porcelain Insulators

(Suspension Type)

Sponsor

ELECTRICAL STANDARDS BOARD

Approved August 5, 1955

AMERICAN STANDARDS ASSOCIATION
INCORPORATED

ASA
C76.1 - 1943

AIEE
No. 21
June 1942

American Standards
for
APPARATUS BUSHINGS
AND
TEST CODE FOR APPARATUS BUSHINGS

APPROVED

American Standards Association

July 23, 1943



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Electrical Standards Committee

Published by
THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West Thirty-ninth Street, New York

ASA
C68.1
1953
UDC 621.317.32

AIEE
No. 4

American Standard
for
MEASUREMENT of VOLTAGE
in DIELECTRIC TESTS

Approved as American Standard by the
American Standards Association
September 11, 1953



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33 West Thirty-ninth Street, New York 18, N. Y.

American Standard Methods of Measurement of

Radio-Noise Voltage and Radio-Noise Field Strength

0.015 to 25 Megacycles/Second
Low-Voltage Electric Equipment
and Nonelectric Equipment

USA Standard

This USA Standard is one of nearly 3000 standards approved as American Standards by the American Standards Association. On August 24, 1966, the ASA was reconstituted as the United States of America Standards Institute. Standards approved as American Standards are now designated USA Standards. There is no change in their index identification or technical content.

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Thermodynamics

GENERAL ELECTRIC
Research Laboratory

SURFACE EFFECTS IN FLOW AND FRACTURE

by

A. N. Holden

Report No. RL-411

August 1950

SCHENECTADY, NEW YORK

DESIGN DATA



DESIGN OF APPARATUS TO WITHSTAND
SHORT-CIRCUIT FORCES

July 20, 1953

GENERAL ELECTRIC STANDARDS

Transactions Paper

(Reviewed and Accepted for Publication)

Excerpt from
Mechanics



RESULTS OF HIGH-CURRENT TESTS ON 161-KV DISCONNECTING SWITCHES

A. M. McNerney
Associate Member AIEE
Tennessee Valley Authority
Knoxville, Tenn.

A paper recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Manuscript submitted September 30, 1954; made available for printing October 27, 1954.

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55-9

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Transactions Paper

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BEHAVIOR OF HIGH VOLTAGE BUSES AND INSULATORS DURING SHORT CIRCUITS

R. M. Milton
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Tennessee Valley Authority
Chattanooga, Tenn.

Fred Chambers
Member AIEE
Assistant to Chief Power Engineer
Tennessee Valley Authority
Chattanooga, Tenn.

A paper recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Manuscript submitted August 16, 1954; made available for printing October 27, 1954.

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Equip - T&D
Mechanics



HIGH-CURRENT TESTING OF AIR-DISCONNECT SWITCHES

B. F. Gostin
Member AIEE
Supervisor, Electrical Laboratory
Tennessee Valley Authority
Chattanooga, Tenn.

A paper recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Manuscript submitted September 20, 1954; made available for printing October 29, 1954.

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Mechanics

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	Stress & Strain	56TP458
	(Deflection Measurements)	DATE
WM Pafenbach, Jr.		8 - 3 - 56
TITLE		
A NEW TECHNIQUE IN LARGE DEFLECTION MEASUREMENTS		

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Mechanics

Conference Paper



A DYNAMIC TORQUEMETER UTILIZING THE RECIPROCAL WIEDEMANN EFFECTS

M. J. O'Neill
Associate Member AIEE
The Perkin-Elmer Corporation
Norwalk, Conn.

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JAN 25 1957

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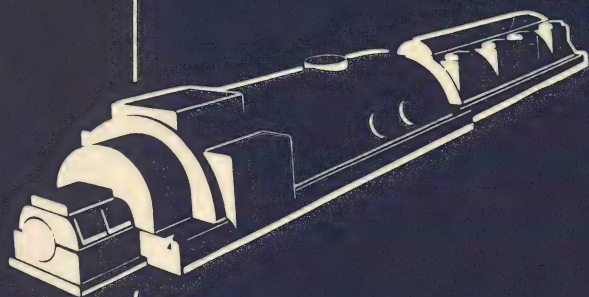
A paper recommended by the AIEE Committee on Special Instruments and Auxiliary Apparatus for the AIEE Winter General Meeting, New York, N. Y., January 21-25, 1957. Manuscript submitted October 18, 1956; made available for printing January 9, 1957.

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Paper No. CP
57-112



Mechanics

The Calculation of Residual Stresses in Thick Plates Using
the Solution of the Problem of an Infinite Plate with a
Circular Hole.

M. Gurtin

TR-57-TG-178

4-22-58

LARGE STEAM TURBINE-GENERATOR DEPARTMENT

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SCHENECTADY, N. Y.

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IN QUEBEC

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ASSISTANT CHIEF ENGINEER

QUEBEC HYDRO ELECTRIC POWER COMMISSION

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CANADA

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
JG Anderson	Transmission Lines	58-PT-373
		DATE
		4/16/58
TITLE		
Preliminary Insulation Estimates for the G. E. Extra-High Voltage Project		

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Weller
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Kammerer
Jesatho
Kingsbury
File Evaluation

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EHV

345 KV DOUBLE CIRCUIT TRANSMISSION

David Burns - The Detroit Edison Company

Edison Electric Institute
Transmission and Distribution Committee
Muehlebach Hotel
Kansas City, Missouri
May 2, 1957

W. F. Bodenstern

PAPER NO. 13-2

INFLUENCE OF TOWER DESIGNS ON
TRANSMISSION-LINE LIGHTNING PERFORMANCE

By F. A. Fisher
J. G. Anderson

SOUTHWESTERN IEEE CONFERENCE
Dallas, Texas

April 20, 1967

EHV

FIELD CONTROL OF INSULATORS
FOR MODERN HIGH VOLTAGE LINES

BY

JOHN M. SHEADEL
DEVELOPMENT ENGINEER
OHIO BRASS COMPANY

PRESENTED AT THE
FALL MEETING
ELECTRICAL EQUIPMENT COMMITTEE
IN JOINT SESSION WITH
TRANSMISSION AND DISTRIBUTION COMMITTEE
PENNSYLVANIA ELECTRIC ASSOCIATION
READING, PENNSYLVANIA

OCTOBER 9, 1953

General Installation and Operation of Kenotron Tubes

Installation

MECHANICAL

The handling of a kenotron in transportation and storage requires great care since the tube may be permanently damaged if subjected to shock. Each tube is suspended within its shipping carton so that it will not come in contact with the sides of the carton during shipment. The tube should be stored in the carton and should be protected from moisture and extreme temperature changes. Furthermore, while the tube is being handled it should be kept in a vertical position with the cathode end down. Under no circumstances should crated tubes be piled on top of one another.

The kenotron should be installed in a vertical position with the cathode base down.

In installations where a nonrigid anode connection is used, reasonable flexibility must be provided to prevent placing a strain on the cathode base. Since the bulb becomes hot during continuous operation, it should not come in contact with any metallic body, nor be subjected to the drops or spray of any liquid.

The accumulation of dust and metallic particles on the outer surface of the glass walls will increase the leakage over this surface. As this may result in tube failure from arc-over, periodic cleaning of these surfaces should be maintained.

When a kenotron is operated at voltages above 75 kv peak inverse, harmful x-rays may be generated. Adequate protection against these x-rays should be provided.

COOLING

Free circulation of cool air around the glass bulb should be maintained. High-temperature air from other apparatus should be prevented from circulating around the tubes. If desired the tubes may be immersed in a tank of oil with the transformers.

*Note: The ratings and characteristics of a particular tube are given under Technical Information on the Description and Rating Sheet for that tube.

ELECTRICAL

Filament power should be supplied from a filament lighting transformer insulated for the proper voltage. This transformer should be provided with a secondary midtap for the plate circuit return lead. The filament excitation supply must be provided with suitable resistors or other regulating devices to apply the power to the filament gradually and to adjust it accurately during operation. The filament voltage should be measured directly at the filament terminals.

The high initial rush of current through the filament when the switch is first closed should be limited by the use of some form of filament starter. The proper use of the filament regulating devices will prevent this initial rush of current from destroying the filament. In any case, the current through the filament should never, even instantaneously, exceed twice the *rated value.

When the apparatus in which the tube is used is to be idle for periods not exceeding two hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately 80 per cent of the *rated value during "standbys." Where stand-by periods exceed two hours the filament voltage may be removed.

The plate circuit should be provided with a time-delay relay which will prevent application of plate voltage until the filament has reached normal operating temperature.

Automatic protective devices should be installed to prevent over-plate-voltage, over-plate-current, or under-filament-voltage conditions.

In the case of multi-phase installations, the plate transformer is usually designed for rectifier use. In the case of a double Y rectifier, the use of an inter-phase transformer is recommended. The cathode base should not be connected to ground or to any other part of the circuit.

The installation of all wires and connections should be made so that they do not lie on or close to the glass of the kenotron. An air space of approximately the length of the tube should be main-

Tidd 500-Kv Test Project

Transmission of Electric Power at Extra High Voltages
and
Field Test Facilities
to Study
Corona, Radio Influence, and Other Features

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OHIO EDISON 345 KV SYSTEM

LYNN FIRESTONE
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OHIO EDISON COMPANY
AKRON, OHIO

E. A. ROTHFUS
CHIEF ELECTRICAL ENGINEER
OHIO EDISON COMPANY
AKRON, OHIO

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TECHNICAL INFORMATION SERIES

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>H. K. Farr</i> (for R.P.B.) R. P. Bass	SUBJECT CLASSIFICATION <i>Bushings - Capacitors</i>	NO. 50TP170-1
TITLE The Operation of 5 Kv Glass and Porcelain Bushings in Salt-Fog Atmosphere Report II		DATE 7/19/51

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AUTHOR G. Camilli W.P. Tootill	SUBJECT CLASSIFICATION BUSHINGS	NO. 51TP1325 DATE 5-1-51
TITLE Bushings for Low Voltage Circuits.		
ABSTRACT		

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Transactions Paper

(Reviewed and Accepted for Publication)



LIGHTNING REFERENCE BIBLIOGRAPHY 1950-1960

AIEE Working Group of the Lightning and Insulation Subcommittee
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MIL-STD-105B

SUPERSEDING

31 December 1958

MIL-STD-105A

11 September 1950

APPENDIX

27 April 1955

MILITARY STANDARD

SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES



R. WELER

MIL-STD-105A

11 September 1950

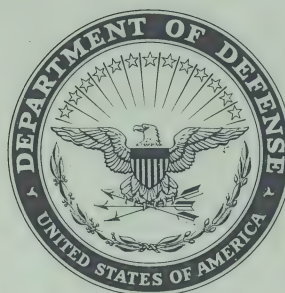
SUPERSEDING

JAN-STD-105

16 February 1949

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QUALITY CONTROL REPORTS

No. 9

September 1945

Statistical Quality Control at Lockheed

By

James R. Crawford

and

Preston C. Hammer



Issued by
Quality Control Program, Carnegie Institute of Technology
Pittsburgh 13, Pennsylvania
for Office of Production Research and Development
War Production Board

QUALITY CONTROL REPORTS

No. 12

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Some Experiments Illustrating Principles of Quality Control

By

Irving W. Burr



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Quality Control Program, Carnegie Institute of Technology
Pittsburgh 13, Pennsylvania
for Office of Production Research and Development
War Production Board

QUALITY CONTROL REPORTS

No. 3

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Statistical Quality Control at the St. Louis Division of American Stove Company

By

Lester A. Kauffman



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for Office of Production Research and Development
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QUALITY CONTROL REPORTS

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Quality Control at the Lukas-Harold Corporation

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Statistical Quality Control in Radio Manufacture

By

Fred Trowbridge

and

John T. Clark



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An Application of Statistical Quality Control at the Hoover Ball and Bearing Company

By

Russell C. Trombly



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Pittsburgh 13, Pennsylvania
for Office of Production Research and Development
War Production Board

QUALITY CONTROL REPORTS

No. 7

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An Adaptation of Statistical Quality Control at Aldens'

By

James M. Ballowe



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Pittsburgh 13, Pennsylvania
for Office of Production Research and Development
War Production Board

QUALITY CONTROL REPORTS

No. 1

May 1945

Introduction of Statistical Quality Control at Illinois Testing Laboratories

By

James A. Fizzell



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Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 14, 1969.



FLASHOVER PROBABILITY OF PARALLEL MULTI-GAP

Toshio Suzuki
Central Research Institute
of Electric Power Industry
Tokyo, Japan

Isamu Kishijima
Central Research Institute
of Electric Power Industry
Tokyo, Japan

Yunosuke Ohuch
Tokyo Electric Power Co.
Tokyo, Japan

Koichiro Anjo
Chubu Electric Power Co.
Nagoya, Japan.

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DISCUSSION IN QUADRUPLICATE DUE February 14, 1969.



THE METHOD OF MAXIMUM LIKELIHOOD APPLIED TO THE ANALYSIS OF FLASHOVER DATA

Gordon W. Brown
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S. S. Shapiro and M. B. Wilk*
Information Sciences Laboratory

Report No. 67-C-323

August 1967

*Bell Telephone Laboratories, Inc.

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Information Sciences Laboratory

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**A SURVEY OF PREDICTION INTERVALS AND
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Report No. 72CRD027

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G J. Hahn, Information Sciences Laboratory

Report No. 68-C-392

October 1968

STATISTICAL ANALYSIS OF 1967 20,000 LB.
SUSPENSION INSULATOR M&E TEST DATA

May 17, 1968
by
W. B. Lounsbury

Insulator Department

Manufacturing Problems Analysis-I

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Mathematical

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DEFENSE ELECTRONICS DIVISION

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AUTHOR H. J. Lyness, A. E. P.

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2

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GENERAL  ELECTRIC

Transactions Paper

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A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES

Theory

C. F. Wagner
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25-29, 1956. Manuscript submitted March 28, 1956; made available for printing May 15, 1956.

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SAFE CLEARANCES AND PROTECTION AGAINST SHOCKS DURING LIVE LINE WORK

A. Elek
Associate Member AIEE

J. W. Simpson
Associate Member AIEE

Both of:
The Hydro-Electric Power Commission
of Ontario
Toronto, Ont., Canada

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H. A. EREY

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A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES

C. F. Wagner
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25-29, 1956. Manuscript submitted March 28, 1956; made available for printing May 15, 1956.

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56-733

Discussion in Duplicate Due July 11, 1956.

District Conference Paper

Misc.



CONTROL OF FLICKER ON DISTRIBUTION SYSTEMS

L. R. Gardner
Associate Member AIEE
Houston Lighting and Power Co.
Houston, Tex.

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Associate Member AIEE
University of Houston
Houston, Tex.

Submitted in abstract or outline form only to the AIEE Transmission and Distribution Committee for presentation at the AIEE Southwest District Meeting, Houston, Tex., April 4-6, 1960. Manuscript submitted February 1, 1960; made available for printing February 10, 1960.

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Paper No. **DP**

60-530

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Some Fundamental Aspects of Recovery Voltages

J. ZABORSZKY
MEMBER AIEE

J. W. RITTENHOUSE
FELLOW AIEE

Summary: Whether any load-interrupter switch successfully interrupts when called upon to do so depends solely upon how the recovery voltage builds up across the switch as a function of time in comparison with the build-up of dielectric strength between the switch contacts. This paper deals with recovery voltages in a graphical manner, so that a visual concept of recovery voltage versus time across a switch is provided in both single- and 3-phase cases involving resistive loads, inductive loads, and capacitive loads. As a special case, the recovery voltage across a switch in a loop-sectionaliz-

ing application is also treated in this paper.

IN RECENT DECADES electric load densities in the United States have been increasing at exceedingly high rates. This has gradually produced increased interest in the basic fundamentals relating to load interruption.

It is the purpose of this paper to demonstrate some of the fundamental properties of recovery voltages in relation to different kinds of switching problems, with a

view to demonstrating the differences in voltage conditions to which load-interrupter equipment might be subjected.

The treatment will illustrate the well-known fact that the ability of a given commercial product to interrupt a flow of power is as much a function of the circuit containing the switch as of the design of the switch itself.

It is hoped that the simplified and sequential approach presented here will serve as a stimulus for future extension of this review.

Paper 62-244, recommended by the AIEE Switchgear Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., January 28-February 2, 1962. Manuscript submitted August 1, 1961; made available for printing December 8, 1961.

J. ZABORSZKY is with Washington University, St. Louis, Mo., and J. W. RITTENHOUSE is with the Hi-Voltage Equipment Company, Cleveland, Ohio.



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TRANSMISSION OF ELECTRIC POWER AT EXTRA-HIGH VOLTAGES

Philip Sporn
Fellow AIEE

American Gas and Electric Service Corp.,
New York, N. Y.

A. C. Monteith
Fellow AIEE

Westinghouse Electric Corporation,
East Pittsburgh, Pa.

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TITLE INSULATION CONFERENCE ON NONTRACKING ORGANIC MATERIALS		
ABSTRACT This data folder consists of technical papers presented at the "Insulation Conference on Non-tracking Organic Materials" held at the Measurements Laboratory, Instrument Department on April 5, 1956.		
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CONCLUSIONS See "concluding remarks" and appendix.		

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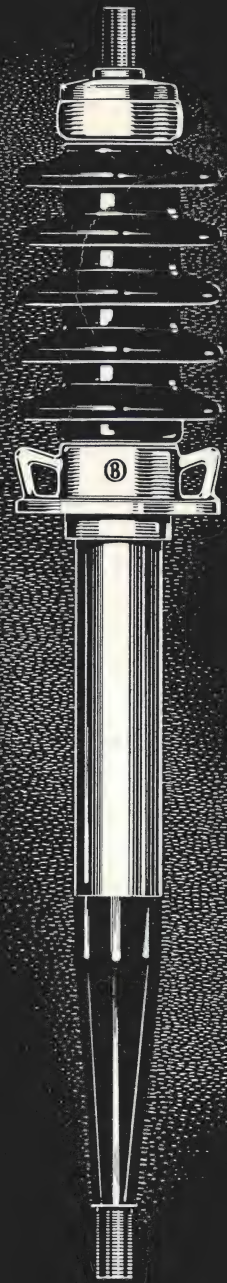


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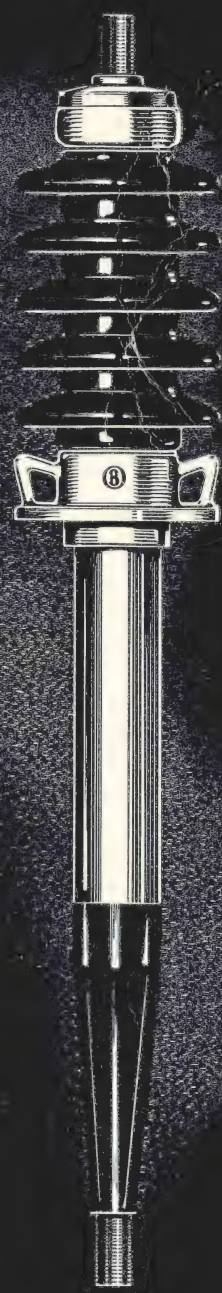
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SYSTEM ECONOMICS OF EXTRA HIGH-VOLTAGE TRANSMISSION

H. P. St. Clair
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New York, N. Y.

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LINE INSULATOR LOSS UNDER NORMAL CONDITIONS —
500-KV TEST PROJECT OF THE AMERICAN GAS AND ELECTRIC COMPANY

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AIEE
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54-33

November 1953
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Discussion for publication
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DIELECTRIC AND OTHER PROBLEMS IN THE DESIGN OF A NEW 330 KV
OUTDOOR AIR SWITCH

A. H. Powell
Member AIEE
General Electric Company
Philadelphia, Pa.

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RESEARCH FOR THE ELECTRIC POWER AND ELECTRIC UTILITY INDUSTRIES IN SWEDEN

Gunnar Jancke
Nonmember AIEE

Ivar Herlitz
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Paper No. **CP**

56-294

Conference Paper

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Proceedings of the American Power Conference)



EXTRA-HIGH-VOLTAGE CABLE RESEARCH --

CHALLENGE OF THE FUTURE

Clement S. Schifreen
Fellow AIEE
Philadelphia Electric Company
Philadelphia, Pa.

A paper recommended by the Electrical Program Committee of the American Power Conference and approved for presentation at the American Power Conference, Chicago, Ill., March 31-April 2, 1959. Manuscript submitted January 26, 1959; made available for printing January 30, 1959.

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Paper No. 60-186

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(5 Papers)

- TP Project EHV - Preliminary Corona Investigations; The Effect of Harmonics on Corona Losses by A. H. Foley, Associate Member AIEE, and F. Olsen, Nonmember AIEE. (Discussion in Duplicate Due February 19, 1960.)
- CP Project EHV - Technical Plan by P. A. Abetti, Member AIEE; D. D. Davis, Member AIEE; and J. H. Hagenguth, Fellow AIEE
- CP Project EHV - Insulation Design by J. G. Anderson, Member AIEE; J. H. Hagenguth, Fellow AIEE; I. B. Johnson, Fellow AIEE; A. J. Schultz, Member AIEE
- CP Project EHV - North Station and Portal-Type Towers by S. Minneci, Member AIEE; A. H. Powell, Member AIEE; R. E. Larson, Associate Member AIEE; G. E. Fortney, Nonmember AIEE; S. D. Alpert, Nonmember AIEE
- CP Project EHV - Conductors, Insulators and Conductor Accessories by J. J. LaForest, Associate Member AIEE; J. Kaminski, Jr., Member AIEE; R. E. Larson, Associate Member AIEE

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DATA GATHERING AND TRANSMISSION SYSTEM FOR PROJECT EHV

P. A. Abetti
Member AIEE

D. W. Caverly
Associate Member AIEE

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EHV

Mr. Boyd

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PROJECT EHV - SYSTEM DESIGN AND NORTH STATION EQUIPMENT

C. B. Lindh
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650-KV SUBSTATIONS FOR PROJECT EHV

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Pittsfield, Mass.

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General Electric Co.
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METAL TOWERS FOR 650-KV OPERATION ON PROJECT EHV

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A STUDY OF USE OF ALUMINUM GUYED TOWERS FOR EXTRA HIGH VOLTAGE TRANSMISSION SYSTEMS

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Member AIEE

B. Cooper

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International Power and Engineering
Consultants Limited
Vancouver, Canada

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EXPERIMENTS WITH GALLOPING SPANS

James J. Ratkowski
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Chicago, Ill.

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RESEARCH AND DEVELOPMENT LEADING TO THE HIGH-POWER VACUUM INTERRUPTER -- AN HISTORICAL REVIEW

J. D. Cobine
Member AIEE
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Schenectady, N. Y.

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PERFORMANCE OF 161-KV AND 115-KV TRANSMISSION LINES

Fred Chambers
Member AIEE

C. P. Almon, Jr.
Fellow AIEE

Both of:
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Chattanooga, Tenn.

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Schenectady, N. Y.

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RADIO NOISE FROM HIGH-VOLTAGE TRANSMISSION LINES

AIEE Radio Noise Subcommittee
of the
AIEE Transmission and Distribution Committee

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Members of the AIEE Radio Noise Subcommittee: H. L. Rorden, Chairman; L. O. Barthold, P. L. Bellaschi, H. H. Brustle, F. C. Creed, F. R. Dallye, H. M. Ellis, C. D. Fiero, H. A. Gauper, E. H. Gehrig, R. E. Graham, F. L. Greene, N. S. Kent, J. J. LaForest, J. R. Leslie, T. W. Liao, R. J. Mather, C. J. Miller, A. C. Neaderland, W. E. Pakala, B. M. Pickens, M. G. Poland, L. M. Robertson, R. H. Schlomann, L. N. Stone, E. R. Taylor, F. L. Taylor, F. J. Trebby, P. D. Tuttle, F. C. Vose, F. A. Denbrock, H. M. Mather.

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62-106

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Product Engineer

DIELECTRIC MATERIALS IONIZATION STUDY

FOR

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CATHODE EFFECTS IN THE DIELECTRIC BREAKDOWN OF LIQUIDS

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Report No. RL-953

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ON THE TOWNSEND MECHANISM OF SPARK BREAKDOWN OF GASES

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Report No. RL-1011

January 1954

CLASS 1

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Space Charge Phenomena in Liquid Dielectrics

By D. W. GOODWIN†

Department of Physics, The University of Birmingham

Communicated by K. A. Macfadyen; MS. received 19th August 1955

Abstract. By means of the electro-optical Kerr effect, distortion by space charge of the uniform potential gradient between electrodes in purified chlorobenzene has been observed. Evidence is presented suggesting that the conduction process occurs in filaments. The modified distribution of field strength is in qualitative agreement with a previous theory.

§ 1. INTRODUCTION

A THEORY of electrical breakdown in liquid dielectrics (Goodwin and Macfadyen 1953) suggests that field distortion is produced in a liquid at high field strengths as a result of electron emission from the cathode and the movement of ions between the electrodes. One important prediction of this theory is that the cathode field strength becomes enhanced in comparison with the anode field strength as the applied field strength is increased to that value required to produce breakdown. It is the purpose of this paper to describe investigations into such an increase in cathode field strength and to compare its magnitude with the predicted value.

Space charge effects in liquids have been observed previously (Dantscher 1931, Vafiadis 1939) using the Kerr electro-optical effect under conditions of continuously applied fields. In the experiments to be described space-charge effects, resulting from the application of rectangular voltage pulses, have been revealed using the Kerr effect. The use of pulsed voltages has been shown previously to overcome experimental difficulties associated with liquids under high electric stress.

§ 2. APPARATUS AND EXPERIMENTAL METHOD

2.1. *The Experimental Method*

The application of a strong electric field to an insulating liquid will make it doubly refracting. If now light, plane polarized in a direction at 45° to that of the electric field, passes through the liquid it will be elliptically polarized. The phase difference Δ between the two components is given by Kerr's law

$$\Delta = B l E^2 \quad \dots\dots(1)$$

where l is the distance the light travels through a field of strength E ; B is known as Kerr's constant. Transmission can then occur through an analyser crossed with the polarizer under zero field strength conditions. Differences in transmission across the gap can be correlated with space charge phenomena (Dillon 1930). The phase difference Δ can be measured with a Rayleigh compensator (Rayleigh 1902), a strip of photo-elastic material under cantilever

† Now at the Radar Research Establishment, Great Malvern, Worcs.

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TITLE		DATE
Effect of Ground Plane Protrusions on the Sixty-Cycle and Impulse Flashover Mechanism of Bushings.		3/10/52
ABSTRACT		

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by

I. Giaever, General Physics Laboratory

Report No. 66-C-263

August 1966

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ROTATING PROBE ELECTROMETER

by

J. C. Devins and S. I. Reynolds

Report No. 56-RL-1594

August 1956

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SCHENECTADY, NEW YORK

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by

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THE SECOND TOWNSEND COEFFICIENT FOR INSULATING SURFACES

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Report No. 55-RL-1437 November 1955

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PUBLISHED

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U.D.C. 537.529

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Short-Time Electrical Breakdown of Solids by External Discharges.

by K.W.Ogilvie, Ph.D.

TECHNICAL REPORT L/T352

1956

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Diel

Conference Paper



INTERNAL OXIDATION MECHANISM FOR NON-TRACKING ORGANIC INSULATIONS

R. S. Norman
Associate Member AIEE

A. A. Kessel
Nonmember AIEE

Both of:
General Electric Company
West Lynn, Mass.

A paper recommended by the AIEE Dielectrics Committee for the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 14, 1957; made available for printing December 6, 1957.

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58-211

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TECHNICAL INFORMATION SERIES

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AUTHOR

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THOMSON LABORATORY

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THE LINASCOPE TRANSMISSION LINE FAULT LOCATOR

K. H. Kidd

Associate AIEE

The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ont., Canada, June 25-29, 1951. Manuscript submitted March 27, 1951; made available for printing May 16, 1951.

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CLASS 1

TIME-SHARING COMPUTER PROGRAMS
FOR ESTIMATING PARAMETERS OF SEVERAL NORMAL POPULATIONS
AND FOR REGRESSION ESTIMATION FROM CENSORED DATA

by

G.J. Hahn and J.M. Miller*
Information Sciences Laboratory

Report No. 68-C-366

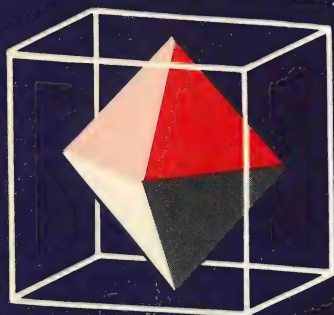
September 1968

*Telecommunications and Information Processing Operations,
2500 Cambridge Road, Schenectady, N. Y.

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/ CERAMICS

Porcelain for High Voltage Insulators

In this paper the mechanical failure of porcelain is discussed with special reference to 3 seldom recognized characteristics: the effect of the porcelain surface on the strength, the apparent anomalous distribution of individual mechanical test values, and the effect of time on mechanical strength. A method of evaluating the result of these factors on electrical insulator performance is suggested.

By
D. H. ROWLAND
ASSOCIATE A.I.E.E.

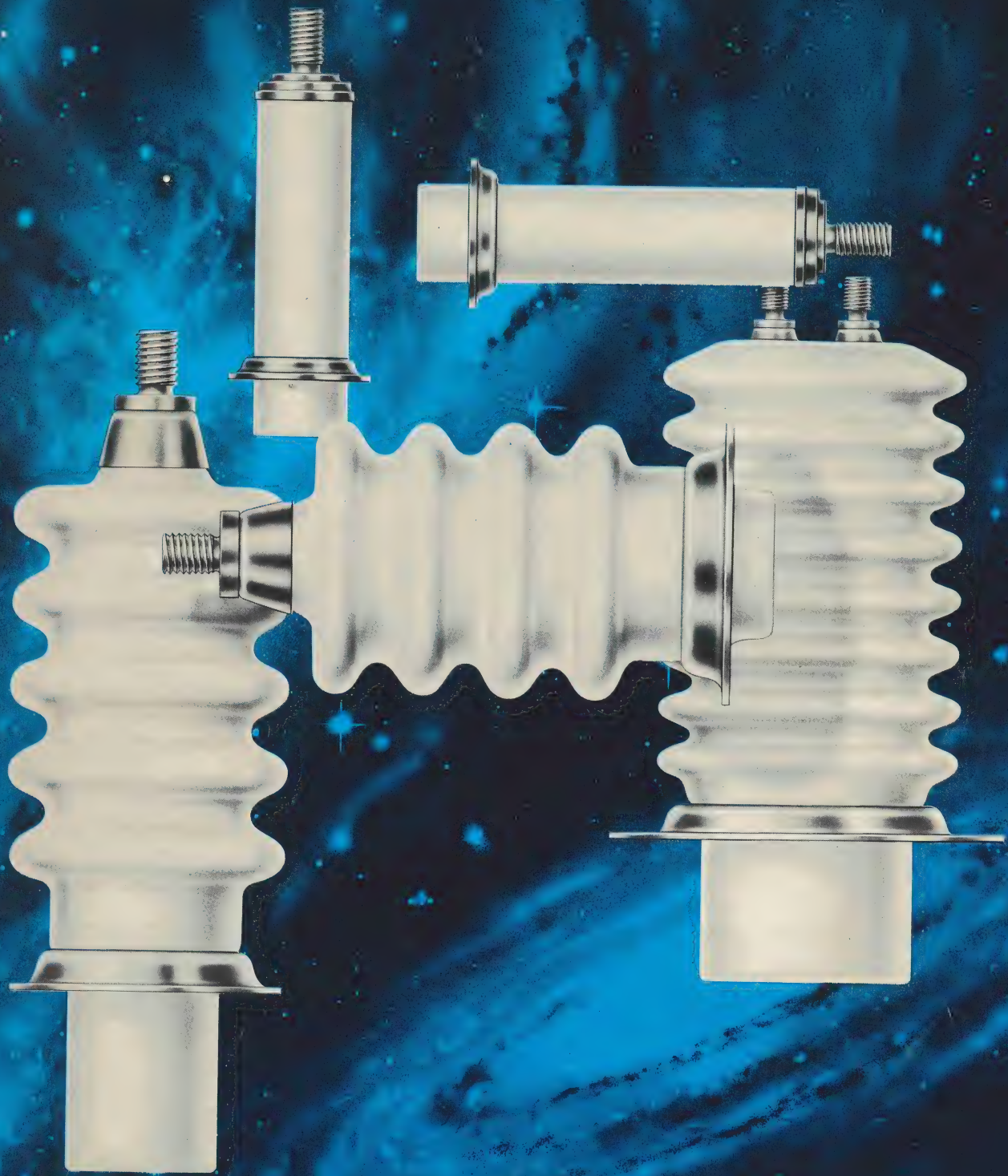
Locke Insulator Corp.,
Baltimore, Md.

THERE CAN BE little argument as to what mechanical characteristics are desirable in high voltage insulators, but the factors which contribute to such characteristics are concealed, more often than not, by an extraordinary amount of sophistic data. Modern high voltage insulators on

the average have improved enormously in the past decade. This improvement has been brought about in most cases by expensive and tedious cut and try tests conducted on assembled insulators. The procedure has been to assume that certain features of the completed units such as mechanical strength, ability to withstand immersion first in boiling water and then in ice water, imperviousness to moisture, and other qualities would insure insulators capable of standing up in service, which, after all, is the only real criterion of insulator worth. Finally specifications such as the A.I.E.E. Standards No. 41 for the testing of high voltage insulators were evolved and it may here be stated, unequivocally, that insulators which will successfully pass these specifications will give an unusually good account of themselves in the field. However, just because 2 groups of insulators of different manufacture successfully pass a certain specification it cannot be assumed that their maintenance cost in the field will be the same. How will they stand up under mechanical shock such as the impact from stones or bullets? What effect will time under load have upon their life? What is the maximum load that they will withstand? Is actual experience over a period of years the only way to find out? The purpose of this discussion is to provide engineers with a greater insight into some of the more recently investigated and rather peculiar mechanical characteristics of ceramic materials with the hope that an understanding of this work will help them to answer these questions and to point out that some of the characteristics which have been viewed with alarm by the uninitiated are really a true part of the whole scheme while other factors which have been unknown, or neglected, have been of major importance. A realization of this is bound to lead to still greater efficiency of systems dependent on the insulating qualities of such materials.

A paper recommended for publication by the A.I.E.E. committee on power transmission and distribution, and scheduled for discussion at the A.I.E.E. summer convention, Pasadena, Calif., June 22-26, 1936. Manuscript submitted March 25, 1936; released for publication April 23, 1936.

10. For numbered references see list at end of paper.



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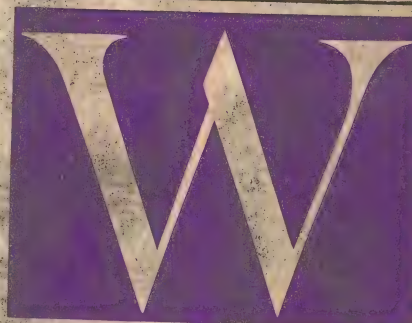
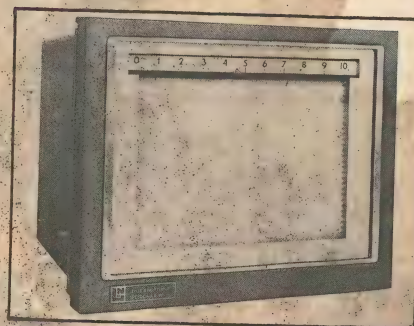




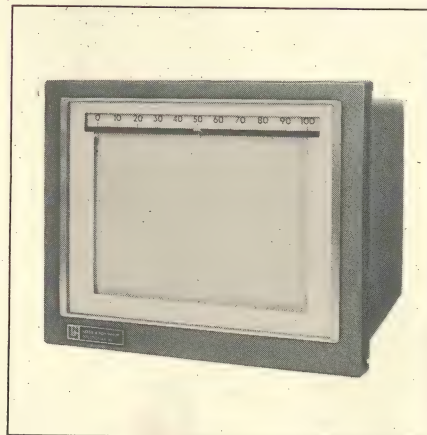
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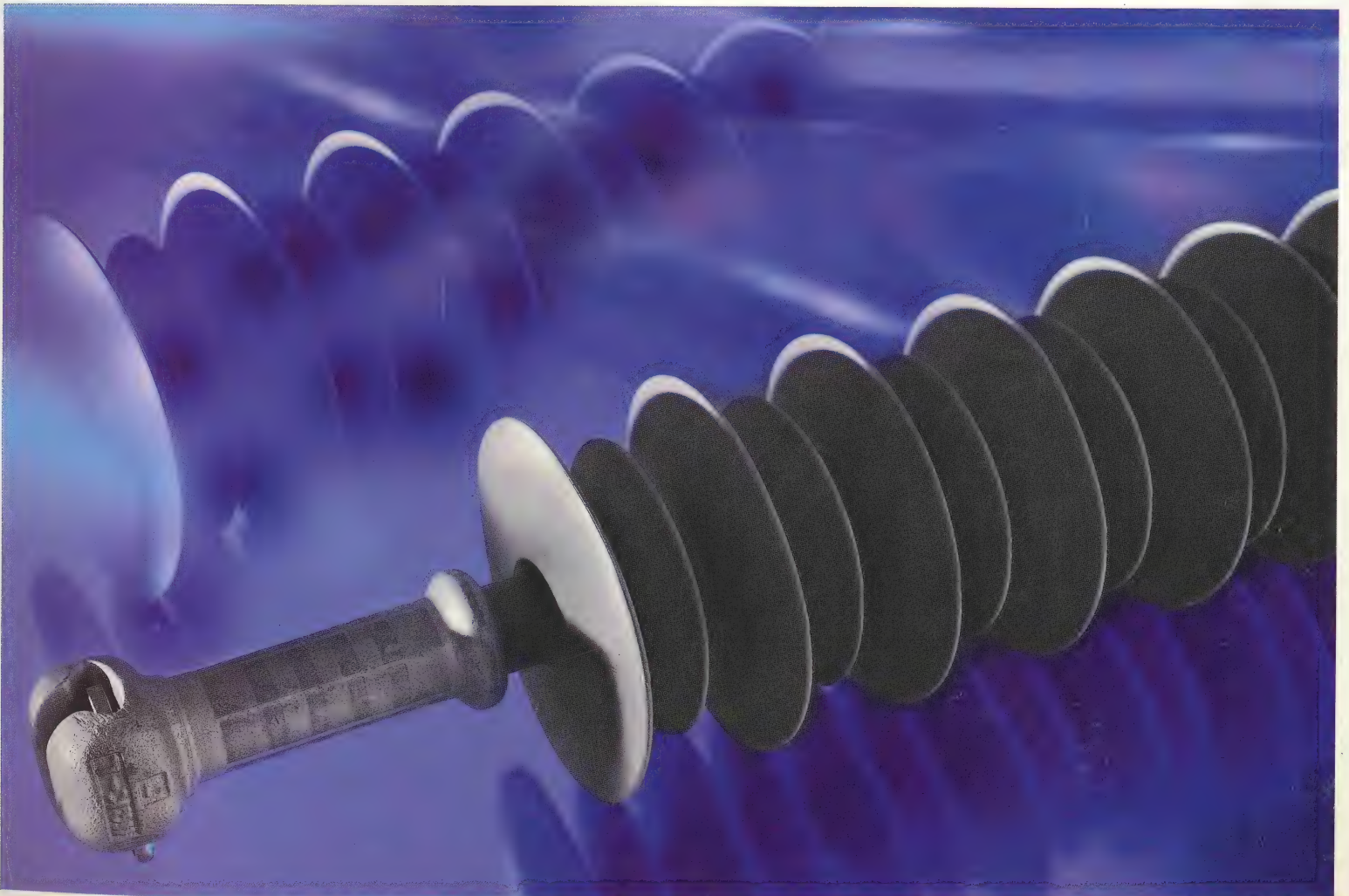
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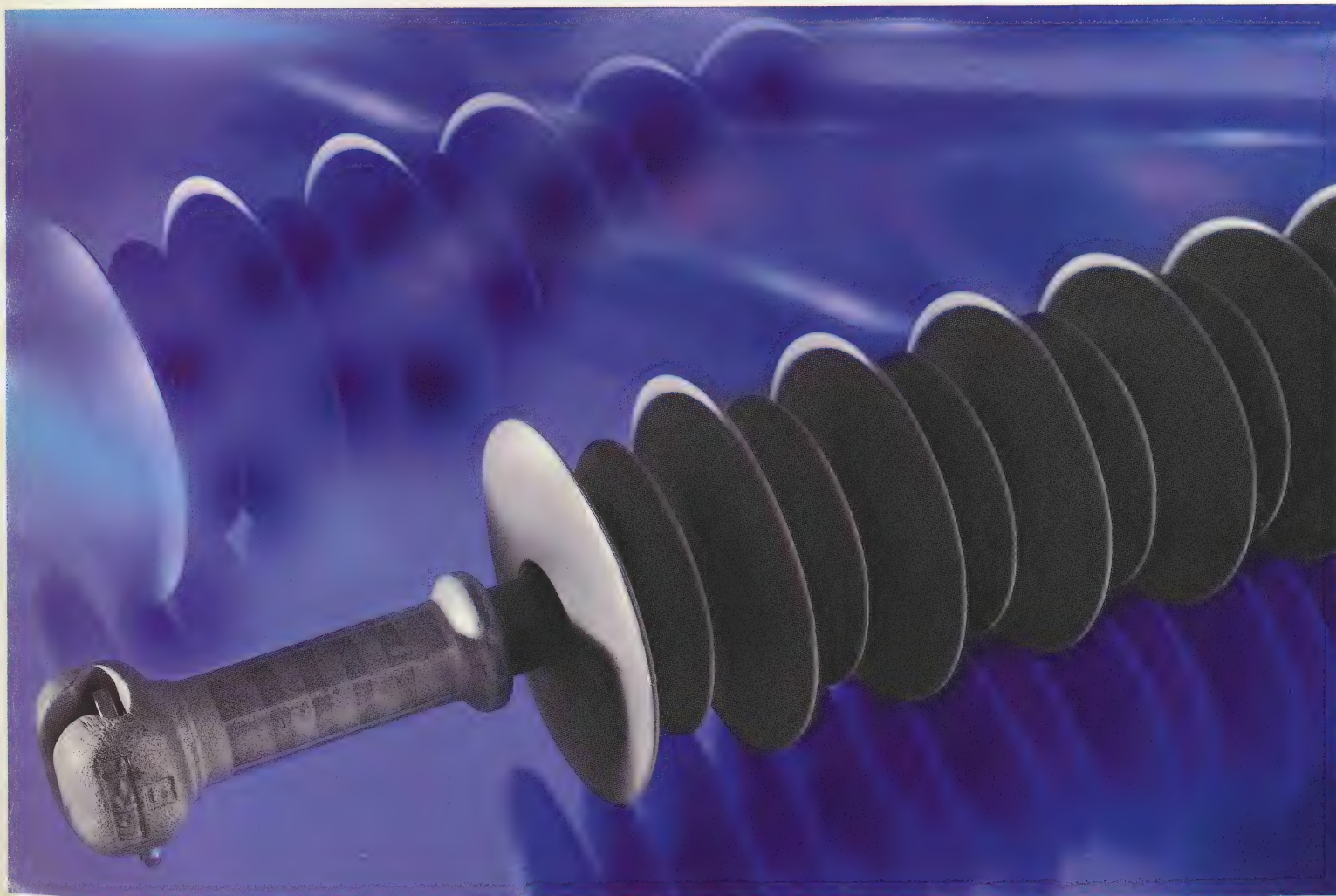


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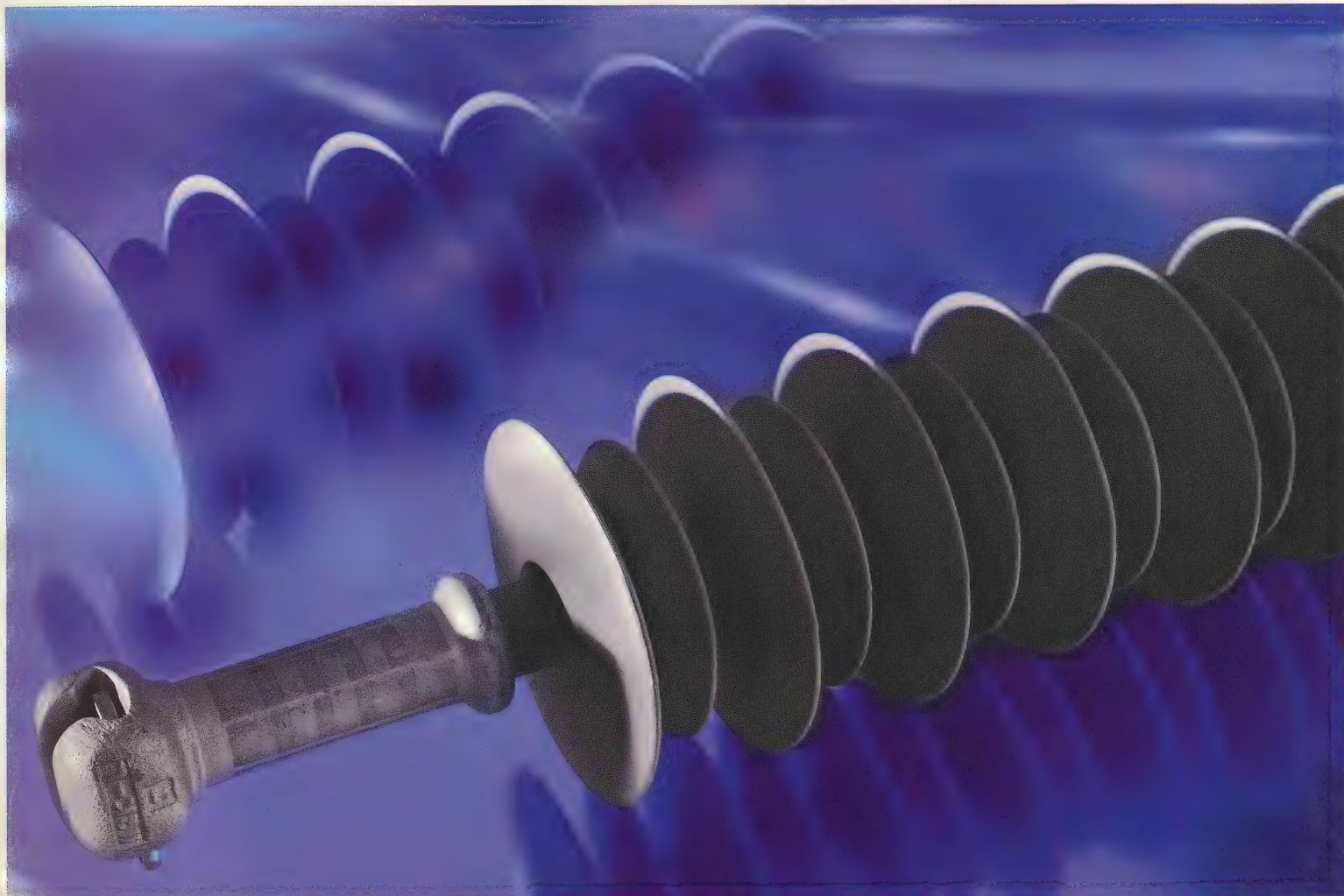


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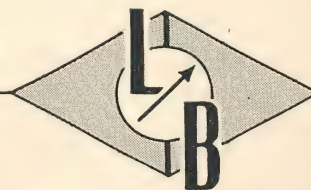
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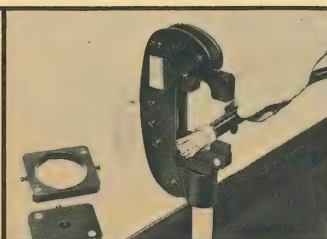
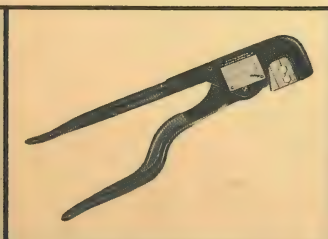
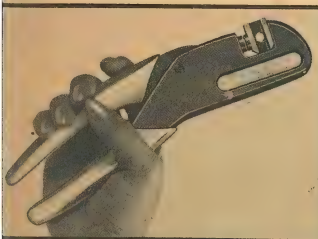
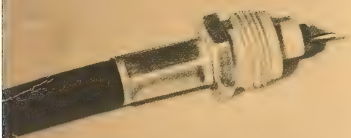
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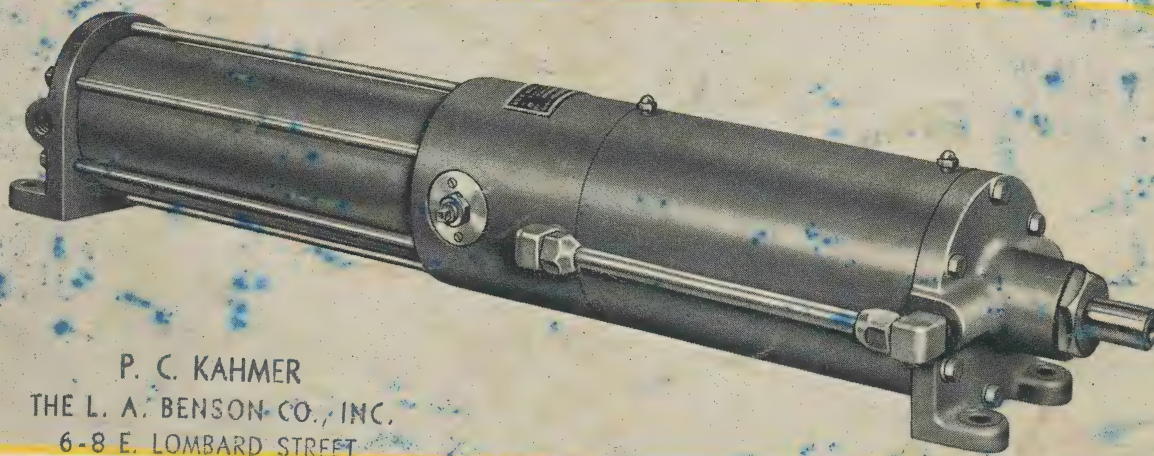
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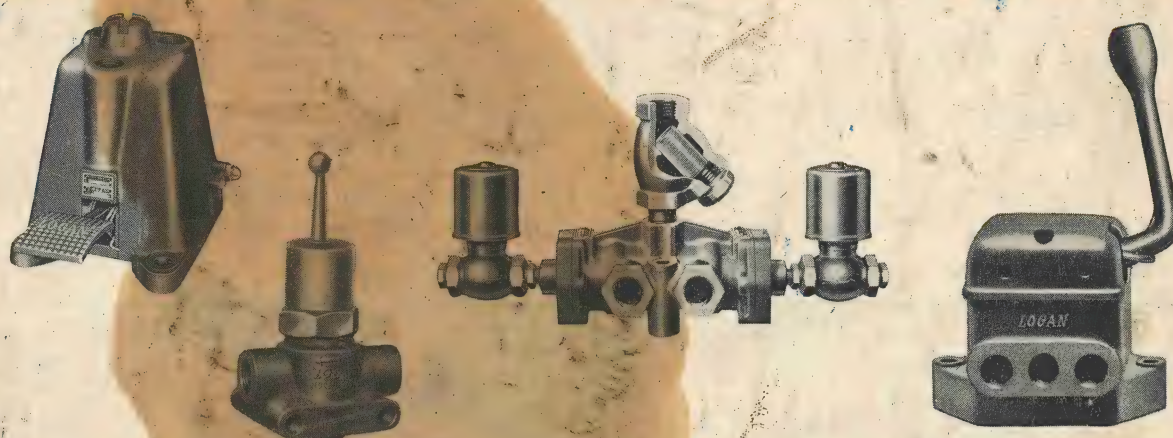
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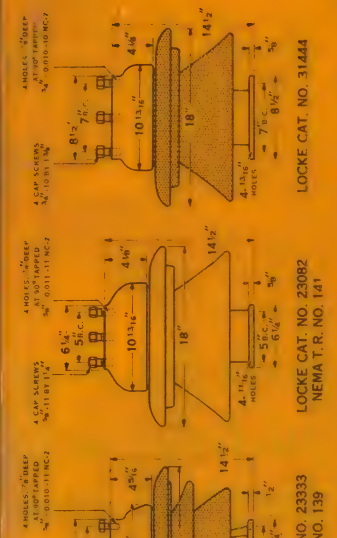
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DRY ARCING DISTANCE, INCHES	102
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WET	660
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WET	525
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To serve the Electric Power Industry, the Insulator Department welcomes opportunities to give you unusual services regarding Switch and Bus Insulators and other high voltage insulation. Please contact your local representative or address your requests to Insulator Dept., General Electric Co., P.O. Box 57, Baltimore 3, Md.

LOCKE CAT. NO. 30153 NEMA T.R. NO. 53	LOCKE CAT. NO. 7785 NEMA T.R. NO. 140	LOCKE CAT. NO. 23333 NEMA T.R. NO. 139	LOCKE CAT. NO. 23082 NEMA T.R. NO. 141	LOCKE CAT. NO. 31444
--	--	---	---	----------------------



NOTES:

Electrical characteristics of combination stacks involving T. R. 140 units and T. R. 141 units must be reduced below the established NEMA Standards for stacks of the same height. This is necessary because of the capacitive unbalance that exists between the T. R. 140 and T. R. 141 insulators. Where the No. 23333 (T. R. 139) insulator is used instead of the T. R. 141, this unbalance does not exist and the electrical characteristics are equal to ratings of non-mixed stacks. Flashover and withstand voltage values are predicated on the use of a 3½" high subbase.

High strength insulator No. 23333 and extra high strength insulator No. 31444 are shown above and on slide with gray tone, indicating our new gray glaze. This color coding, which is optional on these units, makes high strength insulator identification quick and positive at a glance.

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GENERAL ELECTRIC
BALTIMORE, MARYLAND

VOLUME 24 JANUARY, 1936 NUMBER 1

PROCEEDINGS
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Application Blank for Associate Membership on Page IX

VOLUME 23

APRIL, 1935

NUMBER 4

PROCEEDINGS
of
**The Institute of Radio
Engineers**



**Tenth
Annual Convention**
Detroit, Michigan
July 1, 2, and 3, 1935

Application Blank for Associate Membership on Page XI

Fatigue of Metals in Engineering and Design

By

R. E. Peterson



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1962

PRESENTED BEFORE THE SIXTY-FIFTH ANNUAL MEETING
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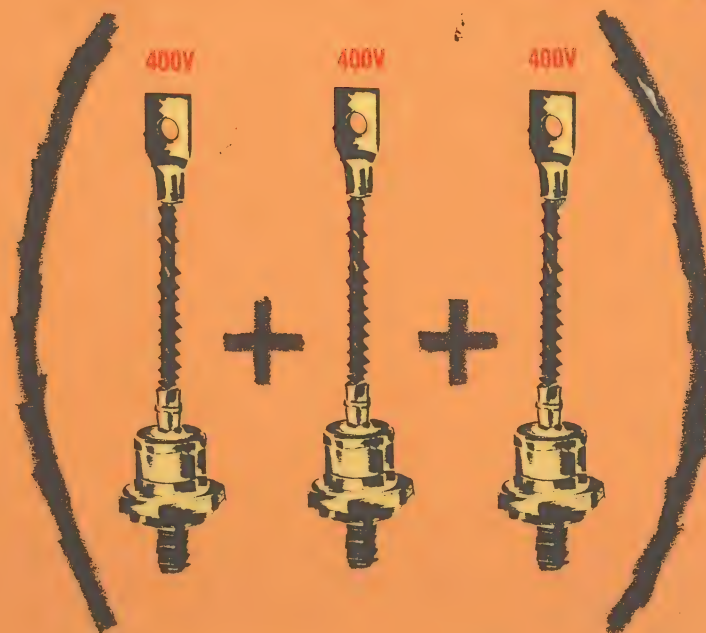
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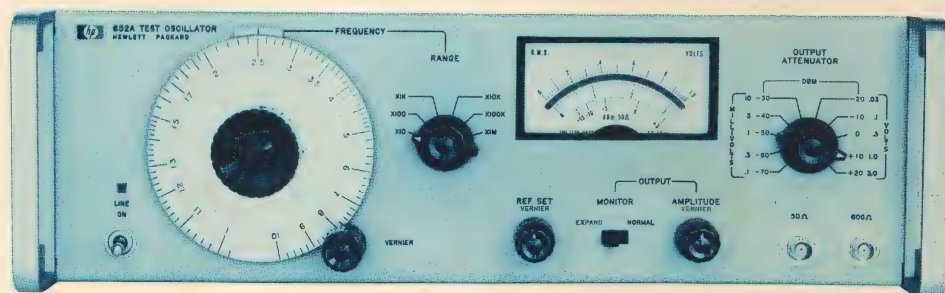
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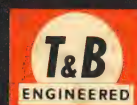
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THE INFLUENCE OF WATER RESISTIVITY AND
PRECIPITATION RATE UPON 60-CYCLE
WET FLASHOVER VOLTAGE

AIEE Committee Report

The Working Group on Rain Tests was appointed in January 1957, for the purpose of studying problems associated with wet flashover and wet holding tests on high voltage insulators such as are used on transmission and distribution lines. These problems are intimately concerned with the resistivity of the water used in the tests and the rate of precipitation with which it falls on the test specimen. In connection with the latter, a study of suitable methods for applying the water to the test specimen may well be an area for investigation particularly for use in wet flashover or holding tests on extra high voltage insulation.

Present European standards for wet testing specify a water resistivity of 10000 ohms per centimeter cube (3900 ohms per inch cube) and a precipitation rate of 3 millimeters per minute (0.118 inch per minute) while present American standards specify a water resistivity of 7000 ohms per inch cube and a precipitation rate of 0.2 inch per minute.

Wet flashover and wet holding voltages have been specified for practically all classes of high voltage equipment including

This report was prepared by the Working Group on Rain Tests of the Subcommittee on Techniques for Dielectric Tests. The personnel of this working group are: C. J. Miller, Jr., Chairman, T. L. Dyer, Jr., H. E. Fiegal, B. E. Kingsbury, and D. L. Whitehead. The material for this paper was accumulated mostly in 1938 to 1940 by the General Electric Company, The Ohio Brass Company, and the Westinghouse Electric Corporation.

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SUBJECT

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H. A. Frey, Baltimore
J. H. Hagengath, Pittsfield
I. B. Johnson, Schenectady
A. J. Schultz, Schenectady
C. H. Titus, Philadelphia
W. R. Wilson, Philadelphia

Enclosed is a copy of the discussion which I propose to submit on the paper, "CALCULATION OF TRANSMISSION LINE LIGHTNING VOLTAGES BY FIELD CONCEPTS", by Professor Lundholm, Dick Finn, and W. S. Price at the coming Chicago Convention. I should be very much interested in any comments that you may have on it. I expect to arrive at the Morrison Hotel in Chicago late on the seventh and shall be there until after the session on the tenth.

Wilfred F. Skeats

W. F. Skeats
CONSULTING ENGINEER
ENGINEERING RESEARCH AND DEVELOPMENT LABORATORIES

Enclosure

WFS/jg

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H. A. FREY

Lightning Theory

*75
459
534*

42/8

*6'6" = 1 9/16 = 27/16
6 1/2 = 13/2 = 22/16
1/4 = 1*

Theory

A HYPOTHESIS CONCERNING
LIGHTNING PHENOMENA AND TRANSMISSION LINE FLASHOVER

by

I. B. Johnson*
Member AIEE

A. J. Schultz*
Member AIEE

Conference Paper Presented at
AIEE Northeastern District Meeting
Pittsfield, Massachusetts

Thursday, May 2, 1957

*General Electric Company, Schenectady, New York

Paper No. DP 57-568

1

Theory

A HYPOTHESIS CONCERNING
LIGHTNING PHENOMENA AND TRANSMISSION LINE FLASHOVER

by

I. B. Johnson*
Member AIEE

A. J. Schultz*
Member AIEE

Conference Paper Presented at
AIEE Northeastern District Meeting
Pittsfield, Massachusetts

Thursday, May 2, 1957

*General Electric Company, Schenectady, New York

Paper No. DP 57-568

Henry

AIEE DISTRICT PAPER 57-561

FACTORS AFFECTING THE LIGHTNING PERFORMANCE
OF TRANSMISSION LINES

J. H. Hagenguth
Fellow - AIEE

J. G. Anderson
Member - AIEE

Power Transformer Department
General Electric Company
Pittsfield, Massachusetts.

Presented at the AIEE Northeastern District Meeting,
Pittsfield, Mass., May 1-3, 1957

P A P E R N O.

DP 57-561

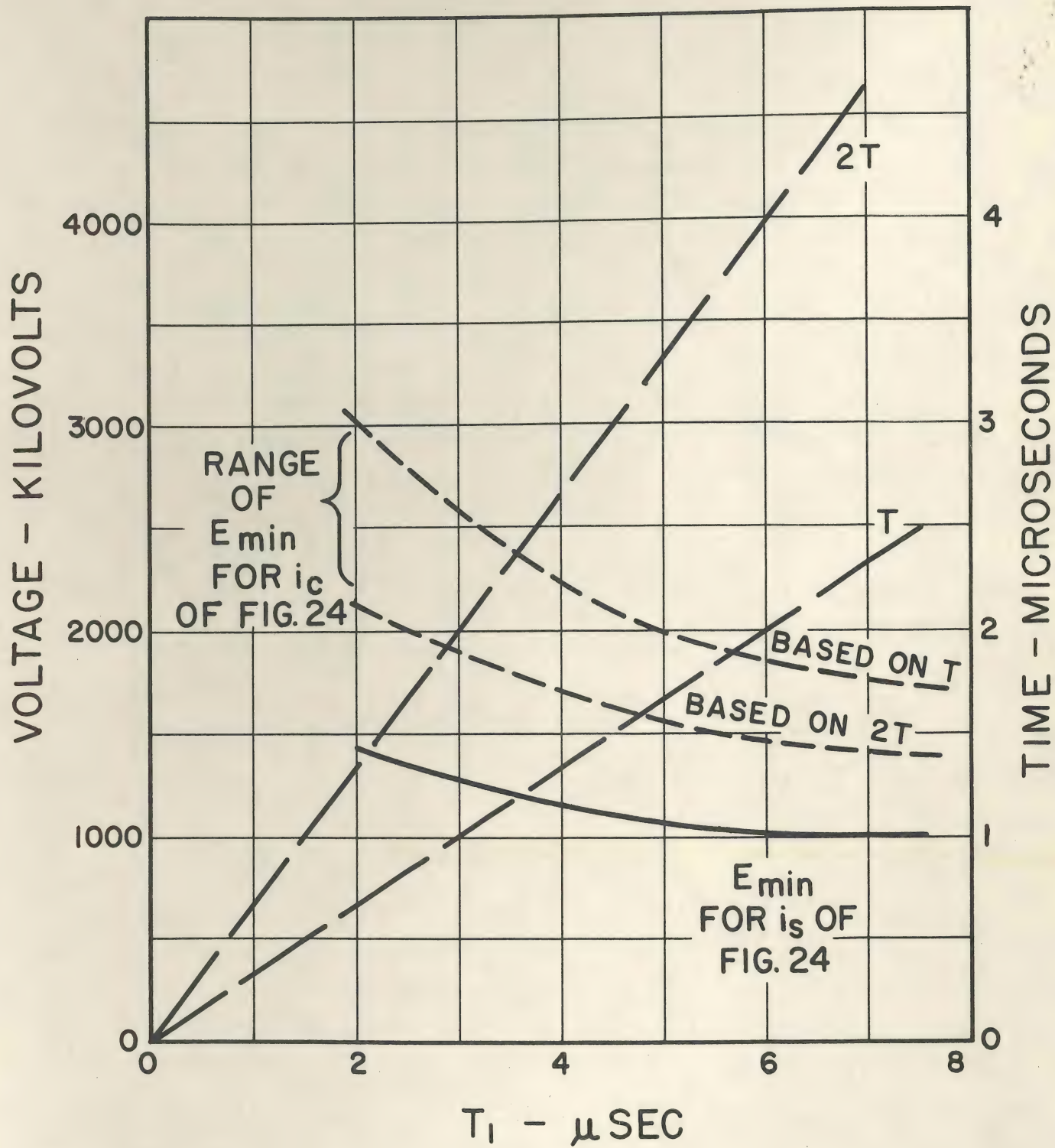


FIG. 25. MINIMUM VOLTAGES USED FOR CALCULATIONS IN FIG. 24.

CHOOSING AND USING INDUSTRIAL DATA

Francis J. Cullen
Industrial Statistician

The National Plastic Products Company
Odenton, Maryland

I am going to discuss three broad phases of Industrial Statistics and illustrate with examples from one of our products, namely, saran monofilament, widely used for seat covers and outdoor furniture which presents unique quality problems not found in other products. The basic principles which I am about to discuss, however, apply to our product and to most any other product including the products developed in the office.

The three broad phases under discussion:

- I Basic Statistical Method
- II Methods of Process Control
- III Methods of Product Control

My discussion shall certainly not include all the techniques in these fields, but I shall try to tie together and follow Statistical Quality Control-wise one product from inception to end use while using some statistical technique from each phase listed above.

I repeat: My examples are all taken, naturally, from the Plastics industry but the basic principles apply whether we are dealing with nuts and bolts or office procedures.

I Basic Statistical Method

In Industrial Statistics basic statistical techniques are often used to define and measure patterns of variation. Statistics may be defined as a "study in variation" and the statistician is often defined as an "expert in identifying and measuring patterns of variation."

Variation is the stuff from which statistics are manufactured. By variation I refer to the inability of nature or man to produce things exactly alike. They may be alike for all practical purposes but if measured finely enough a tendency will be observed for the measurements to concentrate about one value while at the same time there is a spread of the measurements in a definite pattern on each side of the point of concentration.

Thus if we measure selected samples, plot the measurements, observe the pattern formed and compute a few statistics, we will find it much easier to analyze the data and draw proper conclusions.

GENERAL  ELECTRIC

**GENERAL ELECTRIC COMPANY
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Schenectady, N.Y.

**METHODS FOR PLANNING AND ANALYZING
ACCELERATED TESTS**

by

**W. B. Nelson
Information Science and Engineering**

Report No. 73CRD034

March 1973

TECHNICAL INFORMATION SERIES

CLASS 1

This paper is for presentation at the 4th Annual Reliability and Maintainability Conference, July 28 through 30, 1965 in Los Angeles.

PROBABILISTIC LIFE CONSUMED ANALYSIS ON HIGH
TEMPERATURE, HIGHLY STRESSED STRUCTURAL PARTS

By

G. W. Weber, Manager
Reliability Applications
Reliability & Design Methods Engineering
Large Jet Engine Department
General Electric Company
Cincinnati 15, Ohio

April 9, 1965

Introduction

The reliability of complex equipment can be predicted, based on experience with similar equipment and the anticipated effects of changes in the design and application details. Frequently overall equipment goals or requirements are established on the basis of such predictions and then apportioned down to the part level to provide specific part or component reliability goals. In critical jet engine structural design areas, the part probability of failure goals are frequently of the order of .001 to .0001 per 1000 hour life or overhaul period. Classical design approaches, which are based on factor of safety criteria, cannot translate these probability numbers into design decisions regarding dimensions, material properties, stresses, etc. because they are, of necessity, deterministic

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CLASS 1

HAZARD PLOTTING FOR RELIABILITY ANALYSIS
OF INCOMPLETE FAILURE DATA

by

W. B. Nelson
Information Sciences Laboratory

Report No. 68-C-313

August 1968

8-332-6185

Mark Humphrey - Tape

THE QC ANALYSIS SYSTEM

by

J. L. Bemesserfer

Presented at

R & D C Symposium on Applications of
Probability and Statistics in General Electric
Schenectady, N. Y. June 10-11, 1969

A MACHINE SHOP SIMULATION USING GPSS

April 1969

D.C. Hogue

Systems Analysis Engineer
Systems Engineering and Analysis Branch
Information Sciences Laboratory
Schenectady, N.Y.



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TITLE "LIMIT", REJECT ANALYSIS--PLOTS HISTOGRAM, SUGGESTS TEST LIMITS.		G.E. CLASS II GOVT. CLASS NONE
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SUMMARY PURPOSE: 1. ESTIMATE PRACTICAL TEST LIMITS FROM SAMPLE MEASUREMENTS DURING PILOT RUNS. 2. ESTIMATE VENDOR REJECT RATE DUE TO SORTING TO SPECIFIED LIMITS AND DETERMINE POTENTIAL IMPROVEMENT DUE TO CHANGING LIMITS. 3. MAKE ENGINEERING, MANUFACTURING, OR VENDOR FACE FACTS ON PRODUCT QUALITY DURING SAMPLE RUN, BEFORE PRODUCTION. FEATURES: 1. USES RAW, UNSORTED INPUT DATA. 2. PLOTS HISTOGRAM, CALCULATES REJECTS, SUGGESTS LIMITS. 3. MANY GROUPS OF DATA MAY BE HANDLED IN SAME RUN. 4. HANDLES SKEWED DATA WITH REASONABLE ACCURACY. LIMITATIONS: HANDLES SKEWED DISTRIBUTIONS BY DIVIDING THEM INTO TWO "HALF GAUSSIAN" DISTRIBUTIONS AT THE PEAK OR MODE, YIELDING PESSIMISTIC PREDICTIONS ON HIGHLY SKEWED DATA. LANGUAGE: XBASIC AND MK II BASIC		
KEY WORDS STATISTICAL ANALYSIS, HISTOGRAM, SKEWED, REJECT.		

INFORMATION PREPARED FOR _____

TESTS MADE BY _____

AUTHOR ADELORE F. PETRIECOMPONENT AUDIO PRODUCTS DEPT., DECATUR, ILLINOISAPPROVED M West

VARIABILITY OF THE VARIABILITY
Probability Plot Methods of Study

Normal probability plotting has been extremely useful in the analysis of data of various kinds particularly the non-normal distributions that one encounters in actual factory situations. The use of a probability plot of "contrasts" to analyze designed two level experiments by Daniel¹ suggested to us that the method might logically be used in the analysis of process variability. We had always used either $\bar{R}$ or $\hat{R}$ to estimate the inherent (short time) process variability (capability) not only for process control purposes but for process analysis as well. Now it seemed that the range of two plotted on a suitable probability paper might improve our ability to study the variability of process variability. It was anticipated that this might provide advantages similar to these obtained by the use of normal probability paper in studying process variability.

This investigation led to the use of "half-normal" probability paper and the delta plot (difference of two plotted on normal probability paper). To understand these two methods we need to recognize that the difference (keep the sign) between consecutive values from a normal distribution will also be a normal distribution. If the process is stable (in statistical control) the expected peak or average of the distribution is zero, with half the values plus and half minus. Hence a plot on normal probability paper should plot as a straight line. The variability of delta (difference of two) is related to the parent distribution variability as follows:

$$\sigma_{\Delta} = \sqrt{\sigma_X^2 + \sigma_X^2} = \sigma_X \sqrt{2}$$

$$\text{or } \sigma_X = \frac{\sigma_{\Delta}}{\sqrt{2}} = .707 \sigma_{\Delta}$$

Therefore it is a simple matter to convert the estimated variability of delta to an estimate of the variability of the process (parent distribution). If the delta plot was made from the difference of consecutive values in their order of production, then the estimated variability does not include the variability associated with process drifts or other time related effects, except as reflected in consecutive values. If the process under study is stable, both the probability plot of the individual values and the delta plot should be straight lines and the results that we get from this analysis would agree quite well with the conventional $\bar{X}$, σ & R estimates.

1. Cuthbert Daniel, "Use of Half Normal Plots in Interpreting Factorial Two-Level Experiments", *Technometrics* Volume I Number 4 November 1959.

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TECHNICAL MEMORANDUM

OPERATION Systems Analysis
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PREPARED BY W. L. Smith
APPROVED BY W. L. Smith

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ENG.

ATL RELIABILITY MEMO 35

INTRODUCTION TO RELIABILITY

by

Paul F. Albrecht, ATL Reliability

May 5, 1965

1. Need for Reliability

Every material device is subject to failure. Some things "hardly ever fail", such as bridges and aircraft structures. But even these devices can - and sometimes do - fail. Other devices fail "quite frequently", such as TV sets and automobiles. Still other devices fail between these two extremes, such as power transformers and turbine generators.

The fact that all material devices are subject to failure gives rise to the field of RELIABILITY. However, it is not simply the existence of failures which is responsible for the inception and growth of reliability. Material failures have always existed, but "reliability" as a distinct field is relatively new - less than 15 years old.

Equipment capabilities and performance levels have increased enormously in the past 15 years, but only at the expense of a corresponding increase in equipment complexity levels. As complexity increases, the frequency of failure likewise tends to increase. Eventually, the point is reached where the equipment is "down for repairs" most of the time. It was this situation which the Defense Department found in the late 1940's. That is, "failures" had become an obstacle to further state-of-the-art advances.

Concurrently with the increase in failure frequency due to increased complexity, an increase in failure cost occurred with the advent of the missile age. A single part failure in a large rocket would destroy several million dollars worth of equipment. In fact, reliability can trace its origin to the German V-1 rocket development at Peenemunde during World War II.

It is these two factors - increased failure frequency and increased failure cost - which are primarily responsible for the development and rapid growth of reliability as a distinct technology.

DM 64-49

RELIABILITY ANALYSIS AND PREDICTION FOR TURBOJET ENGINES

RESULTS VS. NEEDS

February 7, 1964
(Revised)

D. D. Freberg and R. B. Spector

**Reliability Engineering Operation
Large Jet Engine Department
General Electric Company
Cincinnati 15, Ohio**

ABSTRACT

The Reliability Design Review is an effective tool in assisting designers towards achieving higher levels of Reliability early in the program. The Designer in the end is solely responsible for the Reliability achievement of his component. In this context Reliability activities of the sort described in this paper are a service to the Design Engineer in achieving his goals. Three Reliability prediction techniques and typical examples of the achieved results of each are described:

1. Controls and accessories Reliability Design Review practices and results of the 1959-60 Era.
2. Mechanization of the routine aspects of the Reliability Design Review procedure.
3. Probabilistic approach to failure rate estimation of basic engine structural parts.

SIMULATION METHOD APPLIED TO RELIABILITY ANALYSIS OF TURBOJET
ENGINE COMPONENTS OPERATING IN AIRLINE SERVICE

R.S. Dorsey and H.A. Truscott
Aircraft Engine Group
General Electric Company
Evendale, Ohio
Dial Comm 8*332-4205
June 10, 1969

ABSTRACT

A brief description of a computer program generated to assess the reliability of a turbojet engine compressor disk is given. System simulation and Monte Carlo techniques are methods used in the program. The effects and interactions of Airline maintenance policy and component and engine design parameters are investigated. Results and discussion of a sample problem is given.

INTRODUCTION

Designers of turbojet engine components are seeking realistic answers to vital questions about the reliability of their components when they are exposed to airline service. Some of these questions are:

- What is the probability of component failure?
- When, in calendar time, will a failure occur?
- What effect do factors such as frequency of inspection, inspection capability, unscheduled engine removal rate, monthly utilization, maintenance policy, etc. have on these answers?

The designers must have new tools to generate meaningful answers to this set of complex questions. The answers require several random and deterministic variables. His normal stress/strain-load analysis technique is inadequate for complete answers. Simulation of the real-world process appears to be the approach most likely to achieve realistic answers.

This report describes a computer program that simulates the flow of components through an airline service operational system. Monte Carlo technique is used to simulate the occurrence of the random events in the system and to obtain distributions that provide clues to the statistical behavior of the system. The simulation utilizes IBM's General Purpose System Simulator (GPSS) II language [1,2] .

represented by the largest percentage of tests having the smallest per cent range, other factors being equal. It can be seen that the ASA method shows 75% of the tests yielding data with less than 4.5% range, while the IEC method shows 75% of the tests yielding data with less than 6.5% range. Figs. 3 and 4 show similar results for fog-type suspensions, and all suspensions, respectively. The 75% level of test frequency for fog-types shows 7% voltage range for the ASA method and a 10% voltage range for the IEC method. For all suspensions, the 75% level shows 5 and 7% ranges, respectively, for the ASA and IEC methods. If a range of 5% is desired for all suspensions (Fig. 4) the IEC method will meet this requirement 45% of the time, the ASA method 78%.

Strings of nine of the conventional suspension insulators were also tested using the compromise test method and the results are as shown in Table II.

APPARATUS INSULATORS, CAP AND PIN TYPE FOR USE ABOVE 69 KV

Cap and pin type insulators for use above 69 kv were tested in stacks of 2, 4, 6, and 8 units. Both the IEC and ASA test methods yielded almost identical results (Fig. 5), and both show tendencies of proportionality with respect to arcing distance. Even more so than for suspension insulators, these apparatus insulators have much higher per cent voltage range on each specimen with the IEC test method than with the ASA test method as shown on Fig. 6. For 75% of the tests the IEC method indicated a 9% range, or almost twice the 5% range for the ASA test method. Curves have also been plotted on Fig. 7 to show how the two test methods result in a total variation of all arcs on the four different insulator combinations. Each individual flashover value has been expressed as a percentage of the average of all flashovers on each type of insulator and all of the data can be consolidated on single curves for each test method. These cumulative probability curves will give an indication of the variability to be expected in performing a wet test. The 100% voltage point on the abscissa represents the average flashover value, and, as shown, it would be expected that this average would occur at the median of the number of individual arcs.

The compromise proposal of test method was used to test several stacks of four high of the cap and pin apparatus insulators. Flashover values were obtained which were identical to those obtained with the ASA and IEC test methods (Table III).

APPARATUS INSULATORS, CAP AND PIN TYPE FOR USE BELOW 69 KV

The cap and pin type apparatus insulators, below 69 kv, showed essentially equal performance when tested under either of the two test methods (Fig. 8). A lower mean IEC value of approximately 7% was obtained for the 15 kv insulator, but the remainder of the sizes which were tested yielded practically identical results with either method. No difference existed in the variation in test voltages either on individual specimens or overall.

APPARATUS INSULATORS, POST TYPE, FOR USE BELOW 69 KV

Substantial disagreement between the ASA and IEC test methods is evident in the results obtained on post type insulators below 69 kv. As shown in Fig. 9, the results are very consistent for each method and show good indications of the flashover voltage being proportional to arcing distance. But, the IEC results are approximately 10% lower overall than the ASA results with specific mean values differing by 4 to 19%. This trend is very indicative of the IEC test method being quite incompatible with this type of insulator if the present test voltage levels are to be maintained. As with the cap and pin insulators, the post type insulators yield very consistent data with approximately equal, and quite small, variations in the flashover voltages from arc to arc.



GENERAL ELECTRIC COMPANY
CORPORATE RESEARCH AND DEVELOPMENT

Schenectady, N.Y.

HIGH DENSITY, CONDUCTING MIST TEST
FOR INSULATOR EVALUATION

by

J. M. Atkins and R. L. Gingrich
Physical Chemistry Laboratory

Report No. 71-C-050

January 1971

TECHNICAL INFORMATION SERIES

CLASS 1

PACIFIC GAS & ELECTRIC COMPANY
MOSS LANDING Contamination Test Program

NATURAL FOG

Report Prepared By
R. L. Thompson

ELECTRIC UTILITY ENGINEERING OPERATION
A-C TRANSMISSION ENGINEERING SECTION
AND
HIGH VOLTAGE LABORATORY
November 30, 1965

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TABLES

FIGURES

APPENDIX I

APPENDIX II

APPENDIX III

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TECHNICAL INFORMATION SERIES
Title Page

JES. WHEELER

AUTHOR F. S. Nichols	SUBJECT Hydrated Alumina and common dehydration	NO. 70-MATL-201
		DATE 6/29/70
TITLE Drying and Dehydration of Hydrated Alumina		GE CLASS II
		NO. PAGES 25
ORIGINATING COMPONENT Chemical and Processes Section		
The drying and dehydration of hydrated alumina has been investigated using thermal analysis techniques. In spite of literature references claiming loss of combined water at low temperature, drying of hydrated alumina is not a critical operation. There was no significant loss of combined water after drying for periods up to 14 days at 125°C or one day at 150°C in a circulating air oven. Even after one week at 150°C the combined water was 34% against a theoretical 34.6%.		
KEY WORDS Hydrated alumina, dehydration, epoxy		

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SAMPLE: _____ RUN NO.: _____

SAMPLE: 209804 NO FILLER ORIGIN:	SIZE 0.00404 gms	ATM. N ₂ 60 PSI	RUN NO. 1
	REF. Empty pan	T ΔT	DATE APR 8 '97
	PROG. MODE DSC HEAT	SCALE 5.0 $\frac{^{\circ}\text{C}}{\text{IN}}$ 1.0 $\frac{^{\circ}\text{C}}{\text{IN}}$	OPERATOR JH
	RATE 15 $\frac{^{\circ}\text{C}}{\text{MIN}}$ START 98 $^{\circ}\text{C}$	SHIFT -2 IN.	BASE LINE SLOPE

ACTUAL 1540/min

246

298

343

388

433

478

523

568

613

658

703

748

793

838

883

928

973

1018

1063

1108

1153

1198

1243

1288

1333

1378

1423

1468

1513

1558

1603

1648

1693

1738

1783

1828

1873

1918

1963

2008

2053

2098

2143

2188

2233

2278

2323

2368

2413

2458

2503

2548

2593

2638

2683

2728

2773

2818

2863

2908

2953

2998

3043

3088

3133

3178

3223

3268

3313

3358

3403

3448

3493

3538

3583

3628

3673

3718

3763

3808

3853

3898

3943

3988

4033

4078

4123

4168

4213

4258

4303

4348

4393

4438

4483

4528

4573

4618

4663

4708

4753

4798

4843

4888

4933

4978

5023

5068

5113

5158

5203

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5338

5383

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5473

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5563

5608

5653

5698

5743

5788

5833

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6013

6058

6103

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6193

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8803

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9073

9118

9163

9208

9253

9298

9343

9388

9433

9478

9523

9568

9613

9658

9703

9748

9793

9838

9883

9928

9973

10018

900

EXOTHERM

ΔT

ENDO

INTRODUCTION

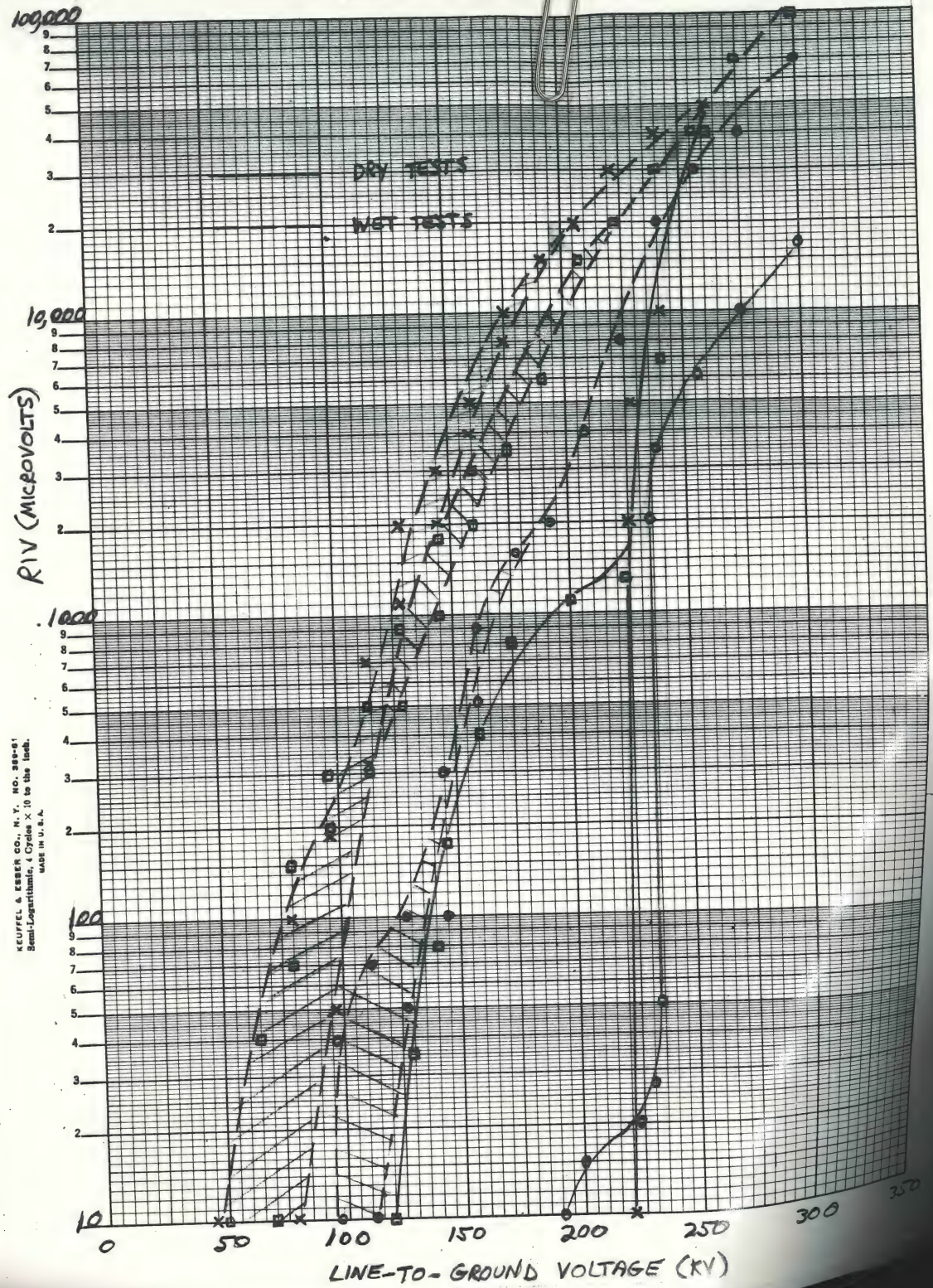
Wet flashover and wet withstand tests provide a necessary ^{means} ~~measure~~ ^{to evaluate the electrical characteristics} of the characteristic ~~to be used in the evaluation~~ of many types of high voltage equipment used on transmission and distribution lines and in substations. The American Standard for wet tests, ASA-C77.1-1943, was developed in order to establish a general standard method for tests that could be performed in the laboratory which ^{and} ~~in turn could be~~ related to levels of acceptable performance in the field. ^{an environment similar} It was intended that this test embody ~~conditions which are like~~ ^{to that} those encountered in the field but yet the test was to be one in which only those ^{with} ~~elements over which reasonable control can be exercised~~ ^{over specified elements.} are specified. A reasonable degree of reproducibility was paramount.

The present American Standard has fulfilled these requirements and the practice of the standard has established specific wet flashover and withstand voltages.

Europe has similarly established a standard, each country having slightly different variations. ~~All these are quite different from the American standard.~~ The European standard specifies a water resistivity of 10,000 ohms per centimeter cube (3930 ohms per inch cube) and a rate of precipitation of three millimeters per minute (0.118 inches per minute) as contrasted to the American standard which specifies a water resistivity of 7,000 ohms per inch cube and a rate of precipitation of 0.2 inches per minute.

It is desirable that an international standard be established which could be used both in Europe and in America. One proposal advanced by the International Electrotechnical Commission (IEC) has been the adoption of the present European standard. In considering such a proposal, it is necessary to investigate the parameters which differ between the proposed European standard and the American standard. A preliminary investigation ⁽¹⁾ ~~reported in a paper, using~~ (58-27) which presented a treatment of some of the aforementioned variables.

~~The American standard as a base-line, presented a comparison of water the effects of water resistivity and rate of precipitation. These ~~variables~~ factors were investigated one at a time, that is, the IEC water resistivity was used, but, the ASA rate of precipitation~~



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A COMPARISON OF EUROPEAN AND AMERICAN
WET FLASHOVER TEST METHODS

Bruce E. Kingsbury

INTRODUCTION

Wet flashover and wet withstand tests provide a necessary means to evaluate the electrical characteristics of many types of high voltage equipment used on transmission and distribution lines and in substations. The American Standard for wet tests, ASA-577.1-1943, was developed in order to establish a general standard method for tests that could be performed in the laboratory and related to levels of acceptable performance in the field. It was intended that this test embody an environment similar to that encountered in the field but yet the test was to be one with reasonable control over specified elements. A reasonable degree of reproducibility was paramount.

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In the present investigation, the combined effect of changing water resistivity and rate of precipitation was measured on suspension, pin-type, and apparatus insulators. Thus the work of the preceding paper has been extended, but, there still remains a need for similar data on other electrical apparatus.

METHOD OF TEST

The American standard practices were followed throughout in this investigation except for the water resistivity and rate of precipitation. The tests, for both IEC and ASA methods, were conducted using the rain angle, nozzles, and pre-wetting techniques as specified by ASA.

Various voltage classes as well as different types of geometrically-shaped insulators were used. Suspension insulators were tested in strings of 1, 3, 5, 6, 7, 8, 9, 10, 12, 15, and 18 units using both conventional and fog-type units. One low voltage pin-type insulator and one high voltage pin-type insulator were tested. Apparatus insulators comprised the remainder of the specimens which were investigated. Insulators designed for operation at 15 kv, 23 kv, 34.5 kv, and 69 kv of both the cap and pin and post-type construction were tested. Above 69 kv, only apparatus insulators of the cap and pin type were tested in stacks of 2, 4, 6, and 8 units.

Baltimore, January 9, 1956.

CC: Mr. C. H. Linder - NEW YORK

To Those Attending the
High Voltage Conference.

Gentlemen:

At the November 22nd High Voltage Conference, I was asked to submit brief reports on the subjects of "Electrical Breakdown", "Withstand Tests", Altitude Derating Factors", "Leakage Distance" and "Clearance Distance". I am attaching copies of these reports.

It is needless to say none of these reports are complete; in an inclusive sense each could be made a very extensive paper in itself. What we have tried to do is to outline very briefly what I believe to be the major knowns and unknowns in the field. We have deliberately avoided a discussion of some of the conventional variables, such as the difference between I.E.C. and American test practices, and also the conventionalized withstand test levels which have been established by the various product sections of NEMA.

In the latter case we have attached to the report on "Withstand Values" a curve which shows the general trend in standardized product withstand levels. The shaded areas of this curve indicate those zones where there is a difference between the withstand levels specified for different types of product. In some cases there are probably very good reasons for these differences, and it was not my thought that you would use these meetings at this stage in their development to try to iron out such product variables.

Very truly yours,

H.A. Frey
Manager - Engineering
Locke Department.

HAFrey/LP

Conference Paper



FIRST 500 kv A-C TRANSMISSION LINE DESIGNS FOR THE BONNEVILLE POWER ADMINISTRATION'S GRID

A. A. Osipovich
Senior Member IEEE

M. G. Poland
Senior Member IEEE

Bonneville Power Administration
U. S. Department of the Interior
Portland, Oregon

A paper scheduled by the IEEE Transmission and Distribution Committee for presentation at the IEEE Summer General Meeting, Toronto, Ontario, Canada, June 16-21, 1963.

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Paper No. **CP**

63-1164

Transactions Paper

(Reviewed and Accepted for Publication)



VOLTAGE GRADIENTS ON HIGH VOLTAGE TRANSMISSION LINES

G. E. Adams
Associate Member AIEE
General Electric Co.
Schenectady, N. Y.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Manuscript submitted October 21, 1954; made available for printing November 10, 1954.

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Paper No.

55-22

Discussion in Duplicate Due February 16, 1955.

A REVIEW OF INSULATION AND CLEARANCE PRACTICES
of
HIGH VOLTAGE SUBSTATIONS

by
E. A. Williams

A paper presented to the joint meeting of the
Electrical Equipment and Transmission and
Distribution Committees, Pennsylvania Elec-
tric Association, Reading, Pa., October 8-9,
1953.

R & I E E Q U I P M E N T D I V I S I O N
I-T-E Circuit Breaker Company, Greensburg, Pennsylvania

MODERN CONCEPTS OF LIGHTNING PROTECTION FOR TRANSMISSION AND DISTRIBUTION SYSTEMS



BY

H. M. TOWNE

GENERAL ELECTRIC COMPANY

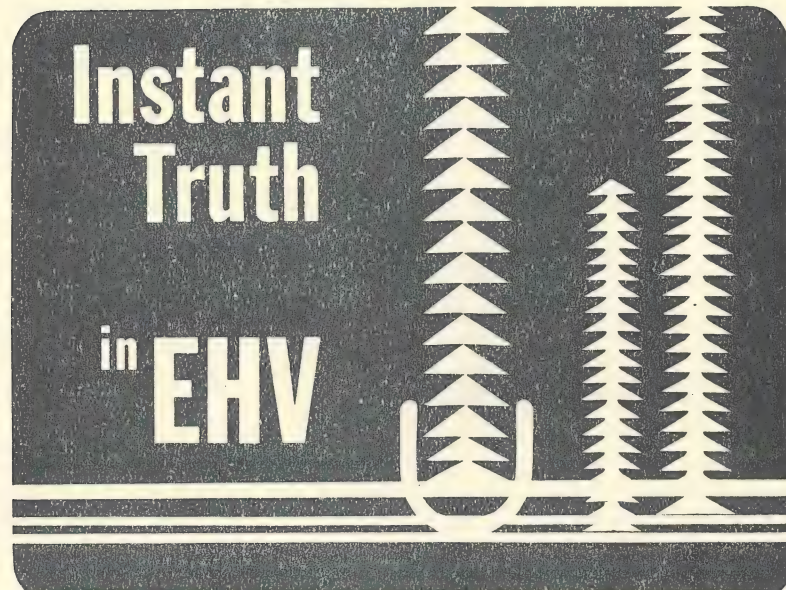
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GENERAL  ELECTRIC

THIRD DRAFT

January 29, 1963

A motion picture script



prepared for

THE INSULATOR DEPARTMENT

Baltimore, Maryland

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Audio-Visual Communications
Schenectady, New York

METIFOR—A Statistical Method for Insulation Design of EHV Lines

J. G. Anderson, Senior Member IEEE L. O. Barthold, Senior Member IEEE

Summary: Using sequential hourly weather data available on punched cards from the United States Weather Bureau, digital weather models of the future climate in the vicinity of a proposed transmission line can be constructed. These models permit statistical forecasts of line performance. Application of the technique to line insulation strength is demonstrated. Performance can be predicted on an over-all basis, or can be studied at specific times of the day, or during fog periods or thunderstorms. Optimizing routines are presented that optimize or permit balancing

of flashover characteristics, and forecast performance as a function of line investment.

Paper 64-37, recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 6, 1963; made available for printing December 11, 1963.

J. G. ANDERSON is with the General Electric Company in Pittsfield, Mass., and L. O. BARTHOLD is with the same company in Schenectady, N. Y.

The authors gratefully acknowledge the contributions of their many associates whose research work, discussions, and direct assistance were of immense value. Of particular mention are the discussions and suggestions of H. C. S. Thom and G. J. Bulgarelli of the United States Weather Bureau; G. K. Carter, P. M. Cabral, and M. S. Dyrkacz for their programming of much of the work; D. D. MacCarthy and E. M. Hunter for their encouragement and guidance; A. F. Rohlf, F. J. Turner, and J. R. Meador for the flashover data to make METIFOR a realistic program; and the many other co-workers who contributed in numerous ways.

The recent upsurge in the use of extra-high-voltage (EHV) transmission has brought with it several new technical and economic attitudes. Both design philosophies and techniques have been reappraised in the light of the increased incentives for cost control and the greater opportunities for precision afforded by recent progress in industry research.

Any discussion of transmission-line design philosophy resolves itself into the consideration of three arguments: (1) the electrical and meteorological *environment* to which the line will be subjected, (2) the *criteria* assigned to its operating performance, and (3) the intrinsic design *dimensions* proposed to fulfill the criteria established.

While the discussion here is confined to electric systems, and more particularly to transmission lines themselves, the stated arguments are found to be inherent in practically any design problem.

Design criteria may be further subdivided into cases where noncompliance is catastrophic as opposed to those in which it is not. A bridge must never collapse, but its pavement need

EHV DC TRANSMISSION

BY E. M. HUNTER, G. D. BREUER AND C. C. HERSKIND
THE GENERAL ELECTRIC COMPANY

Reprinted from TRANSMISSION & DISTRIBUTION, September, 1965

460_{KV} = EHV

The Pennsylvania Electric Company has built the nation's first operating 460-KV power transmission line as part of its continuing program to develop and use the latest technology to provide customers with dependable service.

Penelec also regards the unusual engineering and construction work which has gone into this project as a contribution to the "art" of EHV transmission. The ultra-severe demands, of 460-KV service require:

WIRES—thick as a man's wrist

PORCELAIN INSULATORS—15 feet long

CROSS-ARMS—big as a barn beam

STRUCTURES—up to 130 feet high

TRANSFORMER—holding in its tank all of the oil carried by the largest railroad tank car

SWITCH BLADES—20 feet long, 4 inches in diameter

It took 260 working days to erect this transmission line. It required not only new hardware, but new construction methods as well. Despite this, it is a practical line, with pure EHV research and development a by-product.

During the next two years, intensive tests will be made to obtain a clearer understanding of stresses and strains, of behavior and of effectiveness of design. And, just as important, during that period the line will be performing the function for which Penelec exists—serving its customers.

PRODUCT REFERENCE FILE

THE TEINOGRAPH - A NEW HIGH-VOLTAGE SURGE RECORDER

J. G. Anderson
Member - AIEE

R. U. Giacomoni
Associate Member - AIEE

Both of:
General Electric Co.
Pittsfield, Mass.

To be presented at the AIEE Middle Eastern District Meeting,
Baltimore, Md., May 19, 1959

American Gas and Electric Company 500-Kv Test Project

Corona, Radio Influence, and Economics
on
High Voltage Transmission Lines
and
AG&E Co. 315-Kv System

Reprint of
Six Technical Papers including discussions presented
before the AIEE 1950-51 on the above subject

Group Participating in the Project

American Gas and Electric Service Corporation (Sponsor)
Aluminum Company of America
American Bridge Company
Anaconda Wire and Cable Company
General Cable Corporation
General Electric Company
Locke Insulator Corporation
Ohio Brass Company
Westinghouse Electric Corporation

The American Institute of Electrical Engineers

Transactions Paper

(Reviewed and Accepted for Publication)



THE CALCULATION OF THE RADIO INTERFERENCE LEVEL OF TRANSMISSION LINES CAUSED BY CORONA DISCHARGES

G. E. Adams
Associate Member AIEE
General Electric Company
Schenectady, N. Y.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted October 20, 1955; made available for printing December 20, 1955.

Price: 40¢ To Members
80¢ To Nonmembers

(5¢ per copy additional if
first class mailing desired)

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33 West 39th Street, New York 18, N. Y.
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Paper No.

56-222

Discussion in Duplicate Due February 15, 1956.

EUROPEAN TECHNOLOGY REPORT

EUROPEAN OFFICE
Lowenstrasse 29
Ch 8001 Zurich, Switzerland

For Cited References: Technical Information Exchange, Bldg. 5, Rm. 221, Schenectady, N. Y. • Dial Comm 8-235-5068

A22

72T7

February 21, 1972

HIGH VOLTAGE TECHNOLOGY

The 1972 International Symposium on High Voltage Technology will take place in Munich, W.Germany, on March 9-14, 1972. It is being organized by VDE (German Association of Electrical Engineers) and the IEEE Power Engineering Society. Scientific Chairman is Professor Hans Prinz of the High Voltage Institute, Technical University, Arcisstr.21, D-8 Munich 2, W.Germany.

The conference program is outlined below and a list of the 93 papers to be presented is also given. These papers have been compiled in a conference volume which is now available at the Technical Information Exchange Office of Corporate R&D, Bldg. 5, Room 221, P.O.Box 43, Schenectady, NY. When ordering copies of any of the papers, please indicate exact titles and numbers of the papers as well as the number of this report: 72T7.

A.M. Gurewitsch
A.M. Gurewitsch, Consultant
Applied Science and Technology - Europe
Zurich, Switzerland
AMG/mb

List of Papers to be Presented:

A. The Calculation of Electric Fields in High Voltage Devices

1. "Determination of Boundary Coordinates by means of Finite-Difference Methods" by K. Antolic, Micafil-Zurich, Switzerland

9. "The Electromagnetic Wave of the High Voltage Impulse" by H.Böcker, TU-Stuttgart

17. "Automatic Calculation of Electric Fields" by N.Flatabö et al., TU-Trondheim, Norway

23. "Safety Hazards beneath High Voltage Lines" by E.T.B.Gross, M.H.Hesse, Rensselaer Polytechnic, Troy, NY, USA

30. "Calculation of the Effectiveness of Shielding against Quasistatic Electric Fields" by G.Karady and N.Hyltén, Hydro-Quebec, Canada

36. "Potential Gradients on the Surface of Shielding Electrodes for Ultra-High Voltages" by J.Moeller et al., Messwandler-Bau GmbH, Bamberg, W.Germany

44. "Derivation of System Models Applying the Finite Element Method" by K.Reichert, BBC-Baden, Switzerland

52. "Computation of Electric Fields: Recent Developments and Practical Applications" by M.F.Scott et al., Reyrolle Parsons Ltd., Hebburn, UK

59. "The Electric Field of Polycon Electrodes" by H.Singer, TU, Munich, W.Germany

67. "Calculation of Maximum Stress in Gas Insulated Bus-Bars" by T.Takuma et al., Central Research Institute of Electric Power Industry, Tokyo, Japan

73. "Field Strength Effects in Two-Dielectric Arrangements" by P.Weiss, TU, Munich, W.Germany

B. The Measurement of Electric Field Strength in High Voltage Devices

81. "Contribution to Electric Field Measurement Technique by means of Probes" by J.Aubry et al., Electricité de France, Paris

86. "Electrical Field in Long Rod-Rod Gaps" by G.Baldo, M.Rea, Padova University, Italy

Transactions Paper

(Reviewed and Accepted for Publication)



EFFECT OF BUNDLE-CONDUCTOR FIELD INFLUENCE ON EHV TRANSMISSION LINE DESIGN

R. W. Harmon
Member AIEE
The Ohio Brass Company
Barberton, Ohio

RECEIVED

JAN 17 1961

G. M. BOYD

RECEIVED

JAN 17 1961

H. A. FREY

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., January 29-February 3, 1961. Manuscript submitted August 8, 1960; made available for printing December 2, 1960.

Price: \$.50 To Members
\$1.00 To Nonmembers

(5¢ per copy additional if
first class mailing desired)

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Paper No.

61 171

Discussion in Duplicate Due February 17, 1961.

Transactions Paper 57-1077

SUSPENSION INSULATOR FLASHOVER UNDER HIGH IMPULSE VOLTAGES

by B. E. Kingsbury

Closure by B. E. Kingsbury

The discussions which have been presented by Messrs. Concordia, Fritz and Rohlfis are greatly appreciated.

Mr. Fritz asks some questions which are beyond the scope of this paper and will require further work and study before their answers can be forthcoming. In those cases where long counterpoise systems are required because of poor ground resistances, the advantage of several microseconds delay in flashover for the shorter spaced insulators would provide definite protection in view of the long periods before alleviation of the stricken structure can be effected.

As Mr. Rohlfis points out, the correlation of this and the companion paper are good and the data should provide benefits for transmission design.

By plotting the flashover voltage versus arcing distance, a particular type of insulator can be evaluated under both standards. By using the ASA standard as the base line, it can then be readily determined whether or not there exists a difference between the two standards for any one particular voltage class, and, also, whether or not the trend of the results using the IEC method agrees with the base line as the tests progress upward through the voltage classes. It is logical to consider that the resulting curve of flashover voltage versus arcing distance, while fairly linear as determined by the American standard for most types of insulators, may not be coincidental for the IEC standards. It may not have the same slope, and may not even have the same semblance of linearity. In plotting these curves, only the mean of the average values of similar test specimens is shown. The average curve drawn through these points would depict the expected true performance as obtainable with the particular test standard. This average curve would then be used to determine whether or not a plausible comparison exists both between the two standards and between the ratings and the European standards. The mean values of specific insulators can then be examined as to how well they fit the overall picture.

In some cases it is apparent that certain types of insulators do not show the same general pattern as do the majority of others. This, then, might indicate one further point to be gained from this investigation; i.e., that some geometrical shapes, while designed to adequately meet existing ASA standards, react in an aggravated manner to different conditions of test. That is, they are super-sensitive to various atmospheric conditions and may not perform as expected.

The reliability of the wet test is dependent upon there being as small a variation as possible between the high and low values obtained, upon which the average value is predicated. It was noted that the IEC ~~standards~~ seemed to consistently yield results which were more erratic than those of the American standard. This erratic performance exists not only from specimen to specimen, but also, from arc to arc on the same specimen. Data have been plotted so as to develop frequency distribution curves showing the cumulative percentage of tests as a function of the flashover voltage range. The range for each test has been expressed as a percentage based upon the average of the particular test so that all of the data for each type of insulator can be consolidated and plotted together. Comparisons can be made between the two standards for the different types of insulators tested.

SUSPENSION INSULATORS

Both conventional and fog-type insulators were tested so that the effect of geometry could be determined. The flashover test values for conventional insulators obtained with both the ASA and IEC test methods, when plotted against arcing distance, appear to be linear. The test values shown for the IEC method have a greater variability than the ASA values but do not deviate by more than 8.5% from the average curve values.

The mean values of the IEC test method for fog-type insulators are generally higher than are those for the ASA test method (Fig. 2). An average curve can be readily drawn through the means of the ASA data, and, in comparing specific IEC test data points with ASA mean curve, it is found that as much as a 24.3% difference exists. Such large differences indicate that more data should be obtained, and, if a like differential is determined, then no valid correlation would seem to exist.

The range on individual tests for conventional insulators is shown by Fig. 3. The range between the minimum and maximum flashover voltage for each test specimen is expressed as a percentage based upon the average flashover voltage for that specimen, and all the data was then consolidated so that the frequency of occurrence of tests could be plotted as a function of the per cent range. The preferred test method would be

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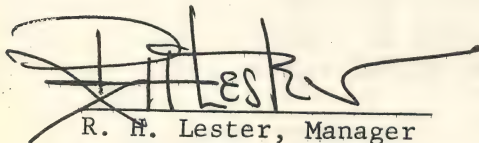
PROGRESS REPORT OF AGING TESTS ON THE 20,000 lb. INSULATORS

Author:



R. Weller
Product Engineer

Approved:



R. H. Lester, Manager
Ceramic Insulator Engineering

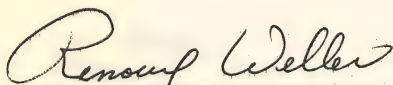
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HM Williams

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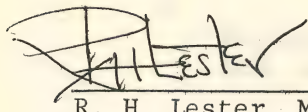
REPORT OF TESTS ON CAST ALUMINUM SUSPENSION
CAP BY ALCOA

Author:



R. Weller
Product Engineer

Approved:



R. H. Lester, Manager
Ceramic Insulator Engineering

Distribution:

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AL Libby
HM Williams

INSULATOR DEPARTMENT

GENERAL ELECTRIC COMPANY

BALTIMORE, MARYLAND
January 29, 1969

TECHNICAL REPORT LK-927

AGING TESTS ON INSULATORS HAVING
TWO COATS OF ADIPRENE

Author:

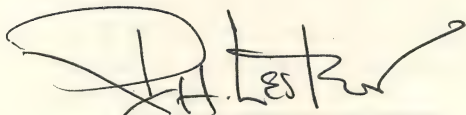


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HM Williams

Approved:



R. H. Lester, Manager
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TR 8380

TECHNICAL REPORT NO. LK-917
EVALUATION AND TESTS ON THE CATALOG 40S298
FOG TYPE INSULATOR

Author:

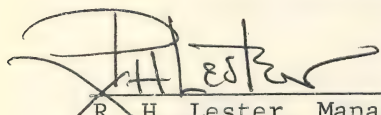


R. Weller
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WB Lounsbury
HM Williams

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R. H. Lester, Manager
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INSULATOR DEPARTMENT

GENERAL ELECTRIC COMPANY

BALTIMORE, MARYLAND
January 13, 1969

TECHNICAL REPORT LK-CR 201

HYDRAULIC TESTING OF NOs. 18290A - 40,000 lb. and
18380A - 50,000 lb. SUSPENSION SHELLS

AUTHOR:

C. D. Croskey
C. D. Croskey
Manager-Ceramic Laboratory

APPROVED:

E. S. Wheeler 8/15/68
E. S. Wheeler
Manager-Engineering

Distribution:

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KW Cermak
JM Jesatko
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FR McVicker
R Weller
HM Williams
RF Worden
CD Croskey (3)

INSULATOR DEPARTMENT

GENERAL ELECTRIC COMPANY

BALTIMORE, MD.

August 6, 1968

TECHNICAL REPORT LK-881

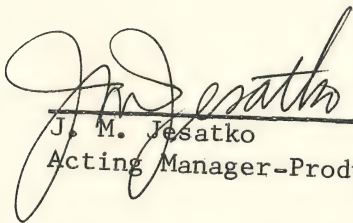
EVALUATION AND TESTS ON NGK SUSPENSION CAT. 525MC, 18,000 LB. INSULATOR

Author:



R. Weller
Product Engineer

Approved:



J. M. Jesatko
Acting Manager-Product Engineering

Distribution: CD Croskey
JM Jesatko
J Kaminski
WB Lounsbury
CH Matthews
ES Wheeler
HM Williams

TECHNICAL REPORT LK-879

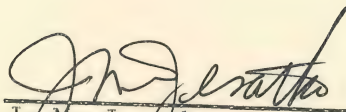
EVALUATION AND TESTS ON THE LAPP
CAT. 8200 INSULATOR 20,000 LB. ASA CLASS 52-3

Author:



R. Weller
Product Engineer

Approved:



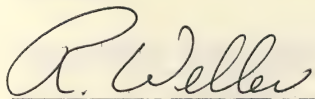
J. M. Jesatko
Acting Manager-Product Engineering

Distribution: CD Croskey
JM Jesatko
J Kaminski
BE Kingsbury
WB Lounsbury
CH Matthews
ES Wheeler
HM Williams

TECHNICAL REPORT LK-861-A
SUPPLEMENT NO. 1

EVALUATION AND TESTS ON THE OB CAT. 47310 SUSPENSION INSULATOR

Author:



R. Weller
Product Engineer

Approved:



J. M. Jesatko
Acting Manager-Product Engineering

Distribution: JM Jesatko
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CH Matthews
ES Wheeler

TECHNICAL REPORT LK-882

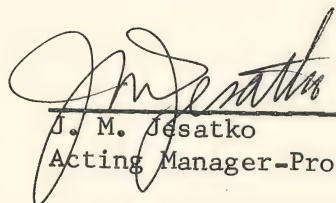
EVALUATION AND TESTS ON THE NGK CAT.
DA-500 MQ 25,000 LB, SUSPENSION INSULATOR

Author:



R. Weller
Product Engineer

Approved:



J. M. Jesatko
Acting Manager-Product Engineering

Distribution: CD Croskey
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CH Matthews
ES Wheeler
HM Williams

Insulator Department

Baltimore, Maryland

June 13, 1968

TECHNICAL REPORT LK-CR-209

STATUS OF RESEARCH ON STABILIZED GLAZED INSULATORS
FOR USE IN CONTAMINATED AREAS

Author:

C. D. Croskey

C. D. Croskey
Manager-Ceramic Laboratory

Approved:

E. S. Wheeler 2/26/69

E. S. Wheeler
Manager-Engineering

Distribution:

GM Boyd
ES Wheeler
BE Kingsbury
RH Lester
AL Libby
R Weller
HM Williams

TECHNICAL REPORT NO. LK-923

TIME-LOAD TESTS ON NGK SUSPENSION INSULATORS

Author:

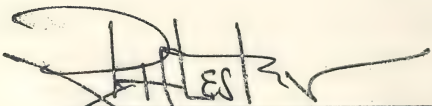


R. Weller
Product Engineer

Approved:

Distribution:

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BE Kingsbury
RH Lester
AL Libby
HM Williams

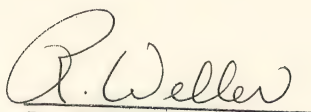


R. H. Lester, Manager
Ceramic Insulator Engineering

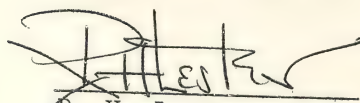
TECHNICAL REPORT NO. LK-924

DEVELOPMENT OF A PEARLITIC MALLEABLE IRON
CAP FOR 30,000 LB. INSULATOR

Author:


R. Weller
Product Engineer

Approval:

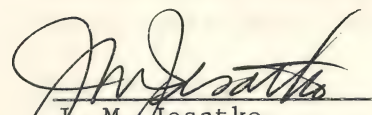

R. H. Lester, Manager
Ceramic Insulator Engineering

Distribution:

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BE Kingsbury
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AL Libby
HM Stickles

TECHNICAL REPORT LK-930
SOLID STATION POST INSULATORS

Author:


J. M. Jesatko
Product Engineer

Approved:


R. H. Lester, Manager
Ceramic Insulator Engineering

Distribution:

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JS Craig
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AL Libby

TECHNICAL REPORT LK-CR 212

FEASIBILITY STUDY --- CONDUCTIVE GLAZES
TIN-ANTIMONY OXIDE TYPES

Author:

C.D. Croskey
C. D. Croskey, Manager
Ceramic Laboratory

Approved:

E. S. Wheeler 7/3/69
E. S. Wheeler
Manager-Engineering

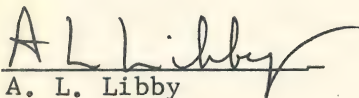
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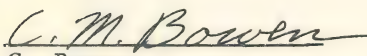
LK 932

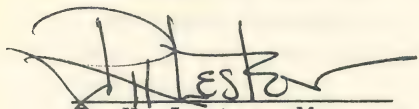
RECORD OF TESTS NO. 24242

THERMAL ENDURANCE TESTS
ON
SUSPENSION INSULATORS
FOR
CONEMAUGH PROJECT


A. L. Libby
Product Engineer


R. Weller
Product Engineer


C. Bowen
Baltimore Gas & Electric Co.


R. H. Lester, Manager
Ceramic Insulator Engineering

INSULATOR DEPARTMENT

GENERAL ELECTRIC COMPANY

BALTIMORE, MARYLAND
December 2, 1968

GENERAL ELECTRIC
INSULATOR PRODUCTS DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

No. 24597
Date Oct 31, 1969
Page 1 of 6

Nature of Tests: RADIO INFLUENCE VOLTAGE AND CORONA OBSERVATION		Material Dual Conductor Spacer
AT 60HZ ON DUAL CONDUCTOR SPACERS		
Refer to Data Sheet No. 24554	Test Req. No.	

**Copies
to**

Preformed Line Products Co.
Dept. of Water & Power, City
of Los Angeles

I. GENERAL

The tests described below were performed in the High Voltage Laboratory, Insulator Products Department, General Electric Company on September 23, 1969 on 500Kv-AC rated two-conductor spacers.

II. CUSTOMER AND SPECIFICATIONS

These tests were made for the Preformed Line Products Company of Cleveland, Ohio. The tests were run to qualify conductor spacers for sale to The Department of Water and Power of the City of Los Angeles (abbreviated "LADWAP" on occasion) and specification No. 7248.

III. WITNESSES

The following persons, other than laboratory personnel, were present during all tests:

Mr. Tom Eistrat	Department of Water and Power, City of Los Angeles
Mr. Raymond J. Champa	Preformed Line Products Company
Mr. Mike Hathway	Preformed Line Products Company
Mr. Jim Jung	Preformed Line Products Company

IV. MATERIAL

The following material items were included in some or all of the tests performed:

1. Alcoa ACSR Conductor, 2050 MCM 76/19 Stranding, 1.700 inches outside diameter, with Alcan Aluminum fittings
2. Alcan All Aluminum Conductor, 2,500 MCM 91 strands, each 0.1657 inches in diameter, total outside diameter 1.823 inches with Alcan Aluminum fittings
3. Preformed Line Products Helical Spacer SU-MS-5462 (Dept. of Water & Power item #11-A)

Signed AM
Approved _____

TECHNICAL REPORT NO. LK-937

LEAKAGE CURRENT MEASUREMENTS ON 15 KV AND 34 KV
GEPOI® INSULATORS

Author:

Fred C. Vose
F. C. Vose, Manager
Polymer Insulator Engineering

Approved:

E. S. Wheeler 11/11/69
E. S. Wheeler
Manager-Engineering

Distribution:

HM Carmichael
J Kelenfy
BE Kingsbury
AL Libby
CS MacConney
M Tabor

TECHNICAL REPORT NO. LK-941
AGING TESTS ON 40S360 GO6 INSULATOR

Author:

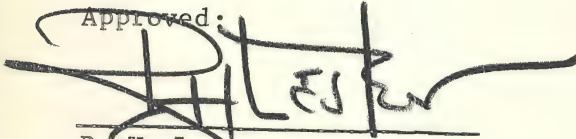


R. Weller
Product Engineer

Distribution:

ES Wheeler
RT Fleming
J Kelenfy
BE Kingsbury
RH Lester
AL Libby
HM Williams

Approved:



R. H. Lester, Manager
Ceramic Insulator Engineering

INSULATOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC COMPANY

BALTIMORE, MARYLAND
December 5, 1969

TECHNICAL REPORT NO. LK-939-DR

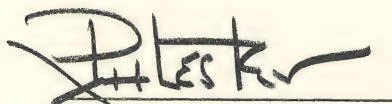
DESIGN TESTS ON THE CATALOG NO. 40S296 FOG TYPE INSULATOR

Author:



R. Weller
Product Engineer

Approved:



R. H. Lester, Manager
Ceramic Insulator Engineering

Distribution:

ES Wheeler
RT Fleming
J Kelenfy
BE Kingsbury
RH Lester
AL Libby
HM Williams

TECHNICAL REPORT NO. LK-938-DR

DESIGN TESTS ON CATALOG NO. 20S185 FOG TYPE INSULATOR

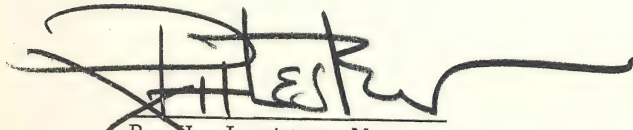
Author:


R. Weller
Product Engineer

Distribution:

ES Wheeler
J Kelenfy
BE Kingsbury
RH Lester
AL Libby
HM Williams

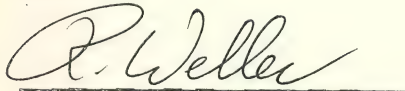
Approved:


R. N. Lester, Manager
Ceramic Insulator Engineering

TECHNICAL REPORT NO. LK-940-DR

DESIGN TESTS ON THE CATALOG 30S263
FOG TYPE INSULATOR

Author:

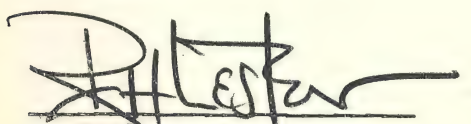


R. Weller
Product Engineer

Distribution:

ES Wheeler
RT Fleming
J Kelenfy
BE Kingsbury
RH Lester
AL Libby
HM Williams

Approved:



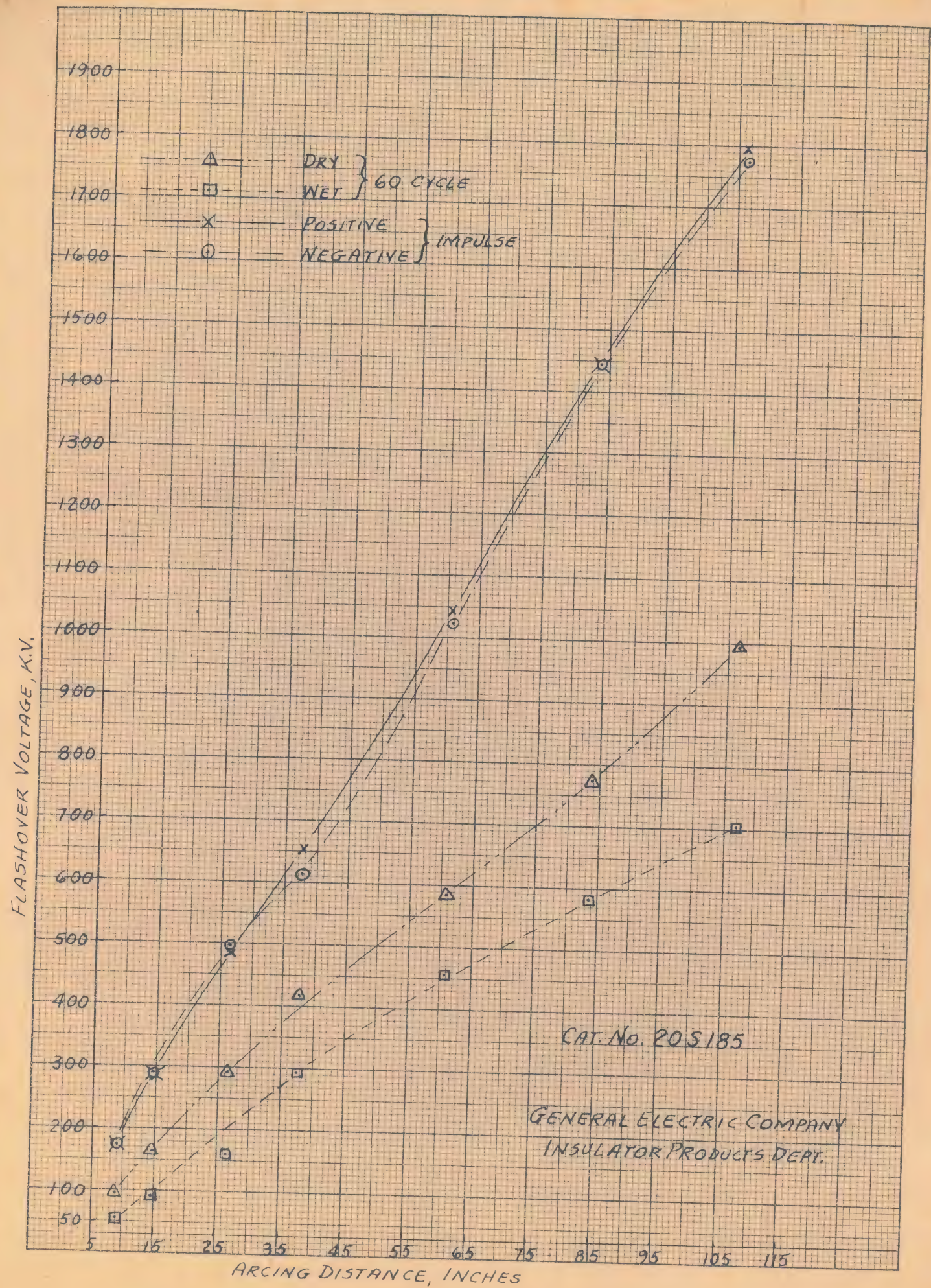
R. H. Lester, Manager
Ceramic Insulator Engineering

INSULATOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC COMPANY

BALTIMORE, MARYLAND
November 18, 1969

RE
10 X 10 TO 1/2 INCH
SLURRY & ROSE CO.
AND
481352



CAT. No. 205185

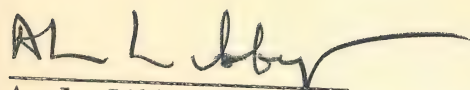
GENERAL ELECTRIC COMPANY
INSULATOR PRODUCTS DEPT.

1

TECHNICAL REPORT LK-936

THERMAL ENDURANCE TESTS
ON
SUSPENSION INSULATORS
FOR
PUBLIC SERVICE ELECTRIC AND GAS COMPANY

OCTOBER 27, 1969



A. L. Libby, Manager
High Voltage and Mechanical Laboratory

INSULATOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC CO.

BALTIMORE, MARYLAND
November 5, 1969

TECHNICAL REPORT NO. LK-951-DR

INFLUENCE OF COATINGS ON THE AGING MECHANISM
OF SUSPENSION INSULATORS

Author:

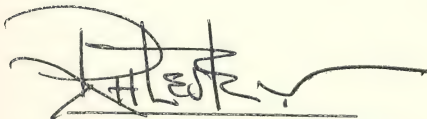


R. Weller
Product Engineer

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CD Croskey
BE Kingsbury
RH Lester
AL Libby
HM Williams

Approval:



R. H. Lester, Manager
Ceramic Insulator Engineering

1-
TECHNICAL REPORT LK-936

THERMAL ENDURANCE TESTS
ON
SUSPENSION INSULATORS
FOR
PUBLIC SERVICE ELECTRIC AND GAS COMPANY

OCTOBER 27, 1969



A. L. Libby, Manager
High Voltage and Mechanical Laboratory

INSULATOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC CO.

BALTIMORE, MARYLAND
November 5, 1969

TECHNICAL REPORT NO. LK-942-DR

DESIGN TESTS ON THE CATALOG 30S268 FOG TYPE INSULATOR

Author:



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TECHNICAL REPORT LK-CR-219

THE EFFECT OF THICK CEMENT ON THE M&E STRENGTH
OF SUSPENSION INSULATORS WHEN STORED IN AIR AND
IN VACUUM

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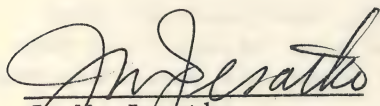
December 4, 1970

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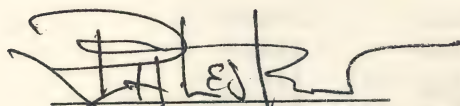
TECHNICAL REPORT LK-976-DR -- Sup. 1

CHARACTERISTICS OF PCB POSTS

Author:


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INSULATOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC COMPANY

BALTIMORE, MARYLAND
July 28, 1971

TECHNICAL REPORT LK-CR-220

A-30 EXPERIMENTAL ALUMINA BODY
LABORATORY PROGRAM
PROGRESS REPORT #1

Author:

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TECHNICAL REPORT LK-CR-221

REYNOLDS RC24-GF ALUMINA: SHOP TRIAL IN 304-3 and
A-30 FORMULATIONS

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FL Page
EH Rickels
R Weller
HM Williams

GENERAL ELECTRIC COMPANY
PROTECTIVE EQUIPMENT PRODUCTS DEPARTMENT BALTIMORE, MARYLAND

May 1, 1972

CALCULATION OF TRANSMISSION LINE
LIGHTNING VOLTAGES BY FIELD CONCEPTS

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Both of American Gas and Electric Service Corporation
New York

District Paper Presented at
AIEE Northeastern District Meeting
Pittsfield, Massachusetts
May 2, 1957

DP 57-537

CALCULATION OF TRANSMISSION LINE
LIGHTNING VOLTAGES BY FIELD CONCEPTS

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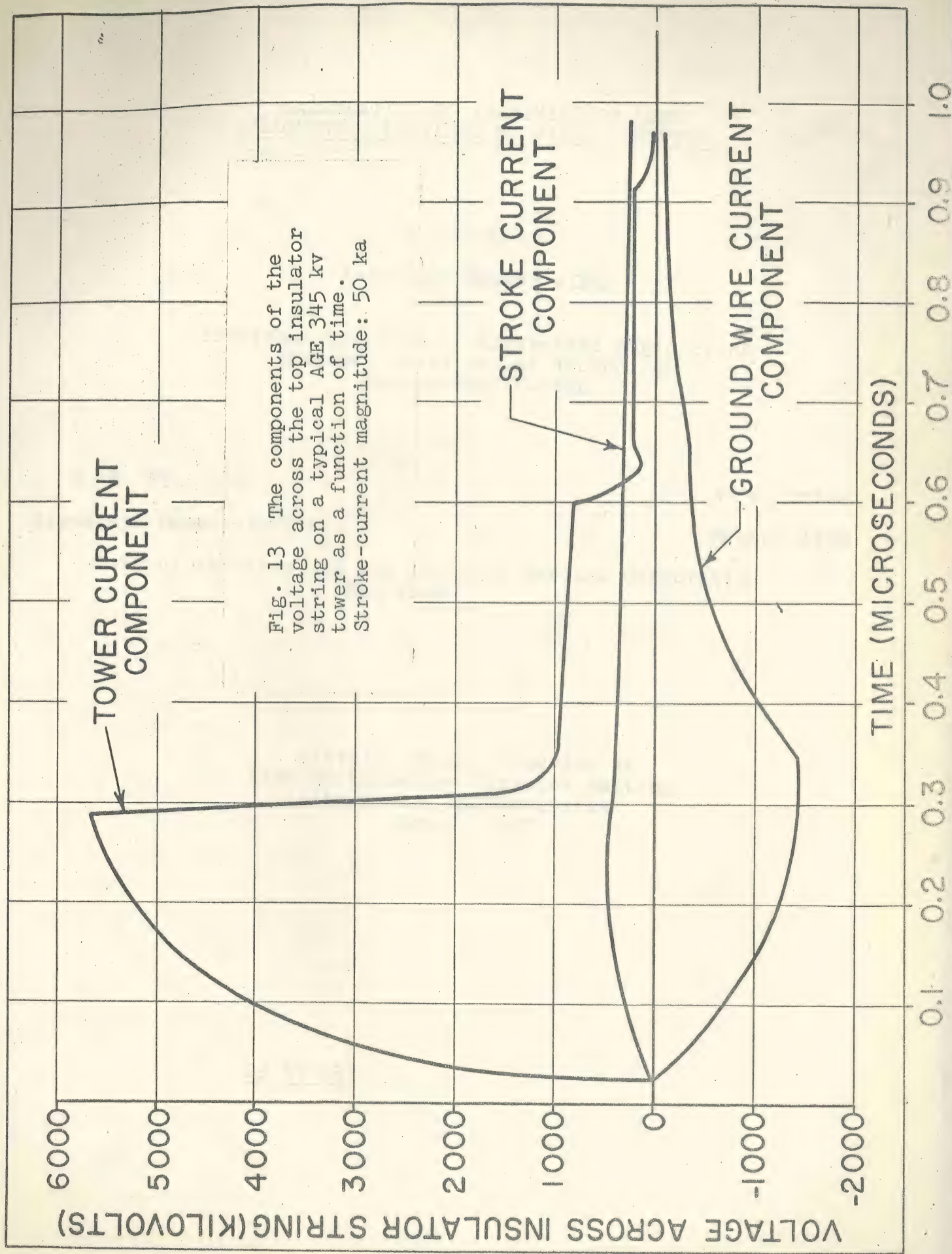
W. S. Price

Member AIEE

Both of American Gas and Electric Service Corporation
New York

District Paper Presented at
AIEE Northeastern District Meeting
Pittsfield, Massachusetts
May 2, 1957

DP 57-537



District Conference Paper



Lightning Theory

AN APPROXIMATE TRANSIENT SOLUTION OF THE TAPERED TRANSMISSION LINE

L. O. Barthold
Associate Member AIEE
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Schenectady, N. Y.

A paper recommended by the AIEE North Eastern District Meeting Committee for the AIEE North Eastern District Meeting, Pittsfield, Mass., May 1-3, 1957. Manuscript submitted February 27, 1957; made available for printing March 13, 1957.

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Paper No. **DP**

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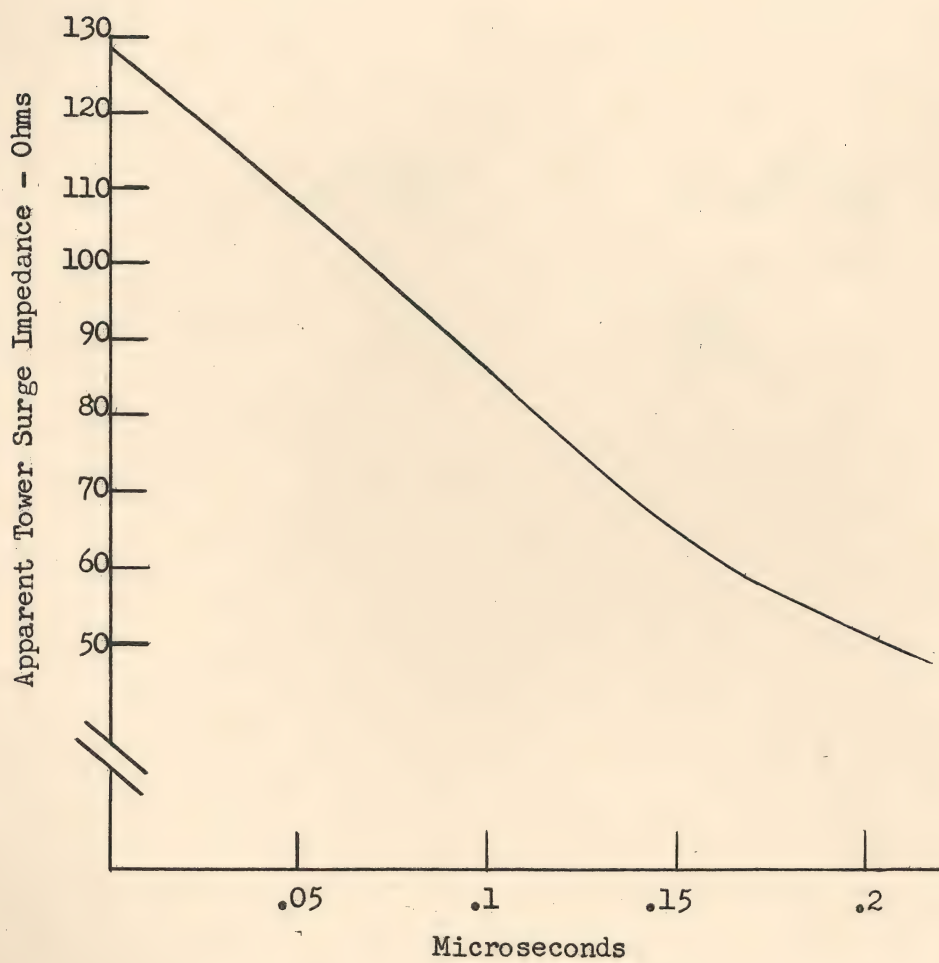


Fig. 9. Apparent Tower Surge Impedance
As A Function of Time
Data From Oscillogram of Fig. 8

FACTORS AFFECTING THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES

J. H. Hagenguth
Fellow - AIEE

J. G. Anderson
Member - AIEE

INTRODUCTION

In recent years there have been an unexplained large number of outages on the 345 kv OVEC system. In a co-operative investigation several of the factors that may influence the outage rate have been investigated. The principal factors involved in the lightning performance problem are:

- Insulation .
- Configuration of line.
- Frequency of strokes to line.
- Frequency of occurrence of current
 - amplitude
 - front time
 - rate of rise
- Charge distribution in the leader channel and in the ground.
- Induced voltage.
- Ground resistance.
- Coupling effects.

This paper will discuss the charge distribution and resulting induced voltage, as well as a comparison method of calculating lightning performance, and will investigate available statistics to explain the flashover performance.

AN ELECTROSTATIC MODEL OF THE LIGHTNING STROKE PROCESS

It is now believed⁽¹⁾ that the concept of the lightning stroke as a simple generator (injecting a current into the line at the point struck) may be a drastic over-simplification for some lines. The stroke not only injects current into the stricken point, but also induces voltages into lines and towers by the electric and magnetic fields produced around the stroke channel. Calculations of these voltage components have been made by Wagner⁽¹⁾, Szpor⁽²⁾, and Razevig and Rozenfeld⁽³⁾, and experimental measurements of the electrostatic components were made by Akopian⁽⁴⁾. In such calculations the channel is generally assumed to be of constant charge density (or constant axial gradient) in order to facilitate solution, and solutions are based on field equation calculations.

However, for complex geometries and charge conditions, the use of the field equations becomes difficult because of the diversity of boundary conditions. A more direct method is the use of models of the lightning process. This is demonstrated in this paper by the use of a geometrical model to determine the currents induced on a phase wire by a direct stroke to an overhead ground wire at mid-span. By this method the buildup of charges on the phase conductors and groundwire by an approaching pilot streamer can be demonstrated, as well as the shielding effects of other conductors or upward streamers from the groundwire. It also permits a study of the buildup of electric fields at the surface of the earth, the measurement of the charges concentrated at various regions of the stroke channel, and an evaluation of phase-conductor induced voltages.

In Fig. 1, a model cloud 12' x 12' was suspended six feet above a conducting ground plane. Since this is a 250:1 model, it represents a cloud 1500 feet above the earth. Greater cloud height could not be obtained because of space limitations, but as long as the cloud is at a considerable distance from the transmission line, it is only the gradients produced near the line that are important, not the actual cloud height.

RLM

INSULATOR RECOMMENDATIONS



LOCKE INSULATOR CORPORATION, BALTIMORE, MARYLAND

NOTES ON RADIO INTERFERENCE

Introductory Remarks:

All forms of radio communications are based on the establishment and propagation of electro-magnetic waves in space. These waves when properly controlled or modulated may be used to transmit signals, intelligence or entertainment in a large variety of ways. The most familiar form is found in the present day commercial broadcasting of entertainment and news. In order to avail himself of these facilities the listener must provide himself with a suitable antenna for intercepting the electro-magnetic waves propagated by radio broadcasting stations. These waves cutting across the conducting antenna, induce feeble alternating voltages in it with reference to ground potential. These voltages, by means of a suitable receiver, may be amplified, rectified and converted into audible sound or other intelligible signals, according to the purpose intended.

Since the antenna to some degree responds to all electro-magnetic waves which cut across it, the receiver must have a means of selecting the one desired, and must be of sufficient sensitivity to respond adequately to the signal to be received. Because of the relatively small magnitude of the voltages induced in practical antennas, the receiver must be an extremely sensitive device capable of responding to almost infinitesimal voltage changes in the antenna. Accordingly it will respond to all electro-magnetic disturbances which cut across the antenna and which have frequency components corresponding to that to which the receiver is tuned. It is for this reason that the radio frequency spectrum (range of frequencies useful for radio communication) is divided into channels by governmental control and international agreement. These channels are allocated with suitable power levels to broadcasting and other forms of communication to prevent what would otherwise be a chaotic condition which would render radio communication impossible or at least unreliable.

It is unfortunate, but nevertheless true that a large variety of unwanted electro-magnetic disturbances either occur in nature or are incidentally produced by many devices which have come to be necessities in the modern mode of living. These may interfere or mar the reception of the desired signals. Natural disturbances (usually referred to as atmospheric static) of which lightning is the most common variety, are caused principally by electrical discharges in the atmosphere. Lightning strokes produce and propagate electro-magnetic disturbances having frequency components throughout most of the useful radio spectrum. With the established system of broadcasting there is little that is now known that can be done to eliminate this source of interference except to improve transmitting and receiving equipment and attempt to improve the strength of the desired signal in relation to the unwanted one. Other types or systems of broadcasting, such as frequency modulation, now mainly confined to ultra high frequencies, practically eliminate natural static and much that is man made. General acceptance and change-over, if ever, to frequency modulation is still several years away on account of the tremendous investment we have in amplitude modulation broadcasting stations and receivers.

METHODS OF MEASURING RADIO NOISE 1940

A Report of the Joint Coordination Committee on
Radio Reception of E.E.I., NEMA and R.M.A.

SUMMARY

This report contains the recommendations of the Joint Coordination Committee on Radio Reception of E.E.I., NEMA and R.M.A., as to the nature, essential characteristics and performance of a meter for the measurement of radio noise. It further gives detailed descriptions of recommended practices in the use of the meter for measuring directly radio noise from low and high voltage apparatus, for making radio noise measurements along overhead lines, for determining broadcast field strengths, and for collecting data for the establishment of radio noise standards.

E.E.I. Publication No. G9
NEMA Publication No. 107
R.M.A. Engineering Bulletin No. 32
Published February, 1940

Price 20¢ to members and their employees
Price 50¢ to non-members in U.S.A.
Price 60¢ to foreign countries

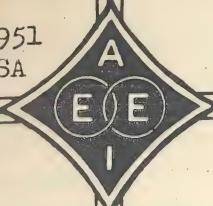
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RADIO MANUFACTURERS ASSOCIATION
1317 F Street, N. W., Washington, D. C.

December 1951
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RIV

INVESTIGATION OF RADIO NOISE AS IT PERTAINS TO THE DESIGN OF
HIGH-VOLTAGE TRANSMISSION LINES

H. L. Rorden
Member AIEE

R. S. Gens
Associate Member AIEE

Both of:
Bonneville Power Administration
Portland, Ore.

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21-25, 1952. Manuscript submitted October 18, 1951; made available for printing December 11, 1951.

PRICE: 30¢ To Members
60¢ To Nonmembers

January 1947



RADIO-NOISE INFLUENCE OF 230-KV LINES

H. L. Rorden

Member AIEE

Bonneville Power Administration,
U. S. Department of the Interior,
Portland, Oreg.

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RIV

INVESTIGATION OF RADIO NOISE
AS IT PERTAINS TO THE DESIGN
OF HIGH VOLTAGE TRANSMISSION LINES

H. L. Rorden

R. S. Gens

Bonneville Power Administration

October 1951

November 1950
Litho in USA



RADIO INFLUENCE TESTS IN FIELD AND LABORATORY —
500-KV TEST PROJECT OF THE AMERICAN GAS AND ELECTRIC COMPANY

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Wm. E. Pakala Member AIEE	Westinghouse Electric Corp. East Pittsburgh, Pa.
S. C. Bartlett Member AIEE	American Gas and Electric Service Corp. New York, N. Y.
C. D. Fahrnkopf Associate AIEE	Westinghouse Electric Corp. East Pittsburgh, Pa.

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DEPARTMENT OF TRANSPORT

**AIR SERVICES BRANCH
TELECOMMUNICATIONS DIVISION**



CANADA

ELECTRICAL INTERFERENCE TO TELEVISION

**Subjective tests to determine the degree of
annoyance caused by interference from automobiles
and electrical appliances to television viewers.**

OTTAWA, AUGUST 1st, 1952.

Baltimore, August 24, 1954.

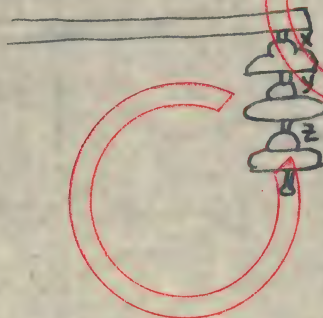
H. A. Frey: -

On August 17th I called on Mr. James A. McCutchen of the REA in Washington for the purpose of obtaining advice and information relative to radio and TV interference problems. Mr. McCutchen is recognized as an expert on this subject, and this call was aimed specifically toward setting up a possible program to make evaluation tests in the Locke laboratory.

In addition to a long discussion with Mr. McCutchen, in which he did most of the talking, we also adjourned to his new noise laboratory which is being fitted up near the REA offices and observed demonstrations and looked over samples of insulators that were known to be noisy in operation.

The following is a list of answers by Mr. McCutchen to questions asked:

- 1) Radio noise and TV noise are not compatible. It is possible that corroded hardware on a string of insulators, such as two No. 16583's in suspension, may give radio interference alone, or TV interference alone, or they may give interference to both radio and TV. A practical example is shown in the following sketch.



1. Corrosion at x and z may cause both Radio and T-V interference
2. Corrosion at y will cause T-V interference only

- 2) It takes from four to seven years to develop enough corrosion on galvanized hardware on a string of suspension insulators before noise will result. This is in a clean atmosphere in a rural locality.
- 3) Samples of No. 16583 suspensions which are known to be noisy appear to be hardly corroded at all except for tightly adhering black spots and blotches where hardware parts are in contact with one another. Examples of this are corrosion on the cotter bolt where it comes in contact with the clevis hole and on the eye bolt where it comes in contact with the cotter bolt. Also on the bearing surface of the clevis McCutchen thinks high frequency charging currents cause some sort of electro plating on adjacent hardware parts to make the black corroded spots.

Corona - RIV
H. Fung

Transactions Paper

(Reviewed and Accepted for Publication)



THE CALCULATION OF THE RADIO INTERFERENCE LEVEL OF TRANSMISSION LINES CAUSED BY CORONA DISCHARGES

G. E. Adams
Associate Member AIEE
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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted October 20, 1955; made available for printing December 20, 1955.

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Paper No.

56-222

Discussion in Duplicate Due February 15, 1956.

The Calculation of the Radio Interference Level of Transmission Lines Caused by Corona Discharges

G. E. ADAMS
ASSOCIATE MEMBER AIEE

Synopsis: The mechanism by which the principal wave, which travels along the line and interferes with radio reception, is generated is expressed in mathematical terms and related to the currents which flow during laboratory tests of samples of conductor. These tests are described in detail. The generating functions so determined are used to calculate the electric and magnetic intensities of the interference field near the line. The statistical properties, namely, the correlation function and the spectral density of the field intensities are employed to superimpose the effects of several line conductors. As an example, a comparison is given of the interference level of two lines equipped with the same conductor but one of horizontal and the other of vertical configuration.

AT THE present time, considerable interest in the radio interference level (RIL) of high-voltage transmission lines exists as evidenced by the numerous papers which have appeared recently on various phases of the subject such as test facilities and results, field experience, noise measurements, and announcements of future plans for study.

The purpose of this paper is to present a method of calculation of the RIL of an actual transmission line from the results of laboratory tests on conductor samples and knowledge of the geometry of the line. Such a method of calculation is useful for many purposes including:

1. Planning and interpreting the results of field tests.
2. Evaluating the effect of the various line design constants on RIL.

Paper 56-222, recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted October 20, 1955; made available for printing December 20, 1955.

G. E. ADAMS is with the General Electric Company, Schenectady, N. Y.

The analysis is an application of a more complete unpublished mathematical development by R. M. Lichtenstein, Rensselaer Polytechnical Institute Troy, N. Y. The author also wishes to acknowledge the many helpful suggestions and comments made by S. B. Crary and C. Concordia and the preparation of the calculating machine programs used in this study by Mrs. M. A. Fuller, all of the General Electric Company, Schenectady, N. Y.

3. Comparing different line configurations as to RIL.

4. Calculating the absolute RIL of a proposed line.

Many studies of radio interference have been made. However, these have consisted almost entirely of test programs, the results of which have usually been very difficult to interpret. Thus, an analysis such as is outlined here becomes a practical necessity.

The corona which is distributed along the line on the surface of the conductor has been considered to be the source of the radio interference. This conductor corona is influenced by many variables in addition to the line geometry such as conductor surface condition, precipitation, temperature, humidity, etc. Since the effect of these additional variables cannot be determined by analytical methods, the calculation procedure must be based upon the results of experiments or tests. These tests should be performed under laboratory conditions so that accurate control of the variables (particularly weather) can be obtained.

Nomenclature

E=electric intensity, volts per meter
H=magnetic intensity, ampere-turns per meter
J=current density, amperes per square meter
 $\nabla^2 = \partial^2/(\partial x^2) + \partial^2/(\partial y^2) + \partial^2/(\partial z^2)$ Laplacian operator
 $\phi^{(n)}$ =scalar potential function, volts
 x, y, z =rectangular co-ordinates, meters
 h =conductor height above ground, meters
 R =conductor radius, meters
 $\nabla = i \partial/\partial x + j \partial/\partial y + k \partial/\partial z$, nabla operator
 t =time in seconds
 $c = 3 \times 10^8$ meters per second = velocity of light in free space
 i, j, k =unit vectors in x, y , and z directions respectively
 $\text{grad } \phi = i \partial\phi/\partial x + j \partial\phi/\partial y + k \partial\phi/\partial z$ =gradient, volts per meter
 $\mu_0 = 4\pi \times 10^{-7}$ =permeability of free space, henrys per meter
 $\epsilon_0 = 1/(36\pi) \times 10^{-9}$ =permittivity of free space, farads per meter
 M =number of sections into which line is divided
 l =length of one section of line in meters
 $R(\tau)$ =correlation function

SD =spectral density
 i_t =current which flows in external circuit when sample of conductor is placed in test cage, amperes
 U_0 =field factor
 k =test cage current spectral density factor
 ψ =scalar potential of charge cloud in test cage, volts
 ρ =charge density, coulombs per cubic meter
 b =test cage radius in meters
 $\langle \rangle$ =mean (with respect to time) value of

Corona Discharges

A strong electric field exists in the region adjacent to the transmission-line conductor during normal operation. This electric field varies periodically with time in the same manner as the applied voltage. Since the frequency of the applied voltage is relatively low, the distribution of the electric field can be calculated by the methods employed when studying electrostatic fields.

The characteristic of the electric field of primary interest is the spatial distribution of electric intensity near the conductor. The electric intensity is a vector quantity having both magnitude and direction. The magnitude will be called the "voltage gradient" and the direction is along a flux line drawn through the point in question.

If the voltage gradient is plotted as a function of distance along a particular flux line, it is found that the gradient attains its maximum value at the conductor surface. Moreover, the surface gradient depends upon the geometry of the conductor surface near the point in question and, in fact, is greatly intensified by the presence of sharp projections or irregularities on the surface.¹

If a free electron is present near the conductor, it will be accelerated by the electric field and move either toward or away from the conductor, depending upon the direction of the field near the conductor. If the gradient along the path taken by the electron is great enough, the electron will ionize an air molecule by collision, thereby creating both a positive ion and another free electron. A separation of charge results since the electron is accelerated in a direction opposite to that of the positive ion by the electric field. Both free electrons can be accelerated further and create additional electrons by collision. In this manner, an electron avalanche is formed.

This movement of charge, both positive and negative, constitutes an electric current. This electric current flows in the space near the conductor and can be characterized by the current density² $J(x, y, z, t)$. If the axis of the conductor is taken to be along the z axis of the co-ordinate system employed, the x and y

Transactions Paper

(Reviewed and Accepted for Publication)



AN ANALYSIS OF THE RADIO INTERFERENCE CHARACTERISTICS OF BUNDLED CONDUCTORS

G. E. Adams
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56-994

Discussion in Duplicate Due October 17, 1956.

GENERAL ELECTRIC

Insulator Department

SUBJECT

Summary of Television
Interference Investigation
File #5702
File #2900

COPIES:

Paul Schratter
AL Starr - Kansas City
CB Vaughn
BE Kingsbury
J. Kaminski.

Baltimore, June 13, 1956.

J. W. Taulman (3)
Dallas.

In response to your request, I am writing a summary of our television interference investigation conducted in the High Voltage Laboratory.

During 1955 we received a few reports from the field that in isolated cases it was believed that suspension insulators were the source of television interference. The Engineering Section requested that our field representatives obtain a string of suspension insulators which had been established as the probable source of television interference.

In the meantime, the High Voltage Laboratory initiated a project to develop a technique for creating, recording, and measuring television interference. This course of action was necessary since television interference, unlike radio interference, is relatively new, no standards of measurement have been developed, no levels established nor have the techniques of recording television interference been standardized.

Our engineers recognized that it was theoretically possible for suspension insulators to generate television interference. It was thought that the principal source of such interference would be in the connecting elements between units, which, in the case of ball and socket type insulators, would be between the ball of one unit and the socket of the next lower unit. This condition could exist when a film of corrosion would form between mating surfaces serving as insulation between them. When this film was sufficiently stressed electrically, and when the constants of the associated circuits were of the proper magnitude, breakdown would occur and act as a small transmitter in the very high frequency band. It was not expected that this condition could exist when there was any appreciable load on the insulators which would provide a reasonable pressure contact.

The technique of developing television interference on suspension insulators basically was accomplished by inserting a thin sheet of paper between the ball and socket connections of two insulators. Stressing the insulators electrically sufficient to cause breakdown of the paper, showed a very definite interference pattern on the television screen. This pattern is essentially the same as electrical breakdowns similar in nature which have been recorded, and publicized in the past. These would include interference of the type produced by the spark plugs of an automobile.

On the picture screen, interference consists of numerous short-black lines chasing across the screen, of narrow band width which would slowly move vertically on the television screen. As the intensity of breakdown ^{was in-}creased by raising the voltage, the number of pulses in the stream ^{increased.} It was observed that the first interference recognized on the television screen consisted of a single narrow band of black pulses caused by the breakdown of the negative half cycle of 60 cycle voltage. As the voltage was

Transactions Paper

(Reviewed and Accepted for Publication)



INVESTIGATION OF RADIO NOISE FROM EXISTING LINES AND EQUIPMENT TO AID IN THE DESIGN OF FUTURE EXTRA-HIGH VOLTAGE LINES

F. L. Taylor
Associate Member AIEE

C. J. Crockford
Nonmember AIEE

R. V. Nicolson
Associate Member AIEE

All of:
The Detroit Edison Company
Detroit, Mich.

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Detroit, Mich.

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Paper No.

57-164

Discussion in Duplicate Due February 6, 1957.

Mr Kaminski
W. E. Pakala

Conference Paper



RADIO INFLUENCE EFFECTS OF SURFACE TREATMENTS ON SMALL CONDUCTORS

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Submitted in outline or abstract form only to the AIEE Committee on Transmission and Distribution for the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Manuscript submitted April 8, 1957; made available for printing May 15, 1957.

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Paper No. **CP**

57-802

R10

Transactions Paper

(Reviewed and Accepted for Publication)



THE RADIO INFLUENCE CHARACTERISTICS OF BUNDLE AND SINGLE CONDUCTORS (TIDD PROJECT)

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Manuscript submitted March 27, 1957; made available for printing May 15, 1957.

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Paper No.

57-804

Discussion in Duplicate Due July 10, 1957.

GENERAL ELECTRIC
INSULATOR DEPARTMENT

Baltimore - December 12, 1957

SUBJECT

COPIES: D.R. Samson
F.C. Vose

Mr. R. O. Lanoue
PITTSBURGH

Ralph, please accept my deepest apologies regarding the long delay in providing you with some dope on the television interference (TVI) problem. I can take credit for two months of the delay, anyway, as your letter became mislaid upon reaching my desk.

Ralph, what I plan to do is give you a brief run-down of what I know on the subject in general and relate some of the very meager test findings which we have, and also lend to you several booklets which, themselves, may throw more light on the subject.

Our initial contact with the problem was in 1955, regarding 69 KV circuits employing suspension units in the Florida Light and Power System. Their problem seemed to be quite severe, periodically. That is, after a damp, foggy day followed by a day or so of very hot, and relatively dry weather, TVI would become a problem in certain areas. Mr. H. A. Frey discussed the general problem with them and they agreed to send us a string of insulators believed to be the cause in order that we might perform laboratory investigations.

In the meantime, Mr. L. J. Stevens and myself went to see a quite qualified expert in the techniques of measuring and deciphering the TVI field (Mr. James McCutcheon, REA). He filled us in on some of his work and field analysis of the problem and gave us a start in the right direction, so that we might better cope with the above mentioned insulators upon their receipt.

It was at his suggestion that we obtained a standard television set of relatively low quality (one containing no filters other than those required in receiver's line cord and related circuits), so that any possible outside disturbances would be discernible on the screen of the set. This TV set is set up in the standard manner to watch any program - an antenna was mounted on the roof with leads brought into the set. In addition a testprobe antenna (several different sizes according to frequency range desired) was added to the receiving circuit and placed in parallel with the outside antenna. Thus we have a "measuring" system in which we can at least obtain qualitative data which is of some value for comparison purposes. Our set-up is as shown on the attached photograph. In the foreground is the TV receiver and in the background is the insulator string under test, and to its left is the test-probe antenna (which is merely a loop of wire). In order to obtain more realistic conditions of operation, an alternator was placed in the main antenna circuit, so that, in effect, we could cut down the incoming signal and simulate a quite distant TV station.

To digress a bit, let's examine some of the mechanisms which must be available to provide TVI. To date, I have seen no literature which indicates in any way that corona, as such, can cause TVI. Therefore, that leaves only the spark, which

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>L. Jandran</i> LF Jandran		SUBJECT CLASSIFICATION 1. Radio Influence 2. Corona		NO. 58PT158	
				DATE 7/14/58	
TITLE CORONA AND RADIO NOISE STUDIES OF BUNDLE CONDUCTORS WITH METALLIC POINT PROTRUSIONS					
ABSTRACT Four different diameter smooth aluminum conductors were tested in 1, 2, 3, and 4 bundle configurations to obtain radio noise, field strength, corona starting voltage and conductor surface gradient data.					
G.E. CLASS IV		REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS		NO. PAGES	
GOV. CLASS NONE				43	
CONCLUSION 1. The corona starting voltages for the four conductors tested increased with increasing conductor diameter, but the generated RIV became less with an increase in conductor diameter. 2.. Conductor-surface gradient (KVP/cm) at corona start is greater for the smaller diameter conductors and became less as the diameter of the conductor increased. 3. In changing from 1-4 bundle configuration, for a given conductor, the corona starting voltages are increased, the RN is decreased and the conductor-surface gradient (KVP/cm) stays fairly constant. 4. With an increase in conductor diameter the conduct-surface gradient (KVP/cm), at corona start, became less for all four conductor configuration tested.					

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For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR Electrical Performed Systems Research

TESTS MADE BY L. Jandran, JE McDonough Tests Completed: 5/5/58

HV Development Electrical Research

COUNTERSIGNED TW Liao SECTION Systems Research
Electrical Performance

BUILDING and ROOM No. 9-102 LOCATION Pittsfield, Mass.

-mjb

Transactions Paper

(Reviewed and Accepted for Publication)



DEVELOPMENT OF A SQUARE LAW RADIO NOISE METER - I

F. J. Trebby

Member AIEE

Kaiser Aluminum & Chemical Corp
Spokane, Wash.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1959. Manuscript submitted October 31, 1958; made available for printing December 4, 1958.

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Paper No.

59-79

Discussion in Duplicate Due February 20, 1959.

Transactions Paper

(Reviewed and Accepted for Publication)



A CORRELATION OF THE PRESENT WITH A PROPOSED STANDARD METHOD FOR RIV MEASUREMENTS ON HIGH VOLTAGE DEVICES

Charles J. Miller, Jr.
Fellow AIEE
The Ohio Brass Company
Barberton, Ohio

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1959. Manuscript submitted November 3, 1958; made available for printing December 2, 1958.

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Paper No.

59-80

Discussion in Duplicate Due February 20, 1959.



TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>JL Wiesztort</i> JL Wiesztort		SUBJECT CLASSIFICATION 1. Insulators, Suspension 2. Radio Interference 3. Noise, Radio		NO. 59PT137
				DATE 7/9/59
TITLE RADIO NOISE TESTS ON STANDARD AND PLASTIC ROD SUSPENSION INSULATOR STRINGS				
ABSTRACT Reported are results of dry tests on 22 and 30 unit porcelain insulator strings and also on comparative lengths of new type plastic rod insulators. Incidental data on 34 and 45 standard unit strings are also included.				
G.E. CLASS IV M		REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS		NO. PAGES
GOV. CLASS None		Pittsfield, Works		10
CONCLUSION Listed below are radio noise results on the various configurations for 460 kv line-to-line (265 kv line-to-ground) and 650 kv line-to-line (375 kv line-to-ground)				
Type Units		Radio Noise (μ volts)		
		265 kv applied	375 kv applied	
22 - 15,000 lb.		200	580	
22 - 36,000 lb.		140	500	
30 - 15,000 lb.		150	340	
30 - 36,000 lb.		75	250	
4 - plastic rod		65	7500	
5 - plastic rod		65	80-3500	
6 - plastic rod		90	105	

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR EHV / J. J. LaForest

TESTS MADE BY JL Wiesztort, J. Stevens Tests Completed: 4/24/59

COUNTERSIGNED HE Fiegel *X/ E Fiegel* SECTION High Voltage Laboratory

BUILDING and ROOM No. 9-102 LOCATION Pittsfield, Mass.

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SEP 21 1959

ENCL. DWT

Corona

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
L.W. Graham	1. Line Traps	59PT141
<i>L.W. Graham</i>	2. Insulators, Switch and Bus	DATE
	3. Noise, Radio	8-26-59
TITLE RADIO NOISE AND VISUAL CORONA START TESTS ON A SIMULATED CARRIER FREQUENCY LINE TRAP AND SUPPORTING INSULATORS WITH CORONA SHIELD RINGS.		

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GENERAL  ELECTRIC

TRANSFORMER DIVISION

R1V

UHL, HALL & RICH
230 CONGRESS STREET
BOSTON 10, MASSACHUSETTS

ENGINEERS FOR:

POWER AUTHORITY OF
THE STATE OF NEW YORK

October 13, 1959

100-9

SUBJECT: Conference Notes 100-9-C6
Niagara-Adirondack Tie Line

Mr. C. F. Davis
Power Authority of the State of New York
The Coliseum Tower
10 Columbus Circle
New York 19, New York

Dear Mr. Davis:

We are transmitting herewith for your information three (3) copies of Conference Notes 100-9-C6 on High Voltage Tests at General Electric Company Laboratory and three (3) copies of General Electric Company's report on these tests.

By copy of this letter we are sending a copy of the conference notes to all persons present at the meeting.

Very truly yours,

UHL, HALL & RICH

By

R. E. Moran

REM:gi
Enclosures

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Transactions Paper

(Reviewed and Accepted for Publication)



THE EFFECT OF RAIN ON R.I.V. CHARACTERISTICS OF HIGH VOLTAGE SUSPENSION ASSEMBLIES

J. Kaminski
Member AIEE

B. E. Kingsbury
Associate Member AIEE

F. C. Vose
Member AIEE

All of:
General Electric Company
Baltimore, Md.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1959. Manuscript submitted November 3, 1958; made available for printing December 3, 1958.

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59-94

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GENERAL ELECTRIC COMPANY
Baltimore, Maryland

Technical Report No. LK-663-DR
May 9, 1960

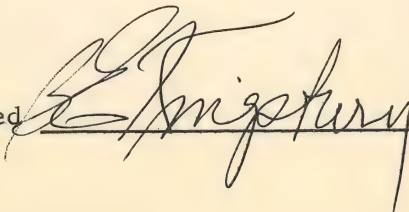
SUBJECT

VISUAL CORONA AND R.I.V. TESTS
ON BUNDLED CONDUCTOR ASSEMBLIES

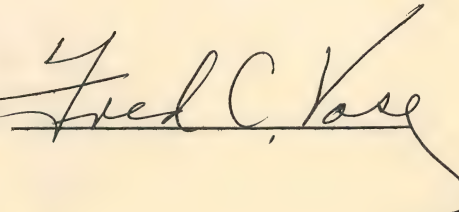
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E. Snigskurny

Approved


Fred C. Vase

RIV

GENERAL ELECTRIC COMPANY

INSULATOR DEPARTMENT

Technical Report No. LK-665-DR

May 23, 1960

SUBJECT

Visual Corona and RIV Tests
On Bundled Conductor Assemblies

Joseph Kaminski, Jr.

This report contains:

3 typewritten pages
2 curves
1 test result

Baltimore Maryland

Signed

Joseph Kaminski Jr

Approved

Fred C. Vore

R1V

OB Test Data

U.H.R.

N.Y. Power Auth.

345 KV line

GENERAL  ELECTRIC



RADIO AND CORONA TESTS
ON
HORIZONTAL 2-CONDUCTOR BUNDLES OF
795,000-CM ACSR "DRAKE" CONDUCTORS
AND ACCESSORIES
FOR
THE POWER AUTHORITY OF THE STATE OF NEW YORK

June 8, 1960
Barberton, Ohio

Charles J. Miller, Jr.
Research Engineer

Transactions Paper

(Reviewed and Accepted for Publication)



DECOUPLING OF TRANSMISSION LINES TO RADIO INFLUENCE VOLTAGES

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Fellow AIEE
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H. A. REY

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For file Bek

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
L.F. Jandran	Switchgear Insulators, Switch & Bus	60PT156
		DATE
		Sept. 14, 1960
TITLE		
Impulse, Sixty-Cycle and Radio Noise Tests on a 650 KV Disconnect Switch		

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GENERAL  ELECTRIC

TRANSFORMER DIVISION

CONFERENCE PAPER
A.I.E.E.

Penelec 460 KV Prototype Line

PREPARATORY RADIO INFLUENCE STUDY

R. J. Bacha - Pennsylvania Electric Company
Johnstown, Pennsylvania
Associate Member, AIEE

W. C. Guyker - West Penn Power Company
Greensburg, Pennsylvania
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E. S. Kocsan - Pennsylvania Electric Company
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October 1960

CONFERENCE PAPER
A.I.E.E.

Penelec 460 KV Prototype Line

PREPARATORY RADIO INFLUENCE STUDY

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Johnstown, Pennsylvania
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W. C. Guyker - West Penn Power Company
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E. S. Kocsan - Pennsylvania Electric Company
Johnstown, Pennsylvania
Associate Member, AIEE

RIV

PREDICTION OF RADIO NOISE LEVELS BY DIGITAL TECHNIQUES

By

A. K. Abboushi
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Project EHV
General Electric Company
Pittsfield, Massachusetts

L. O. Barthold
Member, AIEE
Electric Utility Analytical Engineering
General Electric Company
Schenectady, New York

(To be presented at A.I.E.E. Second PICA Conference to be held in St. Louis, Missouri, November 9, 10, and 11, 1960).

District Conference Paper



ANALYSIS OF MEASURING CIRCUITS FOR RADIO INFLUENCE VOLTAGES

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P. B. Jacob, Jr.
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H. A. FREY

RIV

Transactions Paper

(Reviewed and Accepted for Publication)



DIGITAL CALCULATION OF RADIO NOISE LEVELS

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Associate Member AIEE
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A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Ithaca, N. Y., June 18-23, 1961. Manuscript submitted March 16, 1961; made available for printing April 24, 1961.

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Transactions Paper

(Reviewed and Accepted for Publication)



RADIO INFLUENCE TESTING ON 70 MILES OF 345 KV HORIZONTAL BUNDLE CONDUCTOR

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C. R. Bond
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A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Detroit, Mich., October 15-20, 1961. Manuscript submitted June 15, 1961; made available for printing August 9, 1961.

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Paper No.

61-1027

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Conference Paper



SELECTION OF SINGLE AND BUNDLE CONDUCTORS AND ACCESSORIES FOR ACCEPTABLE RADIO NOISE PERFORMANCE

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J. Kaminski
Member AIEE
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Aluminum Co. of America
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Submitted in abstract or outline form only to the AIEE Transmission and Distribution Committee for presentation at the AIEE Fall General Meeting, Detroit, Mich., October 15-20, 1961. Manuscript submitted August 11, 1961; made available for printing August 17, 1961.

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61-1099

Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due July 5, 1963.



A SUMMARY OF RADIO INTERFERENCE STUDIES APPLIED TO EHV LINES

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J. R. Leslie
Senior Member IEEE

Both of:
The Hydro-Electric Power Commission
of Ontario
Toronto, Ont., Canada

A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-27, 1963. Manuscript submitted March 18, 1963; made available for printing April 17, 1963.

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Paper No.

63-1024

Transactions Paper

(Reviewed and Accepted for Publication)



*Modes
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H. A. Erey*

RADIO NOISE FROM HIGH-VOLTAGE TRANSMISSION LINES

AIEE Radio Noise Subcommittee
of the
AIEE Transmission and Distribution Committee

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DEC 28 1961

H. A. EREY

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., January 28-February 2, 1962. Manuscript submitted October 18, 1961; made available for printing December 6, 1961.

Members of the AIEE Radio Noise Subcommittee: H. L. Rorden, Chairman; L. O. Barthold, P. L. Bellaschi, H. H. Brustle, F. C. Creed, F. R. Dallye, H. M. Ellis, C. D. Fiero, H. A. Gauper, E. H. Gehrig, R. E. Graham, F. L. Greene, N. S. Kent, J. J. LaForest, J. R. Leslie, T. W. Liao, R. J. Mather, C. J. Miller, A. C. Neaderland, W. E. Pakala, B. M. Pickens, M. G. Poland, L. M. Robertson, R. H. Schlomann, L. N. Stone, E. R. Taylor, F. L. Taylor, F. J. Trebby, P. D. Tuttle, F. C. Vose, F. A. Denbrock, H. M. Mather.

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Transactions Paper

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AN INVESTIGATION OF RADIO INFLUENCE VOLTAGES ON TRANSMISSION AND DISTRIBUTION LINES ON THE SAME RIGHT-OF-WAY

F. L. Taylor
Member AIEE
The Detroit Edison Co.
Detroit, Mich.

J. F. Bouska
Associate Member AIEE
Commonwealth Edison Co.
Chicago, Ill.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 7-12, 1962. Manuscript submitted June 8, 1962; made available for printing August 7, 1962.

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Paper No.

62-1367

Discussion in Duplicate Due October 26, 1962.

Conference Paper



345 KV WOOD POLE TEST LINE -

RADIO INFLUENCE AND LEAKAGE CURRENT INVESTIGATIONS

T. W. Schroeder
Fellow IEEE
Illinois Power Company
Decatur, Ill.

G. L. England
Member IEEE
Illinois Power Company
Decatur, Ill.

J. E. O'Neil
Senior Member IEEE
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Westinghouse Electric Corp.
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Paper No. **CP**

63-1021

Transactions Paper

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Discussion in Duplicate Due July 5, 1963.



ANALYSIS OF RADIO NOISE FROM HIGH-VOLTAGE LINES

PART I. METER RESPONSE TO CORONA PULSES

O. Nigol

Member IEEE

The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 18, 1963; made available for printing April 23, 1963.

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63-1022

Transactions Paper

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Discussion in Duplicate Due July 5, 1963.



ANALYSIS OF RADIO NOISE FROM HIGH VOLTAGE LINES

PART II. PROPAGATION THEORY

O. Nigol

Member IEEE

The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 18, 1963; made available for printing April 17, 1963.

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Paper No.

63-1023

Conference Paper



APPORTIONMENT OF OBSERVED BROADBAND NOISE AMONG POWER SYSTEMS

W. R. Foley
Member AIEE

R. E. Frese
Member AIEE

Both of:
U. S. Army Electronic Proving Ground
Fort Huachuca, Arizona

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SEP 4 1962

H. A. FREY

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Paper No. **CP**

62-1350

Conference Paper



APPORTIONMENT OF OBSERVED BROADBAND NOISE AMONG POWER SYSTEMS

W. R. Foley
Member AIEE

R. E. Frese
Member AIEE

Both of:
U. S. Army Electronic Proving Ground
Fort Huachuca, Arizona

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 7-12, 1962. Manuscript submitted June 15, 1962; made available for printing August 3, 1962.

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Paper No. **CP**

62-1350

**Forged Aluminum
Electrical Hardware**

... Excellent Corrosion Resistance
... Longer Effective Life

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Stress corrosion of aluminum alloys



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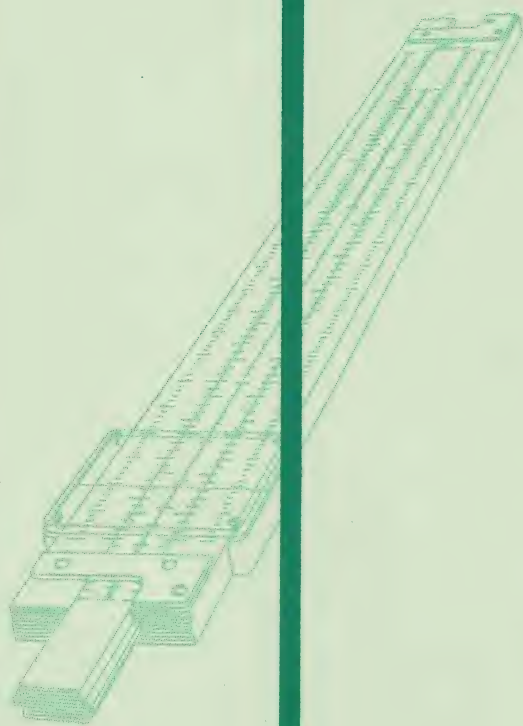
ARMOR PLATE ■ CRYOGENICS ■ MISSILE SKINS ■ STRUCTURAL

Aluminum Line Hardware Resists Salt-Air Corrosion

M. K. DEAN, Electrical Engineer, Hawaiian Electric Co, Honolulu, H. I.

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ALCOA GREEN LETTER

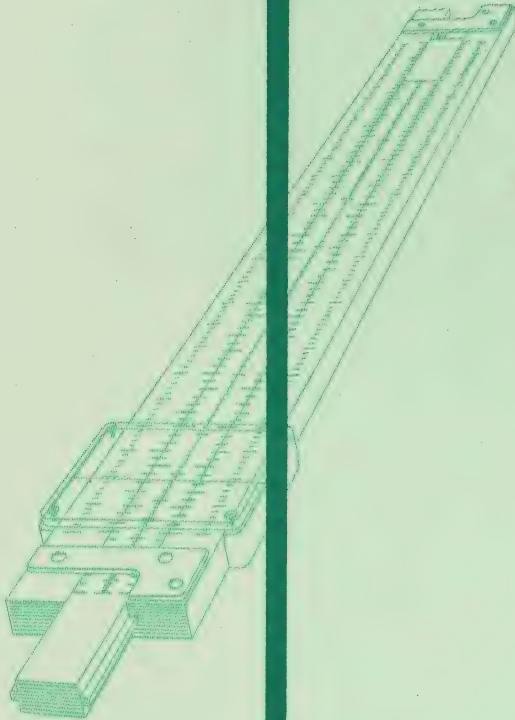


DEVELOPMENT OF HIGH STRESS-CORROSION RESISTANCE IN 7XXX SERIES ALUMINUM ALLOYS



TECHNICAL INFORMATION FROM
ALUMINUM COMPANY OF AMERICA
APPLICATION ENGINEERING DIVISION

ALCOA GREEN LETTER



AVOIDING STRESS-CORROSION CRACKING IN HIGH STRENGTH ALUMINUM ALLOY STRUCTURES



TECHNICAL INFORMATION FROM
ALUMINUM COMPANY OF AMERICA
APPLICATION ENGINEERING DIVISION

A L C O A R E S E A R C H L A B O R A T O R I E S

Technical Paper No. 17

RESISTANCE OF WROUGHT
HIGH-STRENGTH ALUMINUM ALLOYS
TO STRESS CORROSION

BY D. O. SPROWLS

Research Engineer—Alcoa Research Laboratories

Chemical Metallurgy Division

AND

R. H. BROWN

Assistant Director of Research—Alcoa Research Laboratories



ALUMINUM COMPANY OF AMERICA

PITTSBURGH, PENNSYLVANIA

1962

alum.

NEW METHOD OF SPLICING ACSR & ALLOY CONDUCTORS

Adolph C. Neaderland
Supervisor - Project Engineering Section
U-I Division
Burndy Corporation

Paper To Be Presented At
The Pennsylvania Electric Association Meeting,
Pocono Manor, May 2, 1958

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR EJ Mets <i>EW</i> NW Roberts <i>NR</i>	SUBJECT CLASSIFICATION Fatigue of Metals	NO. 57TP469 DATE 7-10-57
TITLE Fatigue Characteristics of Aluminized and Galvanized Plain Forged Steel		

FOR USE OF G-E EMPLOYEES ONLY

GENERAL  ELECTRIC

TRANSFORMER AND ALLIED PRODUCTS DIVISION

**Aluminum, Aluminized Steel
And Galvanized Steel
In Severe Coastal Environments**

By
THOMAS A. LOWE
Research Engineer

Reprinted From CORROSION, Vol. 17, No. 4, PP. 177t-180t, (1961) April

KAISER ALUMINUM AND CHEMICAL CORPORATION
Department of Metallurgical Research

M. Kingsbury

**NEW ALUMINUM PERMANENT MOLD CASTING
ALLOYS C355 AND A356**

By

R. C. Lemon and H. Y. Hunsicker

This paper has been presented at the
60th Annual Meeting of the American
Foundrymen's Society, May 7, 1956,
in Atlantic City, New Jersey.

Distributed by

ALUMINUM COMPANY OF AMERICA

d. R. Hanson

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

CONFERENCE PAPER #56-335

New York, New York
January 30, 1956

THE USE OF ALUMINUM ALLOY AND HIGH STRENGTH - LOW ALLOY STEEL
FOR POLE LINE HARDWARE

John L. Eberly
Hubbard and Company
Pittsburgh, Pennsylvania

THE USE OF ALUMINUM ALLOY AND HIGH STRENGTH LOW ALLOY STEEL FOR POLE LINE HARDWARE

John L. Eberly

INTRODUCTION

In recent years there have been vast improvements in the chemical treatments applied to wooden utility poles and cross arms and, as a result, there has been a substantial increase in the service life of these poles and arms. Consequently it has been necessary to supplement the ordinary galvanized steel pole line hardware with materials which are more resistant to corrosion. Depending upon the severity of the corrosion problem as well as the longevity required for the hardware, it has been found that this problem can be solved by using both aluminum alloy and high strength - low alloy steel as a material. Both of these materials are being used successfully and this paper will discuss both solutions to the problem in two separate parts.

PART I - ALUMINUM ALLOY POLE LINE HARDWARE

REASONS FOR SELECTION OF ALUMINUM ALLOYS

The need for aluminum alloy hardware has been prompted particularly in areas where there is a severe atmospheric corrosion situation which has caused galvanized hardware to fail prematurely. These areas can be placed in three categories; namely, heavy industrial, seacoast, and chemically contaminated. Aluminum alloys also will perform well in locations where erosion is the problem. This situation is normally encountered along seacoast areas where the wind blows sand and particles continuously to the point where any protective material is completely removed on the windward side. There are also many areas inland, especially in some of the plains states, where winds sweeping over unobstructed prairies cause this same situation. There are also locations where maintenance is extremely costly due to the inaccessibility of the hardware.

REASONS FOR ALUMINUM ALLOYS RESISTANCE TO ATMOSPHERIC CORROSION

The superior resistance of aluminum alloys to atmospheric corrosion is due primarily to an inherent characteristic of aluminum; namely, the fact that aluminum has a natural affinity for oxygen. When aluminum is exposed to the atmosphere, a coating of aluminum oxide begins to form on the surface and normally the coating will attain a depth of approximately 50 angstrom units or one fifth of a

Note: Figures in parentheses indicate number of reference which will be found at end of paper.

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
EJ Mets <i>E. J. Mets</i>	Aluminum & Its Alloys	55TP419
TITLE		DATE
Effect of Curing of Concrete on EC Al Strands in Concrete Reactors		3-24-55

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR EJ Mets <i>E. J. Mets</i>		SUBJECT CLASSIFICATION Aluminum & Its Alloys	NO. 55TP419
TITLE Effect of Curing of Concrete on EC Al Strands in Concrete Reactors		DATE 3-24-55	
ABSTRACT Bare EC Al strands cast in concrete were exposed to accelerated curing cycles in an autoclave with similar set of aluminum strands not cast in concrete. Samples representing 1 to 10 cycles were examined for changes in mechanical properties and microstructure.			
G.E. CLASS 3	REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS		NO. PAGES
GOV. CLASS None	PW Data Bureau		15
CONCLUSION After 10 cycles, there was a loss of 35% in T.S. and 33% in Y.S. Approximately one-third of this loss is attributed to the effect of concrete and two-thirds due to the temperature of the autoclave. Percent elongation does not increase after the fourth or fifth cycle with the corresponding decrease in T.S. and Y.S. Loss in mechanical properties by affects of concrete occurs during the first curing cycle, and is due to reduction in area and pitting attack of the aluminum strands.			

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR Concrete Reactor Engineering

TESTS MADE BY EJ Mets, JF Bacon, WP Tootill, Miss MA McGregor

COUNTERSIGNED W. Morrill *W. Morrill* SECTION Metallurgical Development
Materials & Processes Laboratory
 BUILDING and ROOM No. 7 - 260 LOCATION Transformer Division, Pittsfield
General Metallurgy Subsection

USE OF ALUMINUM ALLOYS IN ELECTRICAL TRANSMISSION STRUCTURES

By

Joseph E. Williams and George H. Phillips
Aluminum Company of America

A conference paper to be
presented at the Winter
General Meeting of the
American Institute of
Electrical Engineers, New
York, New York, January
18-22, 1954.

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Metallurgy Bulletin

Vol. 6, No. 1

Internal Information, for use of G-E Employees Only

January, 1953

CORROSION OF ALUMINUM

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g 36-37	ALUMINUM - GENERAL CORROSION BEHAVIOR			
01 6, No. 1	ALUMINUM - GALVANIC CORROSION			
conference paper	CORROSION OF ALUMINUM	M. J. Bolton A. G. Jarvie	The Aluminum Assoc	1/1953
5TP419	USE OF ALUMINUM ALLOYS IN ELECTRICAL TRANSMISSION STRUCTURES	J. E. Williams G. H. Phillips	General Electric Schenectady, NY	1/18/54
56-335	EFFECT OF CURING OF CONCRETE ON EC AL STRANDS IN CONCRETE REACTORS	E. J. Mets	ALCOA	3/24/55
conference paper	THE USE OF ALUMINUM ALLOY AND HIGH STRENGTH-LOW ALLOY STEEL FOR POLE LINE HARDWARE	J. L. Eberly	General Electric Pittsfield, MA	1/30/56
reprint	NEW ALUMINUM PERMANENT MOLD CASTING ALLOYS C355 AND A356	R. C. Lemon H. Y. Hunsicker	Hubbard & Co. Pittsburgh, PA	5/7/56
71P469	ALUMINUM, ALUMINIZED STEEL & GALVANIZED STEEL IN SEVERE COASTAL ENVIRONMENTS	T. A. Lowe	ALCOA	1961
conference paper	FATIGUE CHARACTERISTICS OF ALUMINIZED AND GALVANIZED PLAIN FORGED STEEL	E. J. Mets N. W. Roberts	Kaiser Alum Spokane, Wash	7/10/57
each Paper 17	NEW METHOD OF SPLICING ACSR & ALLOY CONDUCTORS	A. C. Neaderland	General Electric Pittsfield, MA	5/02/58
Alcoa Green Letter	RESISTANCE OF WROUGHT HIGH-STRENGTH ALUMINUM ALLOYS TO STRESS CORROSION	D. O. Sprowls R. H. Brown	U-I Divn Burndy Corp.	1962
Alcoa Green Letter	AVOIDING STRESS-CORROSION CRACKING IN HIGH STRENGTH ALUMINUM ALLOY STRUCTURES	E. H. Spuhler C. L. Burton	ALCOA Pittsburgh, PA	8/1/62
	DEVELOPMENT OF HIGH STRESS-CORROSION RESISTANCE IN 7XXX SERIES ALUMINUM ALLOYS	P. L. Mehr E. H. Spuhler	ALCOA Pittsburgh, PA	7/15/63

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New York, N. Y. 10017

TECHNICAL INFORMATION SERIES

AUTHOR M. J. Bolton <i>M. J. Bolton</i>	SUBJECT CLASSIFICATION <u>Corrosion</u>	NO. 49TP160
TITLE "Atmospheric Corrosion Test Project Progress Report"		DATE June 12, 1950
ABSTRACT The results of two years exposure of metals and metal finishes are presented for test locations at Pitts-		

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TRANSFORMER & ALLIED PRODUCT DIVISIONS



APPARATUS DEPT.

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR M. J. Bolton <i>M. J. Bolton</i>	SUBJECT CLASSIFICATION Corrosion	NO. 49TP160
		DATE June 12, 1950
TITLE "Atmospheric Corrosion Test Project Progress Report"		
ABSTRACT The results of two years exposure of metals and metal finishes are presented for test locations at Pittsfield, Cape Cod, and Lynn, Mass. and Pittsburgh, Pa. Indications of the relative corrosion resistance of many materials and finishes are presented. The results on a new series of zinc base alloys are included. Completion of tests on Copper bearing steel have evaluated its corrosion properties as compared to low carbon steel.		
G.E. CLASS 3	REPRODUCIBLE COPY FILED TECHNICAL SERVICE DIV. PITTSFIELD	NO. PAGES 26
GOV. CLASS None	PW Data Bureau	
CONCLUSIONS 1. Unprotected copper bearing steel has a lower corrosion rate than a similar steel without the copper addition. 2. Chemical treatments on aluminum have shown that after two years exposure, the Alodine(hot dry) process is equivalent to chromic or sulfuric acid anodizing. 3. Speculum electroplates on copper or brass base have good corrosion resistant properties. On steel it does not show up so well. 4. The same thickness of tin on a steel base deposited either from a fluoborate bath or a stannate both shows a different corrosion rate. 5. The many proprietary processes for putting a chemical film on zinc electroplate(Cronak, Ebonal Z, Iridite, etc.) have proved of doubtful value. 6. Indium diffused into various metal electroplates on a steel base accelerates the corrosion rate rather than lowers it. 7. Zinc alloys (Zn-Cu-Be) have not exposed long enough to evaluate them properly.		

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR General Engineering Information

TESTS MADE BY Michael J. Bolton, A. L. Jenny, D. Shutts, J. Nesbit, A. DiNicola

COUNTERSIGNED Weston Morrill *W.M.* DIV Metals Section - Laboratory

TRANSFORMER & ALLIED PRODUCT DIVISIONS

PITTSFIELD

A. I. E. E. 1956 WINTER MEETING
PAPER NO. 56-230

CORROSION AS IT AFFECTS INSULATOR AND CONDUCTOR HARDWARE

BY A. W. BARDEEN AND J. M. SHEADEL

DISCUSSION BY H. J. SANDWICK (THE BREWER-TITCHENER CORPORATION,
CORTLAND, NEW YORK)

The material in this paper is of interest particularly at this time, when the problem of corrosion of insulator components and conductor hardware has become the subject of increasing concern on the part of Utilities operating transmission lines in isolated sea coast or industrial areas.

We, at the Brewer-Titchener Corporation, as producers of forged steel and non-ferrous transmission materials discussed in this paper, are quite naturally concerned with this corrosion problem.

There is little to be added to the first part of the paper dealing with the causes, the variables, the classes, and the effects of corrosion.

SUSPENSION INSULATOR COMPONENT PARTS

A few utilities, a part of whose lines operate under severe corrosion conditions, express a preference for malleable iron versus forged steel suspension insulator caps. A major portion of suspension insulator manufacturers use forged steel caps because of their inherent greater strength and dimensional fidelity. From a corrosion standpoint, it would seem that too much emphasis is being placed on the cap material. Both the cap and stud are subject to corrosion. The critical cross section of the forged cap is approximately five times that of the steel ball pin. Actual

Corrosion

Conference Paper



FIELD EXPERIENCE WITH CORROSION OF DISTRIBUTION MATERIAL

A. S. Hadfield
Associate Member AIEE
Virginia Electric and Power Co.
Williamston, N. C.

Submitted in abstract or outline form only to the AIEE Committee on Transmission and Distribution for the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted November 28, 1955; made available for printing December 8, 1955.

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Paper No. **CP**

56-270

Corrosion
Return
B. E. Kingston

Conference Paper



FIRST REPORT ON CORROSION TESTS OF A NEW STEEL WIRE WITH THICK ALUMINUM COVERING

J. G. Cavanagh
Member AIEE
Copperweld Steel Company
Glassport, Pa.

*H. That you might be
interested in looking at
this. bek.*

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., October 26-31, 1958. Manuscript submitted August 20, 1958; made available for printing September 2, 1958.

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Paper No. **CP**

58-1254

B. E. Kingsbury
Corrosion

GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT

Technical Report No. LK-187-CR

March 21, 1961

SUBJECT:

ACCELERATED CORROSION TEST
FOR SUSPENSION INSULATOR BALL BOLTS

P. B. Horton

This report contains:

4 typewritten pages
4 pages of photographs

Baltimore, Maryland

Signed

P. B. Horton

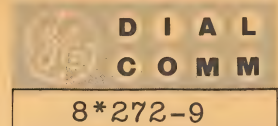
INDEX FOR: CORROSION

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Number	Title	Author	Company	Date
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R56GL69	CORROSION SYMPOSIUM - 1955	RT Foley	General Electric Schenectady, NY	April 25, 1956
AIEE Paper #56-230	CORROSION AS IT AFFECTS INSULATOR AND CONDUCTOR HARD- WARE	AW Bardeen JM Sheadel		1956
AIEE CP 56-270	FIELD EXPERIENCE WITH CORROSION OF DISTRIBUTION MATERIAL	AS Hadfield	Va Elec & Power Co Williamston, NC	Dec 8, 1955
AIEE CP 58-1254	FIRST REPORT ON CORROSION TESTS OF A NEW STEEL WIRE WITH THICK ALUMINUM COVERING	JG Cavanagh	Copperweld Steel Glassport, PA	Sept 2, 1958
LK-187-CR	ACCELERATED CORROSION TEST FOR SUSPENSION INSULATOR BALL BOLTS	PB Horton	General Electric Insulator Dept.	March 21, 1961

GENERAL ELECTRIC

INSULATOR DEPARTMENT
2525 Insulator Drive
Baltimore, Md. 21230



COPIES: ES Wheeler
HA Frey
AJ Pezdek

February 22, 1967

SUBJECT: Catastrophic Damage Due
To Chipping

Messrs. R. Weller
J. Kaminski

I refer you to Test Report No. 23101 in which we reported the potential catastrophic damage that may result from chipping the inner petticoats of the NGK 20,000 lb. suspension insulator (NGK 557MG-20). Similar tests have also been performed to compare the NGK six inch insulator with our six inch insulator (LJ-16583 versus 16583).

These latter tests were performed in essentially the same manner as was done on the ten inch insulators. Briefly, the procedure was as follows:

- A. Impact, with steel nosed pendulum, the second petticoat (There are three petticoats, counting the outer rim.) The magnitude was started at 10 inch-lbs. and increased in 10 inch-lbs. increments until chipping occurred.
- B. Electrical test the units
- C. Thermal shock the units. Three cycles were employed, with bath temperatures being 32° F and 212° F
- D. Electrical test the units
- E. Perform M&E test on units

The results were as follows:

IMPACT TEST

<u>Catalog No.</u>	<u>Sample No.</u>	<u>Impact, in.-lbs.</u>	<u>Electrical Test</u>	<u>Remarks</u>
LJ-16583	1	20	Punctured	cracked shell
	2	30	FO	chipped petticoat
	3	20	FO	chipped petticoat
	4	20	FO	chipped petticoat
	5	20	FO	chipped petticoat
	11	20	FO	chipped petticoat

<u>Cat No.</u>	<u>Sh.</u>	<u>C.L.</u>	<u>Dia</u>	<u>Type</u>	<u>Competitors</u>
405360	40	$5\frac{3}{4}$	10	B & S	
505386	50	$6\frac{1}{8}$	$11\frac{5}{8}$	B & S	
18290	40	$6\frac{1}{4}$	$10\frac{3}{8}$	cl	
18380	50	7	$11\frac{5}{8}$	cl	

Dave Alexander, Victor Ins., Victor, N.Y.
called 2/7/67 with questions regarding
our conn. length & shell dia. on 40 & 50 k sup.

Gave him the above info., except that told
him $6\frac{1}{2}$ " spacing on 18290 which is in error
on the "Active Prod. Listing"

Bsk 2/5/67

Victor Ins. Victor, N.Y.
A/c 716 924-2127



INSULATOR DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

"Competitors"

No. 23101

Date 12/20/66

Page 1 of 4

Nature of Tests:

Impact, Thermal, Flashover, M&E, and Ultimate

Material

NGK-557MG-20
GE-20S840

Refer to

Test Req. No. 7297

Copies
to

The following testing was performed in order to determine a means of discrimination between suspension insulators of different manufacturers regarding the susceptibility to catastrophic cracking of the porcelain component.

Catastrophic cracking is defined as being damage to the insulator either to a critical degree or to a critical area as contrasted to the damage normally expected to be encountered by the type of test here after described.

Insulators from two manufacturers--General Electric Company and NGK--were subjected to tests.

I. These tests consisted of the following:

- A. Impact Insulators were mounted in the standard ASA impact machine. Instead of striking the edge of the shell, as is normal, the pendulum was adjusted so that the nose would impart an impact to the third petticoat from the edge of the shell (second petticoat from the pin hole). Each insulator was impacted with successively increasing magnitude in 10 inch-lbs. increments until chipping occurred.
- B. Electrical Test Then, all insulators were flashed over electrically
- C. Thermal Test Then, all insulators were subjected to one cycle of thermal shock (32° F to 210° F), ten minutes each half cycle.
- D. Electrical Test All insulators were flashed over electrically
- E. Impact Test All insulators were again impacted as in "A", above, except that the inner petticoat was impacted.
- F. Electrical Test Then all insulators were flashed over electrically
- G. Thermal Test All insulators were subjected to five (or less depending upon results) cycles of thermal shock (32° F to 210° F), ten minutes each half cycle.
- H. Electrical Test Then, all insulators were flashed over electrically
- I. M & E and Ultimate Test All insulators were then subjected to M & E test

Signed _____

Approved _____

Nature of Tests:

IMPACT TEST

Material

NGK 557 (6)
205840605 (6)

Refer to

Test Req. No. 7297

Copies to

FILE
BEK

NGK 557 MG 20

ALL UNITS TESTED AT #3 PETZLICAT

SAMPLE VALUE REMARKS

1	20	BROKE AWAY 5 IN. OF "3 SKIN"
2	30	" ALL
3	20	" 1/2
4	20	" 3"
5	30	" 1/2
6	20	" 4"

STEEL NOSE
WAS USED



205840605

1	30	1" CHIP
2	30	" "
3	30	" "
4	60	" "
5	30	" "
6	30	" "

ALL UNITS FLASHED OVER ON

THERMAL TEST

UNITS GIVEN ONE CYCLE OF FULL RANGE THERMAL SHOCK TEST, FOLLOWED BY A 602 FO. ALL UNITS



GE 20S840
TEST REQ #7297



NGK 557MG20
TEST REQ #7297

GENERAL ELECTRIC
INSULATOR DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

RECEIVED

DEC 14 1966

Competitors

No. 23088

Date 9-1-66

Page 1 of 5

Nature of Tests:

Design Tests

ENG.

Material

HBP-47
NGK HRBP-47
Sim. to Locke #2ND

Refer to

W. Lounsbury

Test Req. No.

7299

Copies
to

File

W. Lounsbury
B. Kingsbury

3 No. HBP-47
3 No. HRBP-47

R.T.V. Test

HRBP-47

- Rated 50kv. @ 5 kv.

Test Voltage		5 kv.	50 kv.	RAK 29.84
Spec. No. 1	Noise level	2 kv.	27 kv.	D.B. 88°F
" " 2	"	2 kv.	34 kv.	W.B. 71°F
" " 3	"	2 kv.	31 kv.	VAP 0.611

HBP-47

- Rated 2500 kv. @ 5 kv.

Test Voltage		5 kv.	2500 kv.
Spec. No. 4	Noise level	125 kv.	22.5 kv.
" " 5	"	100 kv.	23.5 kv.
" " 6	"	150 kv.	20.5 kv.

60w Dry F.O. test

Individual readings on 75 volt scale
Connected to 1000:1

HRBP-47

- Rated @ 50 kv.

Spec. No. 1	No. 2	No. 3	RAK 29.84
42 kv.	53 kv.	52 kv.	D.B. 88°F
51.5 "	52 "	52 "	W.B. 72°F
52 "	53 "	51 "	VAP 0.611
53 "			HUM. 0.997
52.5 "			RAO 0.995

Av. Uncorr. 51.4 kv.
Av. Corr. 51.6 kv.

52.6 kv.
52.8 kv.

51.6 kv.
51.8 kv.

HBP-47 Spec. No. 4
62
61
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No. 5
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No. 6
65
58
58
67
52

Av. Uncorr. 60.2
Av. Corr. 60.4

61.2
61.4

59 kv.
59.2 kv.

Signed 282-A.B.

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ES Wheeler

September 27, 1966

COMPETITIONS CLOSET:

A. B. Chance Epoxiglass Insulators

All District Managers
All Headquarters Marketing Personnel

Chuck McKinley learned that A. B. Chance, in recent weeks, has had a delegation at Louisiana Power and Light Co. to determine just what to do about replacing all the epoxiglass insulators that Louisiana Power and Light Co. has installed.

Also, Bob Bauer has learned of a series of failures of the "Epoxy-Glas" struts being used as 55-5 pin-type insulators on the Pacific Power & Light Co. system. In the latter case, struts were being used in an extremely contaminated coastal environment and damage is due to excessive leakage currents. This resulted in charring or burning of the strut, with some units burning the full length of the strut. Apparently, no radio interference problems have been encountered, but Pacific Power & Light is going to replace all units.

We have made tests on the style used by Louisiana Power and Light and a copy of these test results is attached. In the column showing "Equivalent 5-3/4 x 9" insulators", these are catalog values of strings of porcelain insulators which resulted in approximately the same flashover value as the epoxiglass-porcelain combination.

Under Test Group D, it is noted that severe tracking took place in 37 minutes under a special wet flashover test. These results appear to support the situation that is occurring in service.

Under Group F, the mechanical strength of the unit severely limits its application.

We have pointed out in previous communications that epoxiglass and other similar organic insulators are very susceptible to tracking and subsequent breakdown. Our GEPOL insulating material, on the other hand, a patented formula, has a high degree of freedom from tracking which gives us the confidence that chances for GEPOL's success are very high!

J. Kaminski, Jr.
J. Kaminski, Jr.

Product Planner & Application Engineer

pr

ATT.

File - Competitors

B. Kingsbury

RECEIVED

SEP 29 1966

ENG.

QUALITY CONTROL

TECHNICAL REPORT NO. VIII

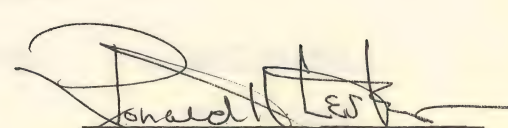
TEST RODS SUPPLIED BY N.G.K.

by

W. E. Taylor

September 26, 1966


Signed


Approved

GENERAL ELECTRIC

INSULATOR DEPARTMENT
2525 Insulator Drive
Baltimore, Md. 21230

RECEIVED

SEP 22 1966

ENG.

COPIES:

AJ Pezdek
J. Kaminski
FR McVicker
ES Wheeler



September 22, 1966

Subject: Arc-Over Tests on OB
and NGK Insulators

Mr. B. E. Kingsbury:

The laboratory recently had the opportunity of making tests on both OB insulators and NGK insulators which had been subjected to short circuit arc-over tests. The arc-over tests were made by the Baltimore Gas and Electric Co. at their Windy Edge test facility and was a continuation of the investigation for Stone and Webster for the Keystone Line. The objective of the tests was to obtain a comparison between the OB and NGK insulators so that a decision could be made on the usage of the insulators for the Keystone Transmission System.

The tests were made on a string of three units, which is similar to the procedure used at S.C.E. in their arc-over tests.

The insulators were brought into our laboratory for conducting the mechanical test after having been subjected to arc-overs of approximately 4,000 - 6,000 amp-sec. Mr. Bill Logan and Mr. Gordon Gaertner of the Baltimore Gas and Electric Company witnessed these tests and also took the insulators back for examination and review by other interested individuals.

The results obtained in the laboratory tests on the OB insulators are as follows. These units were rated at 25,000 lbs. M&E strength.

<u>Sample</u>	<u>M & E</u>	<u>Ultimate</u>	<u>Remarks</u>
1	32,100	32,100	Broke Socket
2	38,350	38,350	Normal Break
*3	Punctured	16,750	Normal Break
1A	34,300	34,300	Normal Break
2A	39,800	39,800	Broke Socket
*3A	30,400	30,400	Normal Break
1B	33,900	33,900	Normal Break
*2B	17,100	17,100	Normal Break
*3B	Punctured	17,600	Normal Break
1C	36,100	36,100	Broke Socket
2C	32,800	32,800	Broke Socket

Competitor's

Mr. Kingsbury

MEMORANDUM

August 31, 1966

Subject: NGK Quality Problem--Reports and
Information on Hand To Date

Messrs. WM Nave
GM Boyd
AJ Pezdek
ES Wheeler

1. The first indication of trouble with NGK insulators received by us came from Pacific Gas and Electric Company. It was reported that a 230 Kv circuit dropped under normal operating conditions--no wind, no rain, no abnormal loading. It was further reported that when additional NGK insulators on the same circuit were examined some (an unknown quantity) were found to be cracked. The NGK representative is reported to have told PG&E that the insulators had been roughly handled in construction and pointed out that a very light impact on the underside of the unit could cause breakage of the shells and subsequent reduction in M&E strength. When these reports were received, a simple test was made here (the so-called screw driver test) by simply dropping a screw driver so as to strike in the trough between any pair of the inner corrugations. It was found that a surprisingly light blow at this point would cause a part of the shell to break off. These tests were made on Japanese 18,000 lb. units and, in some cases, the units after being so broken were found to have mechanical strength tests of as low as between 5,000 and 6,000 lbs. Needless to say, not all units were so affected.
2. Pursuing further simple tests of this sort at Baltimore, it was found that by simply tapping the tips of the smooth inner corrugations with a screw driver or other metallic object, it was very easy to cause chips to spall off. Subsequently it was found that on insulators so chipped, there was a tendency for glaze to continue to flake off around the chip and after a single cycle thermal shock test some of the insulators cracked radially with the cracks progressing up into the head. This, of course, is a very dangerous situation since even if the mechanical strength is unaffected, a crack in the head of the insulator would represent an electrical failure and charging currents passing over this crack over a period of time in service could cause a blow-apart.
3. It was after the rather preliminary work indicated above had been done that Baltimore Gas and Electric Company (John Jones) called me to ask if we would be willing to make some tests for them on competitive insulators. In the course of the conversation it developed that they wished us to make tests on Japanese insulators and that they had heard from PG&E of the above difficulties. The tests were to be made under the direction of Stone and Webster, with representatives from BG&E, Pennsylvania Electric and NGK present. These tests were made, and Mr. Weller has reported on them in detail. However, a brief resume of the results is worth repeating here.

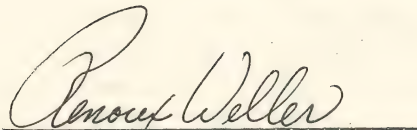
B. E. Kingsbury
Competitor

GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT
Baltimore, Maryland

Technical Report No. LK-819
September 1, 1966

IMPACT TESTS ON NGK AND OB INSULATORS
MADE FOR STONE AND WEBSTER

This Report Contains
13 typewritten pages


Signed

GENERAL ELECTRIC

INSULATOR DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

competitor
No. 22929
Date AUG. 17, 1966
Page of

Nature of Tests:

WITHSTAND MTE,

Material

NGK 30S
Locke 30S.

Refer to

Test Req. No.

Copies
to

FILE

H. FREY

R. WOLLER

B. K.

3 NGK 30,000 LB. UNITS WERE GIVEN A WITHSTAND
OF 126 KV UNDER OIL FOR ONE MINUTE FOLLOWED BY
A FLASHOVER AND MTE TEST.
ONE LOCKE 30S²⁵ WAS ALSO TESTED

SAMPLE	MTE	ULT	REMARKS
1	31500	31500	SHEARED SIDES OF BALLBOLT
2	32100	32100	" " " "
3	32500	32500	" " " "

LOCKE

1	36200	36200	PULLED THRU SOCKET
---	-------	-------	--------------------

Signed. RUS

Approved

GENERAL ELECTRIC

INSULATOR DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

No. 22929

Date AUG. 15, 1966

Page of

Nature of Tests: TIME LOAD AND MTE TEST AND		Material OB. 25,000 LBS NGK. 30000
THERMAL TEST		
Refer to	Test Rec. No.	

Copies
to

FILE

INSPECTOR (A)

THESE UNITS HAVE NAD 10 CYCLES FULL (212°F - 32°F) RANGE

5 NGK.

(5 OB.) UNITS WERE PLACED IN THE TIME LOAD FRAME

FRIDAY 0830 '8-12-66 UNDER 18,000 LBS. LOAD.

UNITS WERE TAKEN DOWN 1300 '8-15-66 AND GIVEN A FLASH-
OVER TEST FOLLOWED BY AN MTE TEST.

SAMPLE	SEC FO.	MTE	ULT	REMARKS
OB				
X1	OK	42000	42000	SHEARED SIDES OF BALL
2	"	40000	40000	"
3	"	39500	39500	MEDIUM BREAK 1 1/32
4	"	46000	46000	CAP FAILED -
5	"	41250	41250	CAP OFF -
NGK 6	"	32150	32150	SHEARED SIDES OF BALL -
7	"	31400	31400	"
8	"	32800	32800	CRACKED BACK OF SOCKET -
9	"	32300	32300	SHEARED SIDES OF BALL -
10	"	32700	32700	"

Signed RUS

Approved

GENERAL ELECTRIC

INSULATOR DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

competitor
No. 22912
Date 7/19/66
Page 1 of 1

Nature of Tests: <u>M+E an UL. an Thermal test</u>	Material <u>NGK 18000</u> <u>LJ1840</u>
Refer to	Test Req. No. <u>7284</u>

Copies
to

File

H. Frey

B. Kingsbury

Thermal Shock Test 6 units, two cycles.
All six units cracked on first cycle.
None of these units will hold voltage.

Sam. No.	Ultimate	Remarks
1.	8400	Chipped 2 inner petticoats before given Thermal test. Normal Break
2.	7900	Small chips on three inner petticoats before given Thermal test. Normal Break.
3.	8150	" " " " " "
4.	5700	Chipped all petticoats of unit before given thermal test. Normal Break
5.	9000	Chipped 3 outer petticoats before given thermal test. Normal Break
6.	7250	Very small chips in all petticoats before given Thermal test.

approx. $\frac{1}{2}$
of these did
flashover when
subj. to elec
test prior to
the thermal
test.

The next two units were not given Thermal test.
The two units cracked while being chipped,
They will not hold voltage.

1.	8800	Chip in First inner petticoat. Normal Break
2.	8250	" " " " " "

Thermal Shock Test 2 units, four cycles. No apparent damage.
These two units will hold Voltage.

1	25000	Very small chips on outer 3 petticoats before given thermal test. No cracks in shell. Broke the Shank
2.	24050	" " " " " "

Signed [Signature]
Approved

K. Weller

→ $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ → 1/4

- Richard Ginori

You will find Test Reports enclosed, as listed below, for your approval and forwarding to Manager - Line Insulator Engineering.

Vessel
EXPORT
Administration

H.M. Stickles
6/9/66

TEST REQUISITION
HIGH VOLTAGE LABORATORY
INSULATOR DEPARTMENTNature of Tests: *M & E*No. *2221*Date *4/25/66*

Auth.No.

Will Witness: Yes ☐ No ☒Requested By: *BEK*

For

Copies To: *RW HAF ATP BEK JK*

Material:

LS 1840

Assembly Date & Shift:

MATERIAL DESCRIPTION:

Standard ☐Developmental ☐Other ☐

- ① approx 132 ins. are @ HV Lab (in alley) from previous shipments
② 200 ins. (from most recent shipment) will be delivered to lab.

TESTS REQUIRED:

Standard Tests ☒Other Tests ☐*Please make M & E tests on:**IN ALLEY -**75 of item ①**COPIES TO:**75 of item ②*

SPECIAL INSTRUCTIONS:

Entered Laboratory File

By

Report Number

Dated

Signed *BEK*

~~JH Kehlbeck~~
~~B Kingsbury~~

Mr. R. H. Lester:

[illegible]

H. M. Stickles

GENERAL ELECTRIC

INSULATOR DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

No. 22878
Date 3/22/66
Page 1 of 3

Nature of Tests:

Material

Refer to

Design & Quality Conformance
R. WELLS

Test Req. No.

7202

NGK-DA-85082
LJ-29069
Post Ins.

Copies
to

File

R. Wells

RIV Tests Rated - 200KV @ 44KV

Sam # 1
KV - 44 100
UV - 3.5 200

Sam # 2
KV - 44 102
UV - 4 200

Sam # 3
KV - 44 99
UV - 3.5 200

Bar - 29.85
WB - 58
DB - 74
VP - 1.307

60 Dry 70 Tests

Rated - 235KV

Sam # 1
227
228
230
229
228

Sam # 2
226
228
228
227
228

Sam # 3
228
227
229
230
226

AV - 228.8KV
Corr. - 262KV

AV - 227.4KV
Corr. - 260KV

AV - 228KV
Corr. - 261KV

3/29/66

Bar - 29.78
WB - 52
DB - 73
VP - 1.156
Hum - 1.144
Rad. - 1.000

60 Wet 70 Tests

Rated - 180KV

Sam # 1
188
187
188
186
190

Sam # 2
188
189
190
187
188

Sam # 3
192
186
186
189
188

AV - 187.8KV
Corr. - 187.8KV

AV - 188.4KV
Corr. - 188.4KV

AV - 188.7KV
Corr. - 188.7KV

Bar - 29.78
DB - 73
Rad. - 1.000
Prec. - .18"/min
Res. H₂O - 6950w
Press. - 36psi

Signed WFS

Approved

GENERAL ELECTRIC

INSULATOR DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

No. 22876

Date 6-28-66

Page of

Nature of Tests:

Impact Test - AND Puncture IT

Material

16583-

UNDER OIL

Refer to

Test Req. No.

7271

GINORI

Copies
to

Sample No. #	Impact Value	Skirt Thick	Remarks
1	100 in. lbs	16/32	1/2 OFF
2	90 " "	"	1/4 "
3	90 " "	17/32	2/3 "
4	90 " "	"	1/4 "
5	110 " "	"	2/3 "

Sample	Puncture Value	Location
1	134 K.V.	BASE OF CAP
2	90 K.V.	THUR THE HEAD
3	132 K.V.	BASE OF CAP
4	128 K.V.	THUR THE HEAD
5	120 K.V.	" " "
6	132 K.V.	BASE OF CAP
7	134 K.V.	" " "
8	130 K.V.	THUR THE HEAD
9	104 K.V.	" " "
10	132 K.V.	" " "

GENERAL ELECTRIC

INSULATOR DEPARTMENT
BALTIMORE, MARYLAND
RECORD OF TESTS

No. 22706

Date 2-15-66

Page 1 of 2

Nature of Tests:

Electrical, Mechanical and
Burning Tests

Refer to

F. Vose

Test Req. No.

7141

Material

A.B. Chance
Epori glass &
Porcelain

Copies
to

File
F. Vose
Kingsbury
Kaminski

One 24" epori glass insulator supporting 2
conventional 9" suspensions of A.B. Chance Co.

60W Dry F.C. test

Individual readings on 300 volt scale

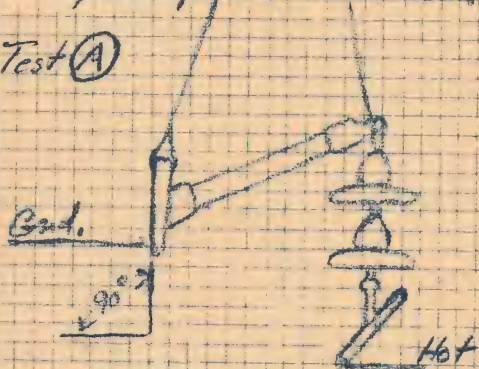
Connected to 150 volt scale, connected to 1000:1

Meter readings converted to KV, with use of calibration
curve of 3-350 KVA transformers in cascade.

Test set up

Nylon rope to wire hook

Test (A)



L.S.V.	KV.
70	224
71	227
71	227
71	227
70	224

Av. Uncorr. 225.8 KV.
Av. Corr. 246 KV.

BAR 30.37
D.B. 80°F
W.B. 60°F
VAR. 0.298
HUM. 1.097
RAD. 1.007

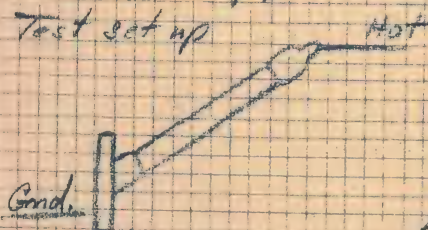
Test (B) Same as (A) except only one 9" suspension hanging
from support.

L.S.V.	KV.
66	211
67	214
67	214
65	208
66	211

Av. Uncorr. 211.6 KV.
Av. Corr. 230.3 KV.

Test (C) Support insulator only

Test set up



L.S.V.	KV.
57	182
57	182
55	176
55	176
55	176

Av. Uncorr. 178.4 KV.
Av. Corr. 194.4 KV.

TEST REQUISITION
HIGH VOLTAGE LABORATORY
INSULATOR DEPARTMENT

Nature of Tests:

MAF TESTS + OTHER
MISC

No.

7207

Date

MARCH 24, 1966

Auth.No.

Will Witness: Yes ☐ No ☒

Requested By:

RW

For

BEK

Copies To:

BEK, RW, HAF, R LESTER, B LANSBURY

Assembly Date & Shift:

For Competitive data

Material:

32440

15,000 LB.

OB 47310

SUSPENSION

MATERIAL DESCRIPTION:

Standard ☐

Developmental ☐

Other ☒

1. All units to have QC inspection before testing

TESTS REQUIRED:

Standard Tests ☐

Other Tests ☐

✓ 1. TEST 5 at 150°F (WATER)

✓ 2. TEST 5 at 0°F (AIR)

✓ 3. TEST 10 at room temp 70°F

✓ 4. TEST 5 at modified thermal load test

32 to 212°F at loading at 4500 lbs

(FOLLOWED BY

MAF TEST ✓

✓ 4a. Make deflection tests on caps of two units for comparison

✓ 5. All units to be given Quality Index Rating by QC before testing

6. Save remainder of units for other tests to be scheduled

7. Note various characteristics such as wax around cement, type of pin, coatings used, stamping on shells and other information

SPECIAL INSTRUCTIONS:

✓ 8. Save some components for shawing and metal analyses.

Entered Laboratory File

By RW

Report Number 22810

Dated 5-18-66

Signed

Weller

TEST REQUISITION
HIGH VOLTAGE LABORATORY
INSULATOR DEPARTMENTNature of Tests: *M & E*No. *7221*Date *4/25/66*

Auth.No.

Will Witness: Yes ☐ No ☒Requested By: *BEK*

For

Copies To: *RW HAF ATP BEK JK*

Assembly Date & Shift:

Material:

*LS 1840*MATERIAL DESCRIPTION: Standard ☐ Developmental ☐ Other ☐

- ① approx 132 ins. are @ HV Lab (in alley) from previous shipments
② 200 ins. (from most recent shipment) will be delivered to lab.

TESTS REQUIRED: Standard Tests ☒ Other Tests ☐*Please make M & E tests on:**IN ALLEY -**75 of item ①**CO. 10116**75 of item ②*

SPECIAL INSTRUCTIONS:

Entered Laboratory File

By

Report Number

Dated

Signed *BEK*

GENERAL ELECTRIC

INSULATOR DEPARTMENT

SUBJECT

- Engineering Comments
File #4412

COPIES:

Baltimore, September 25, 1961

Mailing List 9 Tab D

Subject: Tests on A. B. Chance (Porcelain Products) 15000 Lb.
Suspension Insulator #66255

We have recently completed a series of tests on the subject insulator and I thought you might like to see the results.

Physical Measurements

<u>Sample No.</u>	<u>Dry Arcing Distance</u>	<u>Leakage Distance</u>	<u>Connecting Length</u>	<u>Weight</u>
1	7 15/16	12	5 13/16	12 lb. 5 oz.
2	8	11 15/16	5 13/16	12 lb. 6 oz.
3	8 1/16	12 3/16	5 3/4	12 lb. 6 oz.

M & E and Ultimate Strength (Lbs.)

<u>Sample No.</u>	<u>M & E</u>	<u>Ultimate</u>
1	17150	20250
2	20100	24100
3	20150	25050
4	21150	22250
5	26400	26900
6	23150	23550
7	17100	21700
8	15800	20350
9	19800	21750
10	19800	24200
Average	20060	23010

INDEX FOR: DC - DIRECT CURRENT

Number	Title	Author	Company	Date
IR #429	DIRECT CURRENT TRANSMISSION	GJ Gross	Locke Ins. Corp. Baltimore, MD	May 23, 1947
53-998 IEEE	THE ELECTRICAL DESIGN OF FUTURE EHV SYSTEMS -- An Over-all View	LO Barthold EM Hunter	Elec. Utility Sys. General Electric	March 27, 1962
IEEE CP 63-1096	INSULATION REQUIREMENTS, CORONA LOSSES AND CORONA RADIO INTERFERENCE FOR HIGH VOLTAGE DIRECT CURRENT LINES	N Hylden-Cavallius S Annestrand V. Madzarevic H. Witt	ASEA, Hi Volt Lab Ludvika, Sweden	July 5, 1963
Excerpt	THE CONTI-SCAN HVDC PROJECT	G. von Geijer S. Smedsfelt L. Ahlgren	Pinneburg, WG Swedish State Power Board Stockholm, Sweden	May 9, 1963
T & D	INSULATION REQUIREMENTS, CORONA LOSSES, AND CORONA RADIO INTERFERENCE FOR HIGH VOLTAGE D-C LINES	Same as 63-998 IEEE		May 1964
	THE ROLE OF HVDC TODAY	Pg Engstrom H Stackegard	ASEA, Ludvika, Sweden	Sept. 1964
Memorandum	HVDC TRANSMISSION STATUS REPORT: MARCH 15, 1965	EM Hunter	HVDC Trans Engng G.E. - Schenectady	March 15, 1965
Electrical World	DC INSULATOR SITUATIONS	HA Frey	Locke Dept. GE - Baltimore	July 12, 1965
Reprint	NEW ZEALAND INAUGURATES INTERISLAND HVDC			July 19, 1965
	EHV DC TRANSMISSION	EM Hunter GD Breuer CC Herskind	General Electric	Sept 1965
Excerpt International Science & Technology	LONG DISTANCE POWER TRANSMISSION	Uno Lamm		April 1966

INDEX FOR: DC - DIRECT CURRENT

Number	Title	Author	Company	Date
T&D 2786	UNDERGROUND DC LINK FOR LONDON			April 1966
F 76 228-7	STUDY ON THE INSULATION DESING OF OVERHEAD DC LINES	Y. Watanabe	Central Res. Inst. Elec. Power Ind. Tokyo, Japan	Sept. 2, 1975
RS-k10	BASIC PARAMETERS OF A-C and D-C CIRCUITS	Dr. Robt L. Peters	Consultant Design News	11/22 & 12/7/70

LOCHE INSULATOR CORPORATION
Baltimore Maryland

Technical Report No. 439
May 23, 1947.

Subject

DIRECT CURRENT TRANSMISSION

This report contains:

8 Typewritten Pages
4 Graphs
2 Drawings

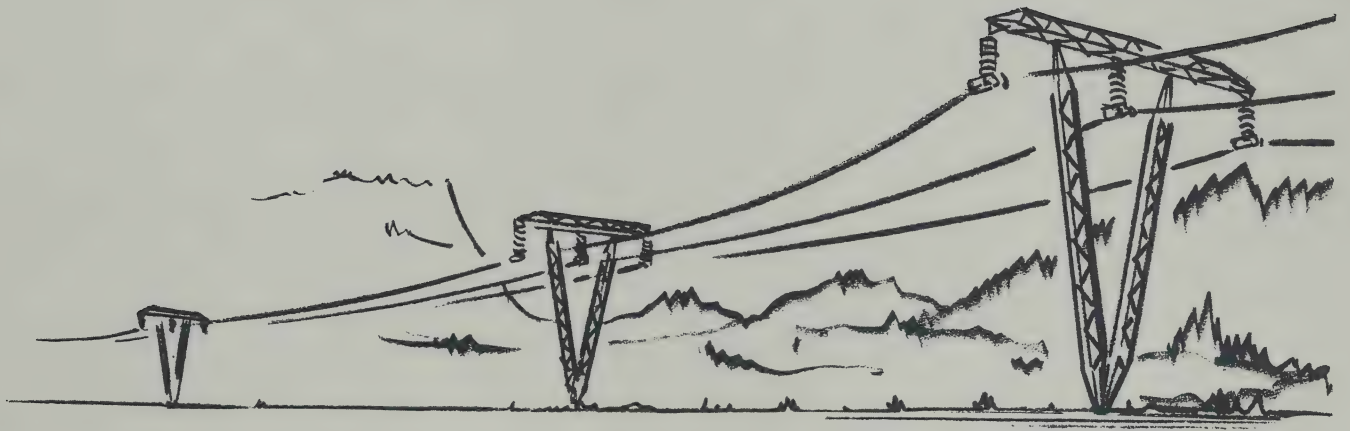
Signed

S. J. L. Hov

Approved

W. H. L. Hov

GENERAL  ELECTRIC



THE ELECTRICAL DESIGN OF FUTURE EHV SYSTEMS

L. O. BARTHOLD
E. M. HUNTER



ELECTRIC UTILITY ENGINEERING

Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due July 5, 1963.



INSULATION REQUIREMENTS, CORONA LOSSES AND CORONA RADIO INTERFERENCE FOR HIGH VOLTAGE DIRECT CURRENT LINES

N. Hyltén-Cavallius
Member IEEE
ASEA, High Voltage Laboratory
Ludvika, Sweden

S. Annestrand
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H. Witt
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A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 21, 1963; made available for printing April 24, 1963.

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P. O. Box A,
Lenox Hill Station,
New York 21, N. Y.

Litho in USA

Paper No.

63-998

Conference Paper



THE CONTI-SCAN HVDC PROJECT

G. von Geijer

S. Smedsfelt

L. Ahlgren

All of:

Swedish State Power Board
Stockholm, Sweden

Submitted in abstract or outline form only to the IEEE Substations Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted April 23, 1963; made available for printing May 9, 1963.

Price: \$.60 To Members
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New York 21, N. Y.

Litho in USA

Paper No. **CP**

63-1096

Table VI. Repeatability of Readings

	Number of Samples	Difference Between Paired Readings, Db	
		Mean	Standard Deviation
Dampers	36	-1.2	4.9
Suspension Insulators with Clamps	30	-1.3	3.8
Compression Joints	6	+3.6	12.9
Dead-End Insulators with Clamps	4	-8.0	5.2
Loop Support Insulators with Clamps	6	-6.0	2.5

type requires a polarizing battery and a cathode follower. The model selected has a threshold sensitivity of 4.3 nanobars, a frequency upper limit of 20 kc, and is so insensitive to external fields that its performance is not impaired even directly under a 600-kv test line.

Tests after assembly showed that this microphone-reflector

combination gives adequate directionality, the 6-db beamwidth at 10 kc being 4.2 degrees. This directionality is sufficient to enable a skilled operator to locate a noise source 100 feet away with an accuracy of about 1 foot and to separate sources which are 3 feet apart. The sound absorption by the atmosphere is negligible at these frequencies in a 100-foot path.

The coronaphone amplifier, filter, and meter circuits, together with the necessary batteries, are housed in the box shown in Fig. 1. Transistors are used throughout the amplifier to reduce battery requirements, thereby increasing portability. Between the microphone and the first stage of the amplifier is a high-pass filter for the attenuation of the relatively large noise energies of low harmonics of 60-cycle and voice frequencies. The maximum voltage gain of the amplifier is 100,000. The effective frequency response is 10 db down at 1,500 and 20,000 cycles. The QP detector has time-constants of 1-millisecond charge time and 600-millisecond decay. An audible output is provided.

The arbitrary units quoted are based on $0 \text{ db} = 2 \times 10^{-4}$ microbars, when the band-pass filters and reflector have been removed from the system.

Insulation Requirements, Corona Losses, and Corona Radio Interference for High-Voltage D-C Lines

N. Hyllén-Cavallius, Member IEEE S. Annestrand H. Witt V. Madzarević

Insulation Requirements

GENERAL CONSIDERATIONS

Both a-c and d-c line insulation is stressed by lightning overvoltages, internal overvoltages, and normal operating voltage. The first two stresses impose requirements mainly on the insulator chain length, while the latter influences the choice of leakage distance, especially when pollution is considered.

For direct current, the fault clearing characteristics can be made much more effective than for alternating current by means of grid control. Further, the internal overvoltages in d-c systems are considerably lower than in a-c systems. The lower requirements on chain length thus imposed means that the insulators' capability to withstand normal operating voltage will be dimensioning in all zones of pollution. As a consequence, it may pay to use d-c insulators with especially long leakage paths even in relatively clean areas. This possible reduction of chain length is of great economic importance as, usually, the largest part of a high-voltage power line passes through clean areas.

The mechanism responsible for insulator pollution and subsequent flashovers, can be as follows. The air is contaminated with small dirt particles which become deposited on the insulator as a layer. The layer is dampened, especially during fog, and if it contains dissociable matter, it also becomes conducting. An arc may develop which dries the surface layer

and increases in length. If the leakage resistance of the entire chain is small enough, the arc will carry a large current and will grow quickly. Eventually it will flash over the entire chain if the arc grows at a quicker rate than the rate at which the chain is dried by the leakage current.

Thus, the severity of the insulator pollution depends both on the atmospheric pollution and on the amount of dissociable matter, for example, salt. (The dissociable matter may be increased by the presence of gaseous SO_2 .) But also the frequency and intensity of rain is of vital importance, as rain

Table I. Characteristic Data for Atmospheric Pollution, SO_2 Content, and Equivalent NaCl Deposit on Line Insulators in Various Districts

	Atmospheric Pollution, Mg/Cm^2 */Month	SO_2 Content in Air, Parts	Equivalent NaCl Deposit on Line Insulators, Mg/Cm^2
Clean areas	0.01-0.2	10^{-8}	0.02-0.05
Industrial areas	0.2-0.8	10^{-7} - 10^{-6}	0.05-0.10
Heavily polluted areas	0.8-4	10^{-6} - 10^{-5}	0.10-0.40

* Milligrams per square centimeter.

Table II. Influence of Distance From Sea on Salt Deposit on Insulators

Distance to the Coast, m*	NaCl Deposit on Line Insulators, Mg/Cm^2
200	0.4
3,000	0.2
10,000	0.1
20,000	0.05

* Meters.

Paper 63-998, recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 21, 1963; made available for printing April 19, 1963.

N. HYLLÉN-CAVALLIUS, S. ANNESTRAND, and V. MADZAREVIĆ are with ASEA High-Voltage Laboratory, Ludvika, Sweden; H. WITT is of Pinneberg, West Germany.

The Role of HVDC Today

By **P. G. Engstrom**, Chief Engineer
and Manager and **H. Stackegard**,
Application and Project Engineer
DC Transmission Department
ASEA, Ludvika, Sweden

Editor's Note: Interest in the possibilities of high voltage dc transmission (HVDC) has been rapidly mounting in the United States and Canada. As we go to press, final Congressional approval has just been given on two 750-kv HVDC lines, connecting the Bonneville power system with Los Angeles and Hoover Dam.

Successful applications throughout the world indicate that this method of power transmission should be studied objectively, with careful analysis of the engineering

and economic factors involved in a particular case.

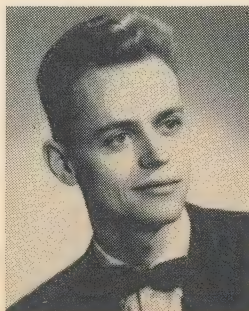
Heretofore, discussion of HVDC transmission in this country has been largely confined to comparisons of construction costs. Other factors of operating characteristics and equipment reliability must also be considered. These are discussed in this article. Additional special design considerations which are related specifically to HVDC equipment and its application will be treated in a subsequent T&D article.

The Authors . . .



Mr. P.G. Engstrom, Chief Engineer at the HVDC Department at ASEA, is a graduate of the Royal Institute of Technology, Stockholm, Sweden. He has been closely associated with the designing of control equipment used with the Gotland-mainland link as well as with the development of all equipment for d-c cable connections between French and English power grids. He is the Swedish representative to the IEC Subcommittee on Mercury-Arc Converters.

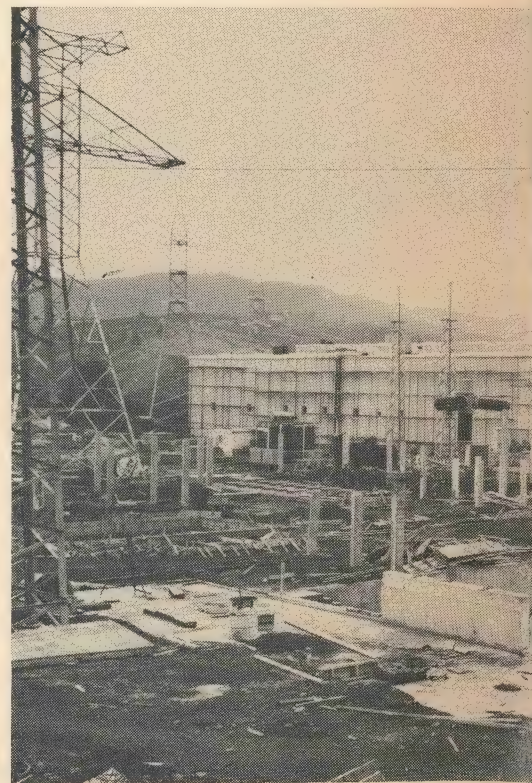
Mr. Hans Stackegard, also an electrical engineering graduate of the Royal Institute of Technology, is an application and project engineer at ASEA's HVDC Department. Prior to this he spent two years as a research engineer on saturable reactor development with the Hevi-Duty Electric Company, Milwaukee, Wisconsin.



SINCE THE FIRST long high voltage DC link connecting the island of Gotland and the Swedish mainland was commissioned ten years ago, six major HVDC projects have been undertaken in various parts of the world. Several other projects are contemplated, including two of very high capacity and length which involve power systems in North America.

The theoretical advantages of direct current for transmission have been recognized. These benefits stem primarily from the fact that the operation of the DC line is independent of line inductance and capacitance. Basic limitations on the general use of DC power systems are the impracticability of transforming direct voltage, the more efficient method of generating power at alternating current, and the difficulty of breaking direct current.

Modern use of HVDC for power transmission became practical with the development by ASEA of a high voltage mercury-



Above photo shows construction currently in progress on New Zealand's Haywards substation. The pit for the smoothing reactor can be seen in the foreground and the two valve damping resistors in the center of photo. Interior views of the sub-

HVDC TRANSMISSION

STATUS REPORT: MARCH 15, 1965

High-voltage d-c has economic application for the movement of large blocks of power from mine-mouth steam plants or remote hydro stations to load centers. It can usually be proved in where the overhead transmission distance is in excess of 400 to 600 miles or in metropolitan areas where overhead right-of-way is unattainable and cable must be used if the length exceeds 25 to 30 miles. Politics as well as engineering will play an important role in the decision for any specific undertaking. Experience has shown that it is most unwise to attempt to generalize on the break-even distance of a-c versus d-c transmission distance. Conclusions should be reached only after careful study of specific cases.

Five HVDC applications have been made by ASEA outside the Western Hemisphere (for listing, see Table I). Two are in commercial operation (Gotland and Cross Channel), and the other four are scheduled for commissioning in 1965. The New Zealand and Konti-Skan applications are particularly significant because of the dependence placed on the d-c link between the a-c networks. The operation of these systems will be followed with interest by all those having like applications.

In this part of the world, plans have finalized for an underseas link to Vancouver Island in British Columbia. ASEA is the prime contractor for the terminal equipment. Canadian General Electric will manufacture the converter transformers.

Also, congressional approval has been given to the overland d-c Pacific intertie. The Dalles-Los Angeles section is presently scheduled for operation for the fall of 1968. The second Dalles-Hoover Dam line is set for 1971. Orders for the terminal equipment and the transmission lines for this project will be placed in 1965.

As to the future pattern of growth, reference may be made to the National Power Survey Report issued on December 12, 1964, by the Federal Power Commission. Its projected 1980 transmission pattern includes the possibility of three major East-West EHV interties and another long-distance interconnection between the Northwest and Middle South, in lengths ranging up to nearly 2,000 miles and with power flows of as much as 4 million kilowatts.

The report visualizes that transmission will continue to be primarily over a-c networks but suggests that ± 500 -kv or ± 750 -kv d-c may be considered for these long-distance interconnections.

DC
AJ Pusdek
BE Kingsbury

July 12, 1965

Mr. J. Kaminski:

During a visit to Schenectady last week, Mr. Kingsbury and I spent a brief period with Gene Hunter discussing D. C. insulator situation.

You were particularly interested in contacts to make to secure the appearance performance business associated with this work. Mr. Hunter said that the General Electric representatives on the joint venture team are George Hauptman and Glen Brewer. Glen Brewer would be the man to contact concerning porcelains. G. E. already has the order on the substation equipment, so that the problem is that of determining exactly what porcelains will be required. I would, therefore, suggest that you call on or write Mr. Brewer on this matter.

Incidentally, if other information is required, Gene Matson, of Schenectady, has the complete system layouts.

The material must be on the site ready for construction by January, 1968. This includes a large number of wall bushings for 400 Kv plus and minus.

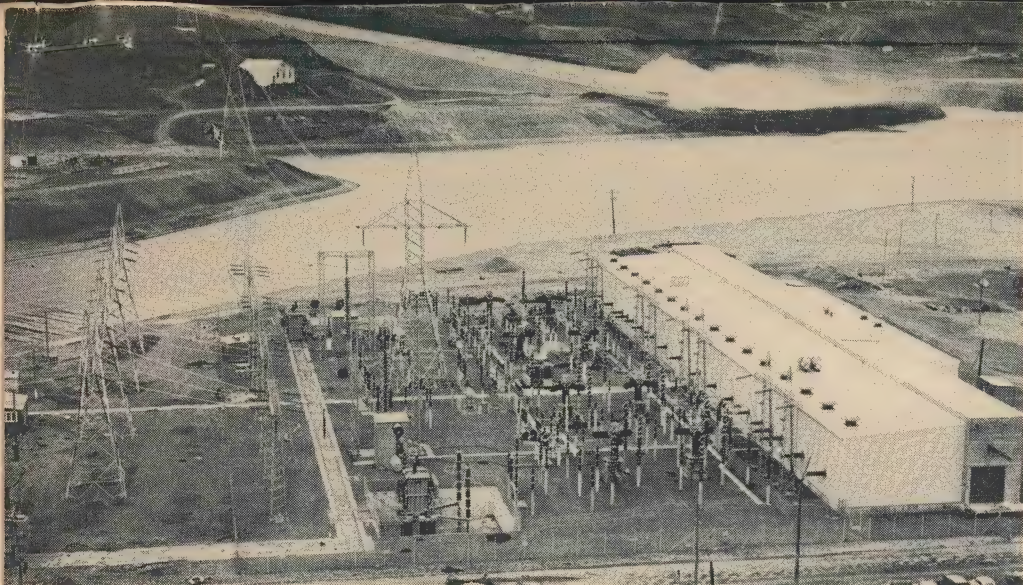
The switchyard and line insulators will be purchased by Bonneville Power (Clip Diamond is Bonneville purchasing agent). The first line will involve 830 miles and is scheduled for 1968 or sooner. The second line of about the same length is scheduled in 1970 or 1971.

Gene Hunter said that Gene Starr of Bonneville has been to Sediver, made and witnessed a number of tests on the glass insulators and is tremendously impressed by glass. This will be one obstacle that we will have to overcome. When our D. C. insulators are ready, perhaps we should get him here to counteract the Sediver influence.

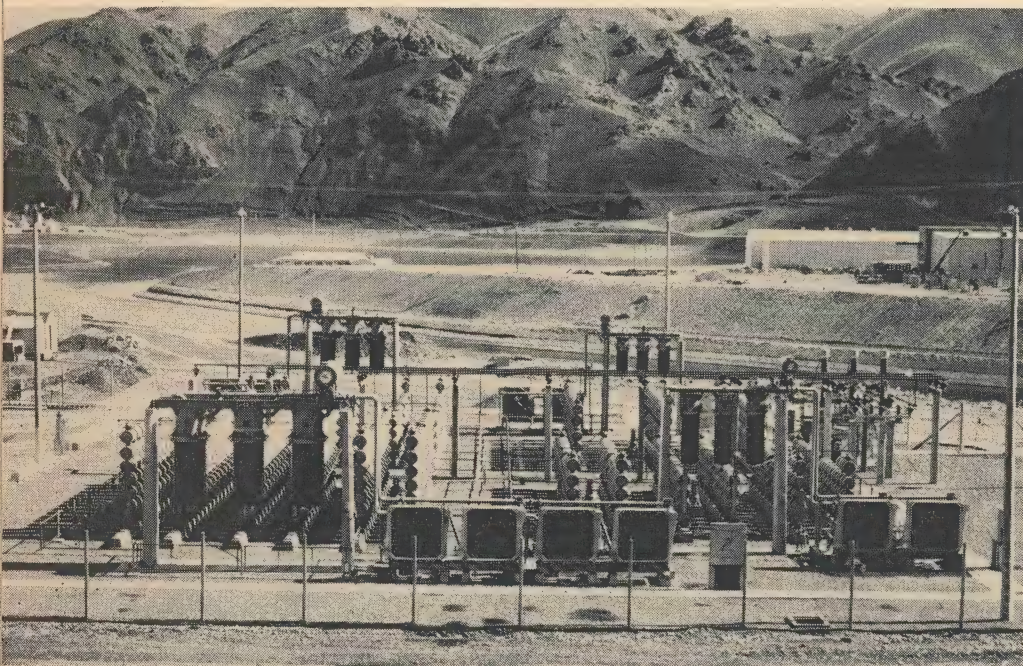
In response to specific questions concerning the most recent recommendations by ASEA on leakage distance, Mr. Hunter gave us the following information: ASEA recommended leakage distance for outdoor application at D. C.: 2.3 CM per Kv line to ground. ASEA recommended leakage distance for indoor application at D.C.: 1.4 CM per Kv line to ground.

These values are somewhat smaller than had been indicated from earlier information and Mr. Hunter indicated that this was not yet completely frozen but that complete information should be available within a few weeks.

New Zealand

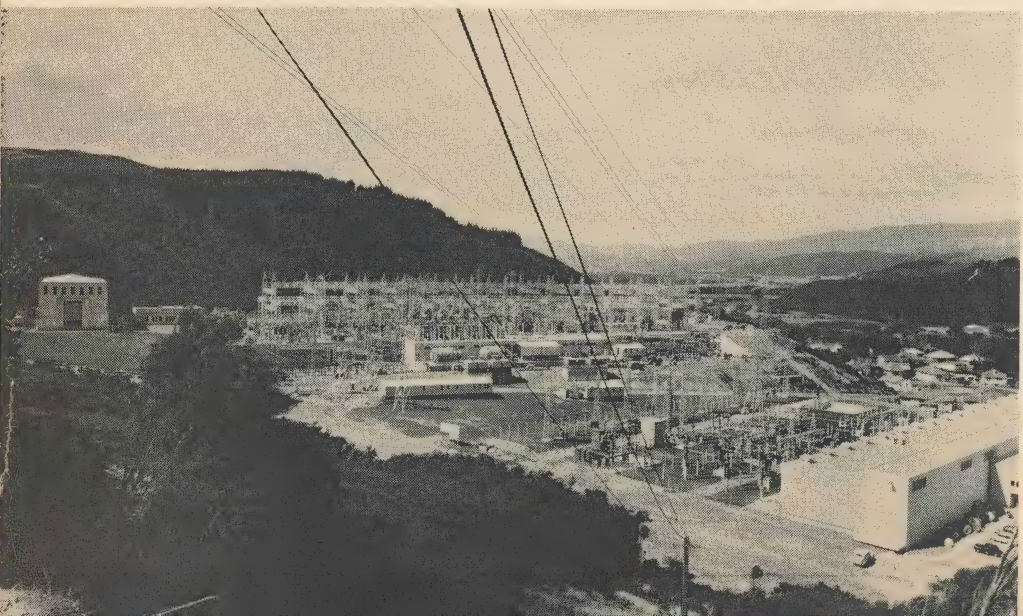


CONVERTER VALVE HOUSE, and dc switchyard at Benmore Hydro Station sends power transmitted at 500-kv dc to North Island 220-kv network



HARMONIC FILTER GROUP is shown at Benmore Ac-Dc Hydro Station which exploits South Island's hydro potential for transmission to North Island network

HAYWARDS SUBSTATION is the northern terminal of dc transmission and southernmost point on the North Island 220-kv ac system supplying city of Wellington



The 500-kv (± 250 kv to earth) dc transmission system recently put in operation at Benmore Station, South Island, places in New Zealand one of today's major advances in electric power technology. The line, now in commercial service and operating in conjunction with the submarine cables across Cook Strait (EW, March 29, 1965, p 24), has a capacity of 600 Mw.

The new line links Benmore Station with Haywards Substation. The latter is the southernmost point of North Island's 220-kv system. This project, like virtually all generation and transmission on both islands, was executed by the New Zealand Electricity Department, a government agency.

Inauguration of the line encountered some delay when a fault developed in one of the three 25-mile submarine cables spanning the water between the islands. But the fault was rectified, and the complicated project has been brought to fruition without further hitch.

Bold Step Endorsed

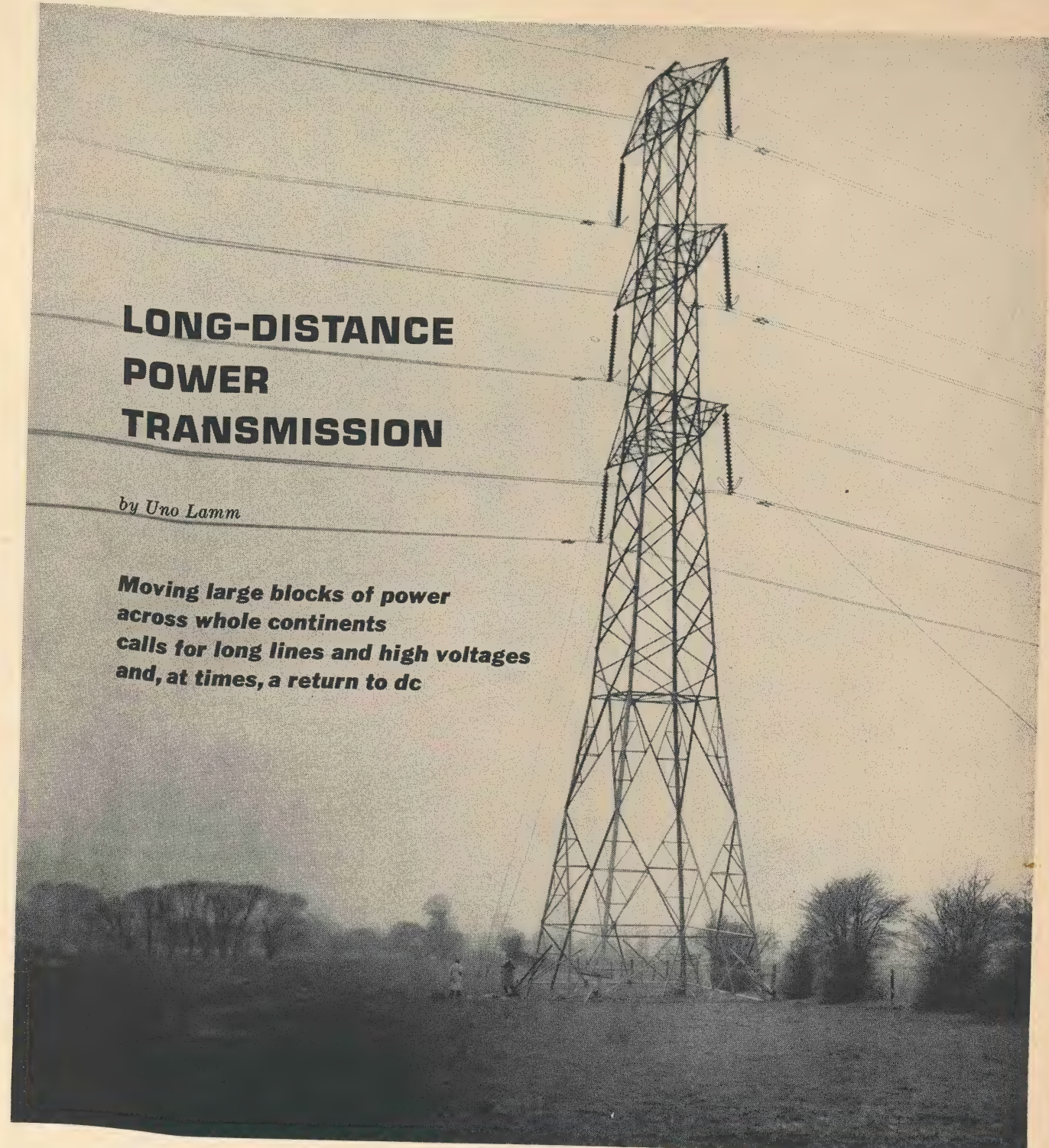
Some interference with telephone circuits and with the remote control equipment of two power supply authorities, also occurred during testing of the line. Extra temporary filtering equipment at Benmore reduced the noise to an acceptable level on South Island, but the converters at the Haywards Substation occasioned no major interference with telephone circuits on North Island.

North Island has 70% of New Zealand's population and 71% of the industry, and its last year's winter peak amounted to 1,314 Mw. Although South Island's comparable demand was only 560 Mw, it possesses far more abundant hydro-electrical sources, some so attractive technically and economically compared with North Island's remaining potential, that the country's power planner endorsed the bold step of

EHV DC TRANSMISSION

BY E. M. HUNTER, G. D. BREUER AND C. C. HERSKIND
THE GENERAL ELECTRIC COMPANY

Reprinted from TRANSMISSION & DISTRIBUTION, September, 1965



LONG-DISTANCE POWER TRANSMISSION

by Uno Lamm

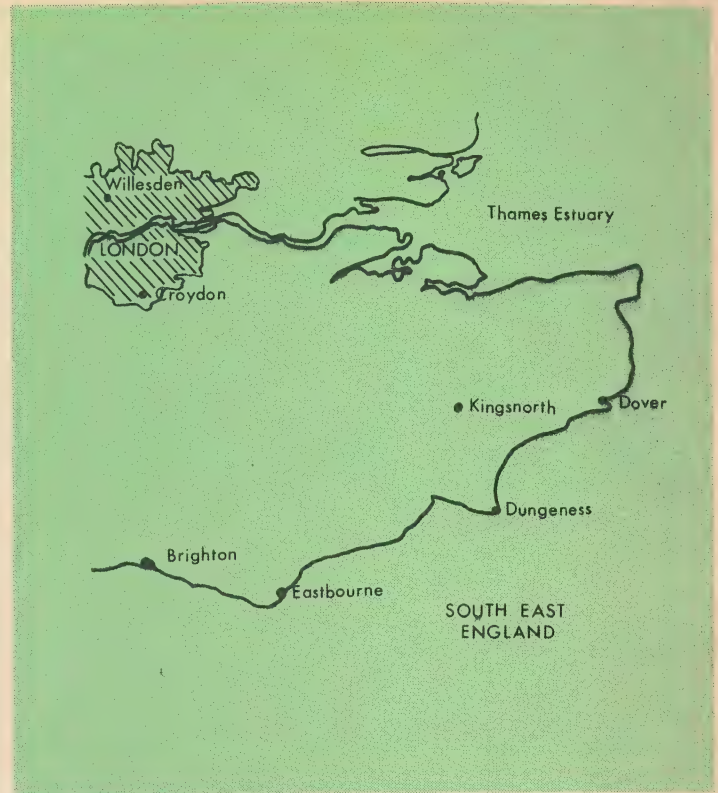
**Moving large blocks of power
across whole continents
calls for long lines and high voltages
and, at times, a return to dc**

IN BRIEF: There are many reasons for wanting to transport electric power over long distances: the desire to build power plants far from cities, the advantages of exchanging power between regions where demand occurs at different times of the day or seasons of the year, and the need to interconnect widely separated areas that have different sources of power. The key to carrying electricity over hundreds of miles, and doing it economically, is to use high voltages—a 700-kV line can carry about four

times as many watts as a 345-kV line. However, there's also the question of whether to use ac entirely or convert ac to dc for the actual transmission. Now that high-voltage convertors are practical, the latter method has been making a comeback in some of the new long-distance links. As the number of applications calling for the uninterrupted transmission of power over transcontinental distances continues to grow, you can expect that dc will play an increasingly important role.—M.F.W.

UNDERGROUND DC LINK FOR LONDON

City to have world's first
underground dc link
for metropolitan area



The world's first underground dc link for a metropolitan area, a 51-mile 266 kv transmission system is planned for London, England. A \$23 million order for electrical conversion equipment has been awarded to English Electric by Britain's Central Electricity Generating Board.

The line is scheduled to be in service by 1970. Power will be carried from a 2,000-Mw steam generating plant now under construction at Kingsnorth, in southeast England, to two points in London — first to Beddington, near Croydon 37 miles northwest of Kingsnorth, and then under the Thames to Willesden, a further 14 miles. Underground cable will be used for the entire 51-mile route. It will be the first dc power link to operate on the British mainland.

The Kingsnorth to London line will be used to move power in quantity underground into a heavily built-up area where overhead lines are out of the question. An important advantage is that dc transmission does not increase the receiving end fault level as power is added to the system. This arises from the precise and almost instantaneous control provided by the converters. The Kingsnorth-London dc link has been designed to operate as an integral part of a network and not, as in most schemes up to now, as a parallel adjunct to an existing alternating-current network.

The English Electric order covers the supply of electrical equipment for a 640-Mw converter station at Kingsnorth and similar equipment for two receiving stations. Half the power (320 Mw) will

be available at each receiving station and the flow of power into each will be separately controlled.

The design and engineering for this contract will be undertaken by English Electric's DC Transmission Division at Stafford, England, where the major part of the equipment will be built. The company is at present completing a 200-Mw dc link between Sardinia and the Italian mainland.

One positive and one negative cable at 266 kv dc to ground, together with a neutral cable, will carry the power over the 37 miles from Kingsnorth to Beddington. At Beddington, 320 Mw of power will be taken from one of these lines and the neutral. The other line and the neutral will continue 14 miles to Willesden to make another 320 Mw of power available there.

At the receiving stations the power will be fed directly into separate secondary transmission systems at 132 kv. When the receiving stations are isolated from the sending end, the dc link can be used as an interconnection for the transfer of power between south and northwest London.

The 56 4-anode mercury arc valves to be manufactured by English Electric are each rated at 133 kv, 1,200A dc in 3-phase bridge connection. At the converter stations, they will be arranged in groups of seven (six form a 3-phase bridge and one is a bypass valve); there will be four such groups at Kingsnorth (640 Mw) and two at each of the two 320 Mw receiving stations. Most of the equipment for the three converter stations will be installed indoors.

STUDY ON THE INSULATION DESIGN OF OVERHEAD DC LINES

Y. Watanabe

Central Research Institute of
Electric Power Industry
Tokyo, Japan

ABSTRACT

This paper presents the results of the study on the insulation design of overhead dc lines. Items are as follows. (1) General method of insulation design is discussed. (2) Withstand characteristics of air gaps and insulator strings for all types of voltage stresses are presented. (3) Features of the insulator string arrangements on the dc lines are discussed.

INTRODUCTION

The overhead transmission lines are subjected to stresses of various types such as the lightning overvoltages, the internal overvoltages and the operating voltage, and they are also exposed to the various meteorological conditions such as wind, rain, snow, icing and pollution. The insulations should be maintained as possible under these various situations. However, it has been generally recognized that it is uneconomical to design to withstand the most severe voltage stress under the most severe meteorological condition.

For the ac lines, the simple and convenient insulation design method, in which the combination probabilities of electrical and meteorological events are roughly considered, has been developed. As the basic concept of the insulation design of the dc lines is as same as that of the ac lines, the similar method is applied on the dc lines. Same concept has been already proposed in ref. 1.

The types of voltage stresses induced on the dc lines are different from those induced on the ac lines. Therefore, it is necessary to investigate the withstand characteristics of air gaps and insulator strings for the voltage stresses of the dc lines.

This paper presents the concept of the insulation design of the dc lines and the necessary withstand characteristics.

GENERAL CONCEPT OF INSULATION DESIGN

In the ac practice, the line insulations are generally decided by the requirements of the operating voltage and the internal overvoltages. Against the lightning, the countermeasure such as setting of ground wires or reducing tower foot resistance are considered to reduce the outage rate. Especially when the more reduction of the outage rate is necessary, the line insulations will be decided by the lightning requirement. According to this concept, lightning outages are induced frequently, while the other outages are restrained to the small frequency. The sensitivity of the insulation level to the lightning outage rate is far duller than those to other outage rates. In other words, while the lightning outage rate is not affected large-

ly by the insulation level, other outage rates are sensibly affected. Therefore, it is necessary for safety that other outage rates are controlled to smaller level than the lightning outage rate. The estimation of the lightning outages can be made by the method used for the ac lines. In this paper, the operating voltage and the internal overvoltages are generally discussed.

The internal overvoltages induced on the dc lines are classified to three types such as a switching impulse type, an ac type and a dc type. The characteristics of important overvoltages of each type

Table 1 Overvoltages on the dc lines

Cause	Builtup time (ms)	Crest voltage (p.u.)	Type
Induction to healthy poles when one pole grounding.	0.3~1	1.5~2.0	Switching impulse
Misfire of one or more value	Basic frequency	1.0~2.0	ac
Start with an open end.	2~20	1.5~2.3	dc

are shown in Table 1^{2,3}. The switching impulse type is a damped oscillation wave with the relatively steep front. The ac type is a basic frequency ac wave superposed on a dc wave. The dc type is a unilateral wave with a long front and a long tail.

The insulation design is made in accordance with several basic insulations, which are "String Length", "Horn space", "Strong Wind Space", "Middle Wind Space" and "Normal Space". Latter three spaces are tower spaces. These basic insulations are the minimum insulations maintained under certain conditions.

"String Length" is decided by the withstand characteristics of the strings contaminated with salt, snow, etc. for the dc operating voltage. The most severe overvoltage to the contaminated string is the dc type overvoltage, but its frequency is very small, so that the probability of the simultaneous occurrence with the severe contamination is negligible. The contamination withstands for other overvoltage are more than 2.6 times that for the dc voltage, while the overvoltage factors are 2.3 p.u. at most. Therefore, the internal overvoltages are not important to "String Length".

"Horn Space" is decided by the internal overvoltages. As the horn spaces are always constant, it is necessary to be correspond to the high withstand probability. However, only the dc type overvoltage is corresponded to the lower withstand probability than other overvoltages, because the dc type overvoltage is induced less frequently than other overvoltages. As discussed later, "Horn Space" is not important to the dc lines, because the required insulator string lengths is larger than the required air spaces. Therefore, the actual horn spaces will be decided almost freely.

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Price: Members \$1.50
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Design News

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RS K10

Basic Parameters Of A-C and D-C Circuits

DR. ROBERT L. PETERS,
Consultant, New York, N.Y.

This nomograph provides a simple method of establishing and relating the basic parameters of both a-c and d-c circuits. It provides nomographic relations of the fundamental parameters allowing rapid comparison of equivalent alternating and direct current circuits in terms of basic functions. For a-c, this graph relates power, apparent power, phase angle, current, voltage and impedance or reactance. For d-c circuits, it relates power, current, voltage and resistance.

With either a-c or d-c, the current can be considered as electronic drift or flow. The force that produces this flow, the electromotive force, is measured as the potential between two points. This potential, or voltage, which tends to produce current or electron movement, can be expressed in electrostatic units but is more commonly expressed in voltage. A volt is the potential that produces a current of 1 amp through a resistance of 1 ohm.

Resistance is the capacity of resisting electron flow. It is the effective force of retardation of current, measured in ohms. An ohm is the resistance that causes a potential drop of 1v in a current of 1 amp. Resistance is the reciprocal of conductance.

Impedance, the vectorial addition of resistance and reactance, is the tendency to impede the flow of an alternating current. Reactance, either inductive or capacitive, is the resistance to react to a sinusoidal current. It is the imaginary part of electrical impedance. The reactance varies with the frequency of the current. Its reciprocal is admittance.

Power, the time rate of transforming energy, (commonly measured in watts, kilowatts or horsepower) is directly proportional to both the voltage and current. A watt is the power expended in 1 joule in 1 second or 10,000,000 ergs in 1 second. An erg is the work accomplished by a force of 1 dyne exerted through 1 cm.

Active power is the time average of instantaneous a-c power:

$$P = EI \cos\phi \quad (1)$$

Apparent power is the a-c product of voltage times current:

$$P' = EI \quad (2)$$

The power factor is the ratio of active

power to apparent power:

$$P_f = P/P' = \cos\phi \quad (3)$$

Power loss may be determined by the reactive power, measured in vars (volt-ampere reactive) and is the product of the reactive current times the effective voltage. This may be equated:

$$P_q = EI_q = EI \sin\phi \quad (4)$$

The reactive current, I_q , sometimes referred to as wattless current or quadrature current, contributes to power losses without contributing usable power. This current can be equated:

$$I_q = I \sin\phi \quad (5)$$

To minimize I^2R losses, the phase angle can be reduced to its lowest value consistent with other circuit requirements. A phase angle of zero produces no reactive current.

The active current may be considered as the current divided by the cosine of the phase angle while the effective resistance may be equated as the actual resistance divided by the efficiency.

TO USE THE NOMOGRAPH:

D-C CIRCUITS:

To Determine the Power:

1) Extracting the decimals, select two of the following:

- a) The resistance on the left line
- b) The current on the right line
- c) The voltage on the line at center

2) Align these values to intersect the power on the line second from right. Restore the decimal notation as indicated.

To Determine the Resistance:

1) Extracting the decimals, select two of the following:

- a) The current on the right line
- b) The power on the next line
- c) The voltage on the line at center

2) Align these values to intersect the resistance on the left line. Restore the decimals as indicated.

To Determine the Voltage:

1) Extracting the decimals, select two of the following:

- a) The current on the right line
- b) The power on the next line
- c) The resistance on the left line

2) Align these values to intersect the voltage at center. Restore the decimals as indicated.

To Determine the Current:

1) Extracting the decimals, select two of the following:

- a) The resistance on the left line
- b) The power on the line second from right
- c) The voltage on the centerline

2) Align these values to intersect the current at right. Restore the decimals as indicated.

Example:

What is the power when the current is 2 amps and the resistance is 5 ohms?

Conference Paper



ELECTROSTATICALLY INDUCED VOLTAGES AND CURRENTS ON CONDUCTING OBJECTS UNDER EHV TRANSMISSION LINES

J. D. Tranen

G. L. Wilson
Member IEEE

Both of:
Massachusetts Institute of Technology
Department of Electrical Engineering
Cambridge, Mass.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 25-30, 1970. Manuscript submitted June 9, 1969; made available for printing December 9, 1969.

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CONSTRUCTION ASPECTS OF THE PINARD-HANMER 500 KV TRANSMISSION LINE

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Both of:

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Toronto, Ont., Canada

A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Department for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 18, 1963; made available for printing April 24, 1963.

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ENGINEERING DESIGN FEATURES OF THE PINARD-HANMER 500 KV TRANSMISSION LINE

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The Hydro-Elec. Pwr. Com. of Ontario
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A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 18, 1963; made available for printing April 24, 1963.

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63-1037

Conference Paper



OVERVOLTAGES ON ONTARIO HYDRO'S 500 KV SYSTEM AND THEIR EFFECT ON SYSTEM DESIGN

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Senior Member IEEE

W. Watson
Member IEEE

G. Nesgos

All of:
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Toronto, Ont., Canada

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APPLICATION OF NEW CONCEPTS TO 500-KV SYSTEM INSULATION COORDINATION

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R. S. Gens
Senior Member IEEE

G. A. Tupper

All of:

U. S. Department of the Interior
Bonneville Power Administration
Portland, Oregon

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Paper No.

63-941

District Conference Paper



A REVIEW OF ELECTRICAL DESIGN FACTORS FOR EHV TRANSMISSION

H. R. Stewart
Fellow IEEE
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Boston, Mass.

Submitted in abstract or outline form only to the IEEE Transmission and Distribution Committee for presentation at the IEEE Northeastern District Meeting, Portsmouth, N. H., May 20-22, 1963. Manuscript submitted February 20, 1963; made available for printing March 15, 1963.

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District Conference Paper



OPTIMIZED EHV TRANSMISSION LINE CONSTRUCTION

F. A. DENBROCK
MEMBER IEEE

Commonwealth Associates Inc.
Jackson, Michigan

A PAPER FOR PRESENTATION AT THE
IEEE GREAT LAKES DISTRICT MEETING
DAVENPORT, IOWA
May 1, 2 and 3, 1963

Conference Paper



ARC CHARACTERISTICS OF INSULATOR STRINGS FOR EHV TRANSMISSION LINES

Y. Ozaki

Central Research Institute of Electric Power Industry
Tokyo, Japan

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N. Y., January 31-February 5, 1965. Manuscript submitted October 5, 1964; made available for printing November 20, 1964.

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ECONOMIC PRIMARY CIRCUIT DESIGN BENEFICIALLY STUDIED BY UNIT SYSTEM

D. K. Blake
Member AIEE
General Electric Company
Schenectady, N. Y.

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Transactions Paper

(Reviewed and Accepted for Publication)



*Not over
750 words
J. H. Neher
J. C. K. Kinsbury
B. B. Kinsbury*

POWER DISTRIBUTION SYSTEM PARAMETERS

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J. H. Neher
Member AIEE

Both of:
Philadelphia Electric Company
Philadelphia, Pa.

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DISTRIBUTION-SUBSTATION AND PRIMARY-FEEDER PLANNING

W. J. Denton
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Des Moines, Iowa

D. N. Reys
Associate Member AIEE
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East Pittsburgh, Pa.

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OPERATING EXPERIENCE WITH 14.4/24.9 KV AS A RURAL DISTRIBUTION VOLTAGE

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OVERHEAD DISTRIBUTION AT 4.16 KV AND 12.47 KV IN URBAN AREAS

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OVERHEAD DISTRIBUTION AT 4.16 KV AND 12.47 KV IN URBAN AREAS

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*Distribution
Systems*



IMPROVE EXISTING 4 KV EXPAND AT 12 KV

G. A. Davis
Member AIEE
Planning Engineer
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Los Angeles, Calif.

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IS CONVERSION TO HIGHER DISTRIBUTION VOLTAGE JUSTIFIED?

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Philadelphia Electric Co.
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USE OF DISTRIBUTION VOLTAGES ABOVE 4 KV

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Jackson, Mich.

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USE OF DISTRIBUTION VOLTAGES ABOVE 4 KV

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Fellow AIEE
Consumers Power Company
Jackson, Mich.

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RESIDENTIAL DISTRIBUTION -- AN ANALYSIS OF SYSTEMS TO SERVE EXPANDING LOADS

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Member AIEE

Both of:
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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted October 24, 1955; made available for printing December 12, 1955.

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THE PRIMARY SERVICE UNIT SYSTEM FOR RESIDENTIAL DISTRIBUTION

A. M. Lockie
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Sharon, Pa.

H. B. Thacker
Member AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted October 24, 1955; made available for printing December 30, 1955.

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W. R. Bullard

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H. A. FREY

GENERAL PURPOSE OVERHEAD DISTRIBUTION ABOVE 5,000 VOLTS IN URBAN AREAS

W. R. Bullard
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Ebasco Services, Inc.
New York, N. Y.

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David N. Reps
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DISTRIBUTION TRANSFORMER LOAD MANAGEMENT

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H. A. FREY

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DISTRIBUTION SYSTEM PRIMARY-FEEDER VOLTAGE CONTROL

PART IV. A SUPPLEMENTARY COMPUTER PROGRAM FOR MAIN-CIRCUIT ANALYSIS

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Mr. Vase

District Conference Paper



PRACTICAL APPLICATIONS OF DIGITAL COMPUTERS TO DISTRIBUTION SYSTEMS

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Associate Member AIEE

Edward L. Busby
Associate Member AIEE

Both of:
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Dallas, Texas

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H. A. FREY

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DETERMINATION OF ECONOMICAL DISTRIBUTION SUBSTATION SIZE

J. A. Smith
Member AIEE
General Electric Company
Schenectady, N. Y.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 19-24, 1960. Manuscript submitted March 14, 1960; made available for printing May 3, 1960.

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ECONOMICS OF PRIMARY DISTRIBUTION VOLTAGES OF 4.16 THROUGH 34.5 KV

J. A. Smith
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General Electric Company
Schenectady, N. Y.

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Conference Paper



THE INFLUENCE OF TRANSMISSION ON DISTRIBUTION SYSTEM COST

D. N. Reys
Member AIEE

J. E. McNabb
Application Pending

Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

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DISTRIBUTION SYSTEM PLANNING THROUGH OPTIMIZED DESIGN PART III. CHOICE OF VOLTAGE-REGULATION POINT IN THE SYSTEM

R. F. Lawrence
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Transactions Paper

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CORRELATION OF RADIAL DISTRIBUTION FEEDER REGULATION VARIABLES AND DETERMINATION OF REGULATOR VOLTAGE CONTROL LIMITS

C. J. Couy
Member AIEE
Duquesne Light Co.
McKeesport, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 19-24, 1960. Manuscript submitted October 30, 1959; made available for printing April 27, 1960.

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SINGLE-PHASE, SINGLE-WIRE TRANSMISSION FOR RURAL ELECTRIFICATION

R. W. Atkinson
Fellow AIEE

R. K. Garg
Associate Member AIEE

Both of:
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P. O. Sindri Institute
Dhanbad (Bihar), India

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DISTRIBUTION SYSTEM PLANNING FOR GROWTH

PART I. SECONDARY SYSTEM PROGRAM DEVELOPMENT

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Associate Member AIEE

R. C. Ender
Member AIEE

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ANALYSIS OF FEEDER SERVICE CONTINUITY

J. E. McNabb
Associate Member AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

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61-227

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*Distribution
Systems*

Transactions Paper

(Reviewed and Accepted for Publication)

A
E E
I

USE OF 34.5 KV SUPPLY TO REDUCE 4.16 AND 12.47 KV

DISTRIBUTION SYSTEM INVESTMENT

Robert H. Sarikas
Associate Member AIEE
Illinois Power Co.
Decatur, Ill.

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G. M. COYD

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G. M. BOYD

POLE TOP DESIGN FOR 23 KV DISTRIBUTION

S. R. Gilligan, Jr.
Member AIEE
The Hartford Electric Light Co.
Wethersfield, Conn.

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APR 14 1961

H. A. EREY.

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61-634

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Conference Paper



IMPROVEMENT OF ELECTRIC SERVICE PERFORMANCE

PART II. SELECTIVE MODERNIZATION OF DISTRIBUTION

J. E. Weed
Associate Member AIEE
Pennsylvania Power and Light Co.
Allentown, Pa.

R. K. Moore
Member AIEE
Pennsylvania Power and Light Co.
Allentown, Pa.

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61-750

Transactions Paper

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VOLTAGE NOMENCLATURE-SECONDARY AND UTILIZATION SYSTEMS

A. S. Anderson
Fellow AIEE
Ebasco Services, Inc.
New York, N.Y.

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61-805

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District Conference Paper



ENGINEERING AND APPLICATION PRINCIPLES FOR ESTIMATING
DISTRIBUTION TRANSFORMER LOADS BY THE LOAD FACTOR METHOD

C. F. Mitchell
Member AIEE
RTE Corporation
Waukesha, Wis.

RECEIVED

MAR 26 1962

H. A. FREY.

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62-609

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District Conference Paper



ECONOMICS OF CONVERTING A DISTRIBUTION SYSTEM

FROM 5 KV DELTA TO 13.2 KV WYE

R. M. Decker
Associate Member AIEE

W. A. Wickes
Associate Member AIEE

Both of:
The Cleveland Electric Illuminating Co.
Cleveland, Ohio

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Middle Eastern District Meeting, Wilmington, Delaware, May 7-9, 1962. Manuscript submitted January 31, 1962; made available for printing March 14, 1962.

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H. A. EREY

District Conference Paper



VOLTAGE REGULATION OF A NEW POWER SYSTEM INTERCONNECTION

W. J. Pitcher
Associate Member AIEE

R. B. Killen
Member AIEE

Both of:
The Dayton Power and Light Co.
Dayton, Ohio

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PLANNING FUTURE DEVELOPMENT OF DISTRIBUTION SUBSTATIONS IN THE TWIN CITIES AREA

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Member AIEE
Northern States Power Co.
Minneapolis, Minn.

G. W. Alexander
Member AIEE
General Electric Co.
Minneapolis, Minn.

J. A. Smith
Member AIEE
General Electric Co.
Schenectady, N. Y.

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Conference Paper



SIMPLIFIED CALCULATION OF ZERO-SEQUENCE IMPEDANCE OF DISTRIBUTION LINES

L. W. Long
Senior Member IEEE
Duke Power Company
Charlotte, N. C.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Region 3 Meeting, Richmond, Va., April 24-26, 1963. Manuscript submitted February 13, 1963; made available for printing February 21, 1963.

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Transactions Paper

(Reviewed and Accepted for Publication)



SHIELDING 13.8 KV DISTRIBUTION CIRCUITS

M. L. Hurstell
Member AIEE

M. G. West
Nonmember AIEE

Both of:
New Orleans Public Service Inc.
New Orleans, La.

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H. A. FREY

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49-60	RADIO INFLUENCE FROM HIGH-VOLTAGE CORONA	GR Stemon	Hydro-Elec Power Toronto, Ont., Ca	December 1948
50-141	DESERT MEASUREMENTS OF CORONA LOSS ON CONDUCTORS FOR OPERATION ABOVE 230 KV	WS Peterson B. Cozzens JS Carrol1	Dept Water & Power Los Angeles, CA Stanford Univ.	April 1950
51-12	CORONA INVESTIGATION ON EXTRA-HIGH-VOLTAGE LINES -- 500 KV TEST PROJECT OF THE AMERICAN GAS & ELEC. CO.	IM Gross CF Wagner O. Naef RL Tramaine	Am Gas & Elec Ser Westinghouse Am Gas & Electric Westinghouse	November 1950
51-204	ANALYSIS OF TOTAL & INCREMENTAL LOSSES IN TRANSMISSION SYSTEMS	LK Kirchmayer GW Stag	GE - Schenectady Am Gas & Elec	May 1951
51-224	LINE INSULATOR LOSS UNDER NORMAL CONDITIONS --- 500 KV TEST PROJECT OF THE AMERICAN GAS & ELEC. CO.	O. Naef RL Tremaine AR Jones	Am. Gas & Electric Westinghouse Westinghouse	May 1951
51-336	THE MECHANISM OF CORONA ON A-C TRANSMISSION LINES	R. Pelissier	Electricite de France Paris, France	Sept. 1951
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57-806	CORONA LOSS MEASUREMENTS ON BUNDLE CONDUCTORS - 500 KV TEST PROJECT OF AG&E	BL Lloyd O. Naef	Westinghouse Corp Am. Gas & Elec.	May 1957
58-57 (8)	DEVELOPMENT OF CORONA SHIELDS FOR SUSPENSION ASSEMBLIES OF BUNDLED CONDUCTOR TRANSMISSION LINES	J. Kaminski, Jr.	General Electric Insulator Dept.	November 1957
59-49	RADIO NOISE PROPAGATION AND ATTENUATION TESTS ON BONNEVILLE POWER ADMINISTRATION McNARY-ROSS 345 KV LINE	GE Adams TW Liao MG Poland FJ Trebbly	GE-Schenectady GE-Philadelphia BPA-Portland, OR Kaiser Alum & Chem.	February 1959
59-79	DEVELOPMENT OF A SQUARE LAW RADIO NOISE METER - I	FJ Trebbly	Kaiser Alum & Chem.	February 1959
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61-795	THE SPECTRUM OF CORONA NOISE NEAR A POWER TRANSMISSION LINE	CW Helstrom	Westinghouse Corp Pittsburg, PA	May 1961
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CP 61-1099	SELECTION OF SINGLE & BUNDLE CONDUCTORS & ACCESSORIES FOR ACCEPTABLE RADIO NOISE PERFORMANCE	LO Barthold J. Kaminski JJ LaForest HE House	GE-Schenectady GE-Baltimore GE-Pittsfield Alum Co. of America	August 1961
62-1096 (2)	LEADVILLE HIGH ALTITUDE EVH TEST PROJECT SINGLE CONDUCTOR TESTS	LM Robertson JC Smith WE Pakala JE O'neil	Pub Ser of Colorado " " " " Westinghouse Corp	May 1962
62-1367	AN INVESTIGATION OF RADIO INFLUENCE VOLTAGES ON TRANSMISSION & DISTRIBUTION LINES ON THE SAME RIGHT-OF-WAY METHOD OF EVALUATING CORONA NOISE GENERATION FROM MEASUREMENTS ON SHORT TEST LINES	FL Taylor JF Bouska MC Perz	Detroit Edison Co Commonwealth Edison Hydro-Elec Power Co Toronto, Ont., Can.	August 1962
CP 62-1405	RADIO INTERFERENCE FROM HIGH VOLTAGE LINES PART II - DISTRIBUTION & CORRELATION	RJ Mather BM Bailey	Fed Power Comm. BPA-Portland, OR	November 1962
63-92	WEATHER, CORONA AND THE DECAY OF TRAPPED ENERGY ON TRANSMISSION LINES	JE Beehler	Am Elec & Power New York, NY	November 1963
64-47	ALTERNATING CURRENT CORONA IN FOUL WEATHER PART I - ABOVE FREEZING POINT	L. Boulet BJ Jakubczyk	Univ. Laval Quebec, Canada	December 1963
64-51	CORONA CHARACTERISTICS OF HELICALLY FORMED ALUMINUM ALLOY ARMOR RODS	PB Jacob, Jr. RL Reese	Miss. St. Univ. Fanner Mfg. Co.	February 1964
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31 CP 65-125	CORONA LOSS CHARACTERISTICS OF EVH TRANSMISSION LINES BASED ON PROJECT EVH RESEARCH	JG Anderson M. Baretsky, Jr. DD MacCarthy	General Electric Pittsfield, MA	May 1965
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70 TP 104-PWR				
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RADIO INFLUENCE FROM HIGH-VOLTAGE CORONA

Gordon R. Slemon
Associate AIEE
The Hydro-Electric Power Commission of Ontario
Toronto, Ontario, Canada

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DESERT MEASUREMENTS OF CORONA LOSS ON CONDUCTORS FOR OPERATION ABOVE 230 KV

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CORONA INVESTIGATION ON EXTRA-HIGH-VOLTAGE LINES —
500-KV TEST PROJECT OF THE AMERICAN GAS AND ELECTRIC COMPANY

I. W. Gross American Gas and Electric Service Corp.
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ANALYSIS OF TOTAL AND INCREMENTAL LOSSES IN TRANSMISSION SYSTEMS

L. K. Kirchmayer
Associate AIEE

General Electric Company
Schenectady, N. Y.

G. W. Stagg
Nonmember AIEE

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LINE INSULATOR LOSS UNDER NORMAL CONDITIONS —

500-KV TEST PROJECT OF THE AMERICAN GAS AND ELECTRIC COMPANY

O. Naef American Gas and Electric Service Corp.
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THE MECHANISM OF CORONA ON A-C TRANSMISSION LINES

R. Pelissier
Nonmember AIEE
Electricite de France
Paris, France

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IMPULSE CORONA -- DETECTION, MEASUREMENT OF INTENSITY AND DAMAGE PRODUCED

J. H. Hagenguth
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(Reviewed and Accepted for Publication)



CORONA STUDIES -- IN RELATION TO INSULATION

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EFFECTS OF CORONA ON TRAVELING WAVES

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FIELD STUDIES OF NOISE AT TELEVISION FREQUENCIES FROM POWER CIRCUITS

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted October 17, 1955; made available for printing November 25, 1955.

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VARIATIONS IN RADIO AND TELEVISION INTERFERENCE FROM TRANSMISSION LINES

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, January 30-February 3, 1956. Manuscript submitted October 20, 1955; made available for printing December 15, 1955.

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CONSIDERATIONS IN SPECIFYING CORONA TESTS

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A paper recommended by the AIEE Committee on Dielectrics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted October 19, 1955; made available for printing December 14, 1955.

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THE FRENCH 380 KV SYSTEM

MEASUREMENT OF CORONA LOSSES ON TRANSMISSION LINES UNDER NORMAL OPERATING CONDITIONS

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Jean M. Carteron
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A paper recommended by the AIEE Committee on Transmission and Distribution for the AIEE North Eastern District Meeting, Pittsfield, Mass., May 1-3, 1957. Manuscript submitted January 28, 1957; made available for printing March 13, 1957.

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AN ELECTRONIC ELECTROMETER AS A VERSATILE CORONA DETECTOR

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Both of:
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A paper recommended by the AIEE Committee on Special Instruments and Auxiliary Apparatus and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Manuscript submitted November 16, 1956; made available for printing April 12, 1957.

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CORONA LOSS MEASUREMENTS ON BUNDLE CONDUCTORS -

500-KV TEST PROJECT OF AG&E

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DEVELOPMENT OF CORONA SHIELDS FOR SUSPENSION ASSEMBLIES OF BUNDLED CONDUCTOR TRANSMISSION LINES

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General Electric Co.
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A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 14, 1957; made available for printing November 7, 1957.

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DEVELOPMENT OF CORONA SHIELDS FOR SUSPENSION ASSEMBLIES OF BUNDLED CONDUCTOR TRANSMISSION LINES

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RADIO NOISE PROPAGATION AND ATTENUATION TESTS ON BONNEVILLE POWER ADMINISTRATION McNARY-ROSS 345 KV LINE

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Transactions Paper

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DEVELOPMENT OF A SQUARE LAW RADIO NOISE METER - I

F. J. Trebby
Member AIEE

Kaiser Aluminum & Chemical Corp
Spokane, Wash.

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H. A. FREY

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A CORRELATION OF THE PRESENT WITH A PROPOSED STANDARD METHOD FOR RIV MEASUREMENTS ON HIGH VOLTAGE DEVICES

Charles J. Miller, Jr.
Fellow AIEE
The Ohio Brass Company
Barberton, Ohio

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M. A. FREY

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THE EFFECT OF RAIN ON R.I.V. CHARACTERISTICS OF HIGH VOLTAGE SUSPENSION ASSEMBLIES

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THE EFFECT OF RAIN ON R.I.V. CHARACTERISTICS OF HIGH VOLTAGE SUSPENSION ASSEMBLIES

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WAVE PROPAGATION ALONG UNBALANCED HIGH VOLTAGE TRANSMISSION LINES

G. E. Adams
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Schenectady, N. Y.

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RELATIONSHIP BETWEEN CORONA AND RADIO NOISE ON TRANSMISSION LINES

PART II. CONDUCTOR AND INSULATOR CORONA

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Both of:
General Electric Company
Pittsfield, Mass.

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DEVELOPMENT OF A SQUARE LAW RADIO NOISE METER - II

F. J. Trebby

Member AIEE

Kaiser Aluminum & Chemical Corp.
Spokane, Wash.

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Transactions Paper

(Reviewed and Accepted for Publication)

Mr. Von
Carson



THE ELECTRIC STRESS GRADING OF INSULATOR STRINGS AND THEIR RADIO INFLUENCE VOLTAGES

A. S. Denholm
Associate Member AIEE
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THE CALCULATION OF ATTENUATION CONSTANTS FOR RADIO NOISE ANALYSIS OF OVERHEAD LINES

G. E. Adams
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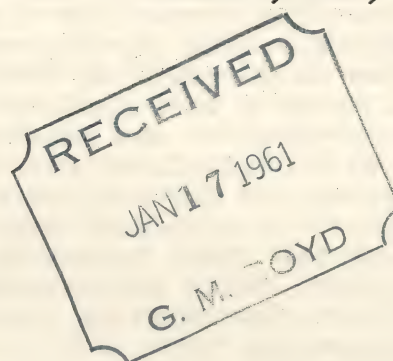
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(Reviewed and Accepted for Publication)

A
E E
I

INSTRUMENTATION FOR POWER LOSS AND METEOROLOGICAL MEASUREMENTS AT THE ONTARIO HYDRO COLDWATER PROJECT

J. M. Vanderleck
Member AIEE
The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada



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H. A. FREY

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THE SPECTRUM OF CORONA NOISE NEAR A POWER TRANSMISSION LINE

Carl W. Helstrom
Nonmember AIEE
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(Reviewed and Accepted for Publication)



✓

RADIO INFLUENCE TESTING ON 70 MILES OF 345 KV HORIZONTAL BUNDLE CONDUCTOR

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Both of:
Ohio Edison Co.
Akron, Ohio

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H. A. EREY

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Conference Paper



SELECTION OF SINGLE AND BUNDLE CONDUCTORS AND ACCESSORIES FOR ACCEPTABLE RADIO NOISE PERFORMANCE

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Corona

Transactions Paper

(Reviewed and Accepted for Publication)



LEADVILLE HIGH ALTITUDE EHV TEST PROJECT SINGLE CONDUCTOR TESTS

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A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Denver, Colo., June 17-22, 1962. Manuscript submitted March 21, 1962; made available for printing May 1, 1962.

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Paper No.

62-1096

Discussion in Duplicate Due July 6, 1962.

Transactions Paper

(Reviewed and Accepted for Publication)

A
E E
I

LEADVILLE HIGH ALTITUDE EHV TEST PROJECT SINGLE CONDUCTOR TESTS

L. M. Robertson
Fellow AIEE
Public Service Co. of Colorado
Denver, Colo.

J. C. Smith
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A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Denver, Colo., June 17-22, 1962. Manuscript submitted March 21, 1962; made available for printing May 1, 1962.

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AN INVESTIGATION OF RADIO INFLUENCE VOLTAGES ON TRANSMISSION AND DISTRIBUTION LINES ON THE SAME RIGHT-OF-WAY

F. L. Taylor
Member AIEE
The Detroit Edison Co.
Detroit, Mich.

J. F. Bouska
Associate Member AIEE
Commonwealth Edison Co.
Chicago, Ill.

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H. A. FREY

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 7-12, 1962. Manuscript submitted June 8, 1962; made available for printing August 7, 1962.

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Paper No.

62-1367

Discussion in Duplicate Due October 26, 1962.

~~M. C. Perz~~
~~" Kanishk~~
~~" Kunglun~~

Corona

Conference Paper



METHOD OF EVALUATING CORONA NOISE GENERATION FROM MEASUREMENTS ON SHORT TEST LINES

M. C. Perz
Associate Member AIEE
The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 7-12, 1962. Manuscript submitted June 13, 1962; made available for printing August 15, 1962.

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Paper No. **CP**

62-1405

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Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due February 15, 1963.

IEEE

RADIO INTERFERENCE FROM HIGH VOLTAGE LINES

PART II. DISTRIBUTION AND CORRELATION

R. J. Mather
Senior Member IEEE
Federal Power Commission
Washington, D. C.

B. M. Bailey
Member IEEE
U. S. Dept. of the Interior
Bonneville Power Administration
Portland, Oregon

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the Winter General Meeting, New York, N. Y., January 27-February 1, 1963. Manuscript submitted April 17, 1962; made available for printing November 20, 1962.

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Paper No.

63-92

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(Reviewed and Accepted for Publication)

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WEATHER, CORONA AND THE DECAY OF TRAPPED ENERGY ON TRANSMISSION LINES

J. E. Beehler
Senior Member IEEE
American Electric Power Service Corp.
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A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 1, 1963; made available for printing November 29, 1963.

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Paper No.

64-47

Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due February 21, 1964.



ALTERNATING CURRENT CORONA IN FOUL WEATHER

PART I. ABOVE FREEZING POINT

L. Boulet
Senior Member IEEE

B. J. Jakubczyk

Both of:
Université Laval
Faculté des Sciences
Quebec, Canada

A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 4, 1963; made available for printing December 5, 1963.

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Paper No.

64-51

Conference Paper



CORONA CHARACTERISTICS OF HELICALLY FORMED ALUMINUM ALLOY ARMOR RODS

P. B. Jacob, Jr.
Senior Member IEEE
Dept. of Electrical Engineering
Mississippi State University
State College, Mississippi

R. L. Reese
Member IEEE
The Fanner Mfg. Co.
Cleveland, Ohio

Submitted in abstract or outline form only to the
IEEE Transmission and Distribution Committee for
presentation at the IEEE Winter Power Meeting,
New York, N. Y., February 2-7, 1964.

Conference Paper



CORONA CHARACTERISTICS OF HELICALLY FORMED ALUMINUM ALLOY ARMOR RODS

P. B. Jacob, Jr.
Senior Member IEEE
Dept. of Electrical Engineering
Mississippi State University
State College, Mississippi

R. L. Reese
Member IEEE
The Fanner Mfg. Co.
Cleveland, Ohio

Submitted in abstract or outline form only to the
IEEE Transmission and Distribution Committee for
presentation at the IEEE Winter Power Meeting,
New York, N. Y., February 2-7, 1964.

JOE KAMINSKI

Conference Paper



CORONA AND TRACKING ON AERIAL SPACER CABLE
IN TWO OUTDOOR ACCELERATED TEST STATIONS
AN INTERIM PROJECT REPORT

J. C. Thompson
Member IEEE
Houston Lighting and Power Co.
Houston, Texas

G. H. Redden
Member IEEE
Olin Mathieson Chemical Corp.
Chattanooga, Tenn.

A paper recommended by the IEEE Insulated Conductors Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N. Y., January 31-February 5, 1965. Manuscript submitted November 2, 1964; made available for printing December 29, 1964.

Price: \$1.00
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Paper No.

31 CP 65-125

Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due July 16, 1965.



CORONA LOSS CHARACTERISTICS OF EHV TRANSMISSION LINES

BASED ON PROJECT EHV RESEARCH

J. G. Anderson

M. Baretzky, Jr.

D. D. MacCarthy

All of:
General Electric Company
Pittsfield, Mass.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, Detroit, Mich., June 27-July 2, 1965. Manuscript submitted March 29, 1965; made available for printing May 5, 1965.

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Paper No.

31 TP 65-700

Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due October 20, 1965.



ALTERNATING CURRENT CORONA IN FOUL WEATHER.

PART II - BELOW FREEZING POINT

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Quebec Hydro-Electric Comm.
Montreal, Que., Can.

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Quebec Hydro-Electric Comm.
Montreal, Que., Can.

B. J. Jakubczyk
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A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE EHV-AC Transmission Conference, Richmond, Va., October 4-6, 1965. Manuscript submitted July 5, 1965 ; made available for printing August 20, 1965.

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Paper No.

31 TP 65-808

Transactions Paper

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DISCUSSION IN QUADRUPLICATE DUE February 13, 1970.



LONG AND SHORT LINE RADIO INFLUENCE CHARACTERISTICS

B. M. Bailey
Member IEEE
Bonneville Power Administration
Portland, Oregon.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 25-30, 1970. Manuscript submitted September 12, 1969; made available for printing November 21, 1969.

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Paper No.

70 TP 103 - PWR

Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 13, 1970.



SOME OBSERVATIONS OF FOUL WEATHER EHV TELEVISION INTERFERENCE

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Bonneville Power Administration
Portland, Oregon.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N. Y., January 25-30, 1970. Manuscript submitted September 11, 1969; made available for printing December 2, 1969.

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Paper No.

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Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 13, 1970.



PREDETERMINATION OF CORONA LOSSES UNDER RAIN INFLUENCE OF RAININTENSITY AND UTILIZATION OF AN UNIVERSAL CHART

J. J. Cladé
Member IEEE

C. H. Gary

Both of:
Electricite de France
Paris, France.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 25-30, 1970. Manuscript submitted September 15, 1969; made available for printing November 21, 1969.

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Paper No.

70 TP 106 - FWR

INDEX FOR: COATINGS (See Contamination)

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13-24	IMMERSION TEST FOR UNIFORMITY AND THICKNESS OF ALUMINUM ON ALUMINIZED STEEL	HJ Wittrock	Kaier Alum. Co. Spokane, WA	4/17/53
4TP432	METAL COATINGS - ALUMINIZING OF STEEL	JF Bacon EJ Mets	General Electric Pittsfield, MA	6/17/54
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IEE	SURVEY OF INSULATOR TREATMENT WITH SILICONES AND OTHER COMPOUNDS	H. N. Ekval		1/22/57
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1A-176 (3)	SPRAY APPLICATION OF SILICONE GREASE TO COMBAT INSULATOR SURFACE CONTAMINATION	RH Lester	General Electric Baltimore, MD	5/59

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Number	Title	Author	Company	Date
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GENERAL ELECTRIC
Research Laboratory

CONDUCTING COATINGS FOR VERY HIGH VOLTAGE GRADIENTS

by

Katharine B. Blodgett, Research Laboratory, and
Lynn H. Stauffer, General Engineering and Consulting Laboratory

Report No. RL 111

October, 1948

SCHENECTADY, NEW YORK

Cooling

Locke Aug 1949

TECHNICAL INFORMATION SERIES

REPORT NO. 49TP208-3

TITLE
CONDUCTING GLAZE ON PORCELAIN
INSULATORS

AUTHOR L.W. SPOONER
AUGUST 8, 1949

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR L. W. Spooner	SUBJECT CLASSIFICATION -----	NO. 49TP208-3
		DATE Aug. 8, 1949
TITLE Conducting Glaze on Porcelain Insulators		
ABSTRACT The properties of a ceramic conducting glaze on a British made porcelain insulator were studied. The dependence of resistance upon temperature, voltage and time at elevated wattages was measured. Probable composition and condition of firing are reported.		
G.E. CLASS III	REPRODUCIBLE COPY FILLED TECHNICAL SERVICE DIV. PITTSFIELD	NO. PAGES 6
GOV. CLASS None	PW Data Bureau	
CONCLUSION This ceramic glaze has a resistivity of 0.6 meg per square at 30°C and a large negative temperature coefficient. The resistivity is independent of voltage gradient within the limits of our tests. When immersed in oil, a wattage intensity of 5.8 watts per square inch was dissipated without significant change for more than 50 days. Fe_3O_4 appears to be the conducting element and the glaze was probably fired in air.		

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INFORMATION PREPARED FOR Engineering Information

TESTS MADE BY L. W. Spooner and R. E. Leab

COUNTERSIGNED S. E. Q. Ashley L. W. Spooner DIV. Pittsfield Works Laboratory

TRANSFORMER & ALLIED PRODUCT DIVISIONS

PITTSFIELD

Coatings

PROGRESS REPORT

No. 53-24

IMMERSION TEST FOR UNIFORMITY AND THICKNESS
OF ALUMINUM ON ALUMINIZED STEEL

H^c J. WITTROCK

April 17, 1953

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PR NO. 53-24

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KAISER ALUMINUM & CHEMICAL CORPORATION

Division of Metallurgical Research

P. O. Box 1451
Spokane 10, Washington

PROGRESS REPORT

Project No. 817-2

Date: April 17, 1953

SUBJECT: IMMERSION TEST FOR UNIFORMITY AND THICKNESS OF ALUMINUM
ON ALUMINIZED STEEL

SUMMARY

An immersion test, similar to the Preece test for galvanized steel, was developed for determining the uniformity and thickness of the aluminum coating on aluminized steel. A variety of etching solutions were explored. The preferred solution contains copper and fluoride ions, and hydrofluoric or sulfuric acids. When the latter acid is used, the fluoride may be added as a solid ammonium salt. This reduces the hazard to personnel.

The test consists of repeatedly immersing the aluminized steel specimen in a suitable etching solution and noting when the intermetallic compound and the bare iron become exposed. The aluminum appears bright and granular, while the intermetallic layer is dark grey and matte. Wherever it has become exposed, the iron is coated with an adherent layer of copper. A clear distinction is thus afforded between the aluminum, the aluminum-iron intermetallic compound, and the iron. Weight loss measurements indicate a removal of the aluminum coating at the rate of 0.00023 inch per immersion.

The test requires only about ten minutes to perform. It can undoubtedly be used in its present form, but further work is needed for a complete understanding of the operating variables.

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
JF Bacon	Metal Coatings	54TP432
EJ Mets <i>EJMS</i>		DATE 6-17-54
TITLE Aluminizing of Steel		

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
JF Bacon EJ Mets <i>EJM</i>	Metal Coatings	54TP432
TITLE		DATE
Aluminizing of Steel		6-17-54
ABSTRACT		
1012 steel has been hot-dip aluminized, with and without flux pre-treatments. The effects of immersion time, bath temperature and bath composition, on coating thickness, structure, appearance, mechanical properties and corrosion resistance, have been examined.		
G.E. CLASS	REPRODUCIBLE COPY FILED	NO. PAGES
3	TECHNICAL DOCUMENTS	
GOV. CLASS	PW Data Bureau	24
None		
CONCLUSION		
Better aluminum coatings were obtained on mild steel without any flux preparation. Aqueous flux solutions had no significant advantage, while molten fluxes appear desirable for larger ferrous parts to obtain uniform coating thickness.		
The presence of 3% Fe in a commercially pure aluminum bath increased coating thickness up to 25% with no significant effect on ductility or corrosion resistance.		
Accelerated corrosion tests show the superiority of aluminized steel in industrial-type atmosphere.		

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Distribution Transformer Engineering

TESTS MADE BY E. J. Mets and J. F. Bacon

COUNTERSIGNED R. T. Foley *RTF*

SECTION Metallurgical Development
Materials & Processes Laboratory
Transformer Division, Pittsfield

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GENERAL ELECTRIC
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Coating

DETECTION OF THIN INSULATING FILMS ON METALS

by

D. G. Flom and R. H. Savage

Report No. RL-1188 - *Submitted by D. G. Flom and R. H. Savage* October 1954

CLASS 1

SCHENECTADY, NEW YORK

~~Mr. [unclear]~~
Pls note + pass to
product Engineering
10/27

H. A. Frey
Lacke Dept.
Baltimore

TECHNICAL INFORMATION SERIES

Title Page		
AUTHOR	SUBJECT CLASSIFICATION	NO.
EJ Mets EJ Mats	Metal Coatings	54TP481
		DATE
		12-9-54
TITLE		
Preparation & Corrosion Resistance of Aluminized Power-Line Hardware		

~~Handwritten notes and signatures on the left side of the page, including "Mr. [unclear]" and "Mrs. [unclear]".~~

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR EJ Mets <i>EJ Mets</i>	SUBJECT CLASSIFICATION Metal Coatings	NO. 54TP481
		DATE 12-9-54
TITLE Preparation & Corrosion Resistance of Aluminized Power-Line Hardware		
ABSTRACT Power-line hardware parts have been hot-dip aluminized and evaluated in accelerated corrosion exposures of salt fog and sulfur atmosphere by comparison with standard galvanized parts.		
G.E. CLASS 3	REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS	NO. PAGES
GOV. CLASS None	PW Data Bureau	11
CONCLUSION Caps and ball bolts have been successfully hot-dip aluminized without the use of flux. Accelerated corrosion tests in salt fog show aluminized coatings of 1.5-2 mils to be 2-3 times more resistant to attack than galvanized coatings of 3-4 mils. In sulfur atmosphere, this advantage is at least five times over galvanized coatings.		

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TESTS MADE BY J. F. Bacon - E. J. Mets

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GENERAL ENGINEERING LABORATORY

Coatings

COATING BY THE FLUIDIZED BED TECHNIQUE

By

J. Gaynor

Report No. R56GL204

June 29, 1956

(211)

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General Engineering Laboratory

SCHENECTADY, NEW YORK

TECHNICAL INFORMATION SERIES

AUTHOR	SUBJECT CLASSIFICATION	NO.
J. Gaynor	Coatings	R56GL204
		DATE
		6/29/56
TITLE		
COATING BY THE FLUIDIZED BED TECHNIQUE		
ABSTRACT		
A review of the patent literature on coatings via powdered solids is presented. In addition, the results of an experimental program, not yet complete, to apply polymer, glass, ceramic, and metal coatings to a variety of substrates, via a fluidized bed		
G.E. CLASS	REPRODUCIBLE COPY FILED AT LIBRARY OF GENERAL ENGINEERING LABORATORY SCHENECTADY, NEW YORK	NO. PAGES
2		
GOV. CLASS.		12
CONCLUSIONS		
technique, where the article to be coated is not heated prior to exposure to the fluidized bed, are presented. The state of the art including the work in General Electric is discussed and a plan for action suggested.		

INFORMATION PREPARED FOR GENERAL ENGINEERING LABORATORY

TESTS MADE BY J. Gaynor, Wm. J. Vallier

AUTHOR Dr. Joseph Gaynor

COUNTERSIGNED M.L. Feldman *M. L. Feldman* H.R. Schmidt

COMPONENT CHEMICAL ENGINEERING

Coatings

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR GH Smith	SUBJECT CLASSIFICATION Steel-Silicon Gauging Thin Films	NO. 56TP483 DATE 12-24-56
TITLE Gauging Thin Non-Magnetic Coatings on Oriented SX-10 Strip		

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR GH Smith	SUBJECT CLASSIFICATION Steel-Silicon Gauging Thin Films	NO. 56TP483 DATE 12-24-56
TITLE Gauging Thin Non-Magnetic Coatings on Oriented SX-10 Strip		
ABSTRACT An evaluation of the Pocket Handi-Gauge, Aminco Brenner Magne-Gauge, Elcometer, and G-E Thickness Gauge Type B for measuring the thickness of thin insulating coatings on oriented electrical steel strip has been made.		
G.E. CLASS 3 GOV. CLASS None	REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS PW Data Bureau	NO. PAGES 47
CONCLUSION 1. With proper use, the Pocket Handi-Gauge, Aminco Brenner Magne-Gauge, Elcometer, and G-E Thickness Gauge Type B can be used to measure the thickness in the range 0.1 to 0.6 mil of non-magnetic films on oriented electrical steel strip. 2. Sample to sample variations, size of sample, backing material under sample, and direction of testing (with- or cross-grain) were found to influence the calibration of the instruments. 3. The accuracy (3 Sigma) for readings taken with the gauges was: ± 0.18 mil for the Pocket Handi-Gauge, ± 0.15 mil for the Magne-Gauge, ± 0.03 mil for the Elcometer and G-E Type B. (Project No. 1-3-4)		

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INFORMATION PREPARED FOR General Engineering Information

TESTS MADE BY HI Marcil, Mrs. BM Perkins, Mrs. MO Dojka, GH Smith

COUNTERSIGNED W. L. Chu SECTION Metallurgical Development

BUILDING and ROOM No. 7-223 LOCATION Materials & Processes Laboratory Transformer Division, Pittsfield

~~Insulators~~
Coatings

SURVEY OF INSULATOR TREATMENT
WITH
SILICONES AND OTHER COMPOUNDS

AIEE Lightning and Insulator Subcommittee

Report by
H. N. Ekvall

January 22, 1957

Mr. B. Kingbury

GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT

Technical Report No. IK-153-CR

June 24, 1957

SUBJECT

COATING TO DEVELOP A HYDROPHOBIC SURFACE

Ronald H. Lester

This report contains:

4 typewritten pages
4 tables
1 nomograph
2 photographs

Baltimore, Maryland

Signed

R. H. Lester

Approved

D. C. Trues

B. Kingsbury

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GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT

Technical Report No. LK-153-CR
Supplement #1

October 9, 1957

Coating To Develop a Hydrophobic Surface

Ronald H. Lester

This report contains

3 typewritten pages
2 tables
6 charts

Baltimore, Maryland

Signed

Ronald H. Lester

Approved

W. C. Thies

JAN 29 1958

Coatings

Conference Paper



INTERNAL OXIDATION MECHANISM FOR NON-TRACKING ORGANIC INSULATIONS

R. S. Norman
Associate Member AIEE

A. A. Kessel
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A paper recommended by the AIEE Dielectrics Committee for the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 14, 1957; made available for printing December 6, 1957.

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Paper No. **CP**

58-211

Transactions Paper

(Reviewed and Accepted for Publication)

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H. A. FREY



Coatings

A SYSTEM FOR GAGING PLATING THICKNESS

R. G. Myers
Associate Member AIEE
Argonne National Laboratory
Lemont, Ill.

D. L. Waidelich
Fellow AIEE
University of Missouri
Columbia, Mo.

A paper recommended by the AIEE Special Instruments and Auxiliary Apparatus Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Manuscript submitted January 17, 1958; made available for printing April 25, 1958.

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Paper No.

58-933

Discussion in Duplicate Due July 9, 1958.

SPRAY APPLICATION OF SILICONE GREASE TO COMBAT INSULATOR SURFACE CONTAMINATION

By R. H. Lester
Ceramic Research Engineer
Insulator Department
General Electric Company

Industrial and natural contaminations have created operating problems on electric utility systems for many years. Attempts to nullify the effects of these contaminants on electrical insulators have included special insulator designs, umbrella shields of varying shapes, high pressure washing equipment, and the application of special waxes, oils, and greases. Each method has its specific benefits and shortcomings.

Over-insulation, the use of insulators larger than normally required, has solved many problems. Special fog type insulators, built with lengthened leakage distances, have been used with reasonable success in a number of areas. This added leakage distance may not be sufficient when considering the tremendous decrease in surface resistance caused by the electrolytic form of the moistened contaminants.

Periodic washings with high pressure water jets has been necessary in some areas. In some local applications, it has been a practice to take a station out of service for a period of time, remove the insulators, clean them by hand with special preparations, and replace them. Boiling in caustics has sometimes been necessary to remove certain bonding contaminants.

An early approach to the solution of the contamination problem was the trial of surface treatments with oils, waxes and greases, but the organic nature of these materials often resulted in their rapid deterioration under corona conditions. In October 1950, a silicone fluid, (see page 6, Ref. 1), was introduced and showed considerable improvement over the organic material. Other noteworthy investigations have since been made in the use of silicone greases and waxes, (see page 6, Refs. 2, 3, 4 and 5.) In 1958 a forward step in the solution of contamination problems was made by the introduction of a new silicone. This new silicone is suitable for use in the conventional grease form but has the outstanding advantage in that it may be placed in solution for spray application.

Field and laboratory tests show that the liquid silicone can be applied to moderately contaminated insulators without the necessity of first cleaning the insulator to remove the contaminant and successful reapplication of the liquid silicone has been achieved with cost savings benefits by simply spraying over dirt saturated grease. The purpose of this article is to explain the coating theory of the new silicone and to briefly describe the laboratory testing required to demonstrate its effectiveness.

THEORY OF SILICONE FUNCTIONING

The theory of the use of the early silicone waxes was to provide a hard, smooth surface, and to hinder the dissolved contaminating salts from spreading by capillary action. The wax tends to "bunch" the moisture droplets, retarding the formation of a continuous electrolytic film, hence the low resistance paths are broken up, reducing the flow of leakage current and the formation of excessively distorted voltage gradients.

The intent of the new silicone is three-fold. The first is to accomplish the same droplet "bunching" obtained by the waxes, the second is to provide a thick durable layer of silicone capable of prolong weather exposure, and the third is to provide a material that engulfs the individual contaminating particles as they are deposited on the silicone surface. The result of the third factor is that the engulfed particle is prevented from becoming an electrolyte through the exclusion of its contact with moisture.

To better understand the hydrophobic, or water shedding, properties of the silicone greases consider the solid-liquid-gas system shown in Figure 1. (Also see page 6, Refs. 6 and 7.) This figure depicts the equilibrium that exists between a water droplet, air, and a silicone grease surface. The phases present contact each other along a line such that the points X are intercepts. There are three interfacial energies involved in the system, each of which tends to minimize the area of its own interface. They are represented in the figure by the vectors γ_{SG} , γ_{SL} and γ_{LG} . Vector γ_{LG} tangential to the liquid surface at X forms with the solid-liquid interface an angle θ , which

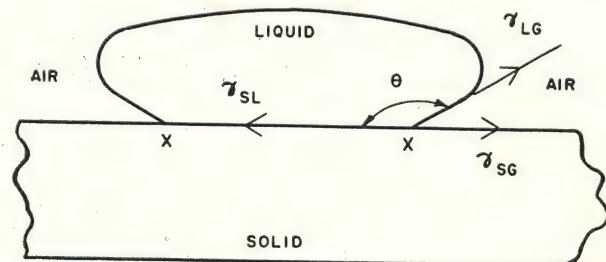


Figure 1
Schematic of Contact Angle Showing
Interfacial Forces Acting on a Liquid Drop
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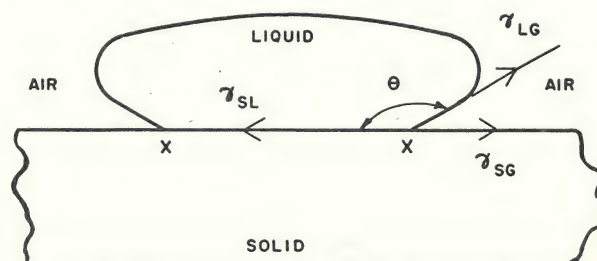


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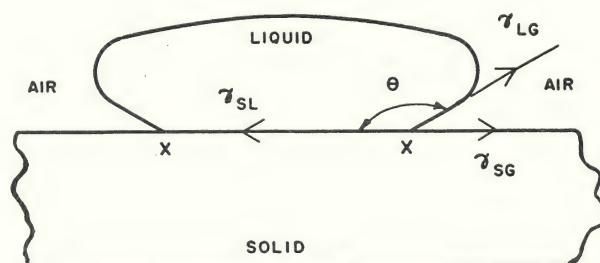


Figure 1
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on a Solid Plate in Air

Coatings

Prince Kingbury

Color	DC-5 Colorless	Insulgreen Colorless
Pentathum ASTM D217-98		
Unworked	200-240	180-240
worked (max)	300	310
Bleed % 24hr at 400°F	10	10
Evaporation % 24hr at 400°F	3	2 1/2
Dielectric Strength V/mil at 15mils	500	750
Dielectric Constant at 23°C ASTM D150-47T		
AT 100 cycles	2.85	—
AT 105 cycles	2.85	—
AFTER 96hrs at 96% RH at 25°C		
AT 100 cycles	3.00	—
AT 105 cycles	3.00	3.10
Power Factor at 23°C ASTM D150-47T		
AT 100 cycles	.0001	—
AT 105 cycles	.0009	—
AFTER 96hrs at 96% RH at 25°C		
AT 100 cycles	.001	—
AT 105 cycles	.003	.0025
ARC Resistance standard ASTM D-995-98 T	80	125
* ARC Resistance MIL I-8660	58.4 block	170 white
* Dielectric Strength .050" gap	589 pack	633 pack

* RUN AT GEL

See Insulgreen Bureau

P. H. Lofgren
Jan 1961

Engineering Comments
File #4412

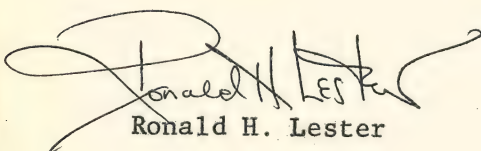
Baltimore, October 30, 1961

Mailing List 9 Tab D

Subject: INSULJEL-INSULGREASE PRESENTATION AT DETROIT EDISON

Attached you will find a copy of a presentation given to Detroit Edison and information on the small pressure sprayer we found useful for spraying INSULJEL. Many of the utilities will have these sprayers in their shops, but if this is not the case, the investment is only slight and will soon save the dollars spent on aerosol cans. Packing replacements are required from time to time, but this is a simple purchase and the packing cost but four cents.

Presentations such as attached can be made most effective when we hear from each of you in the field. Each innovation or new use of INSULJEL and INSULGREASE is a potential piece of sales promotion. My thanks to Paul Jorgenson and Heintz Burnham who have been feeding back this field information enabling us to talk about our good points and improve upon our weak ones.


Ronald H. Lester

ep

Attachments



SILICONES DIVISION

UNION CARBIDE CORPORATION

270 PARK AVENUE, NEW YORK 17, N. Y.

Coatings

Mr. B.E. Kingsbury, Supv.
High Voltage Lab.
General Electric Company
So. Charles & Cromwell Sts
Baltimore 30, Md.

Dear Sir:

Thank you for inquiring about our new UCAR Silicone Metal Protectants. We appreciate your interest.

I believe you will find that the enclosed Product Information and Price Bulletins will answer most of the questions you may have. However, we would like to call to your attention the fact that, due to their limited shelf life at room temperature, these materials are not suitable for aerosol packaging. Also, they cannot be used on silver or pewter hollowware, although a product for this application is available under separate license.

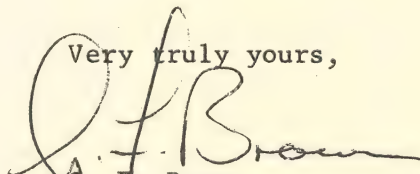
To facilitate your preliminary evaluation of UCAR Metal Protectants, we have established a Sample Treating Service which you will find fully described in the enclosed Customer Service Bulletin.

For your convenience in ordering samples for in-plant evaluation, we have enclosed a Sample Order Form and reply envelope which may be used to order the minimum sized one pint samples at \$15.00 per pint.

If you have any further questions, why not use the back of this letter and the reply envelope, or if you wish, you can contact any Silicones Division Sales Office for further information.

Thank you again for your interest. We hope that you will evaluate UCAR Metal Protectants at your earliest convenience, and see for yourself how these new materials can help you solve your corrosion problems.

Very truly yours,


G. F. Brown
Advertising Manager

GFB/gm

Attachments

BALL BOLTS

Coatings

I. 2 COATS IN STD. MANNER

#1		C		C	
	82	116	120	92	
	89	116	119	92	
	86	119	117	108	
	84	119	118	87	
	85	120	117	84	
	85	118	118	96	
	3.13	4.83	4.83	94	
		2.88	2.88	3.55	

#2		+C		C		C		C	
	89	117	107	65	119	82	115		
	94	117	108	65	118	87	115		
	97	117	108	72	118	84	116		
	86	117	108	63	119	84	115		
	85	117	108	64	119	84	115		
	90	5.17	4.45	66	5.35	84	5.00		
	3.40	3.15	2.57	2.38	3.28	3.07	3.00		

Avg. 3.03

II. 1 COAT OUT OF BARREL

#4		C		C		C		C	
	104	73	73	96	99	66			
	102	62	68	102	98	78			
	103	63	68	102	102	67			
	103	72	72	103	104	70			
	103	66	68	101	101	67			
	4.10	87	90	106	3.98	68			
	2.30	2.42	2.50	4.03	2.20	2.45			
				2.23					

#5		C		C	
	88	31	94	63	
	90	36	95	63	
	88	31	94	63	
	90	31	94	63	
	89		94	64	
	3.30	1.62	3.57	2.32	
	1.65		1.87		

Avg. 2.16

Number	Title	Author	Company	Date
Paper	RELATIONSHIP BETWEEN CORONA & RADIO NOISE ON TRANSMISSION LINES Part II: CONDUCTOR & INSULATOR CORONA	TW Liso JJ LaForest	General Electric Schenectady, NY	
Paper	ON PROCEDURES FOR RELIABILITY EVALUATION ON TRANSMISSION SYSTEMS	RJ Ringlee SD Goode	Public Service Co. of Colorado	
Booklet	PUBLIC SERVICE COMPANY OF COLORADO -- WELCOMES YOU TO THE HIGH-VOLTAGE HIGH-ALTITUDE RESEARCH PROJECT AT LEADVILLE, COLORADO			
Paper	LINE HARDWARE DISCUSSION - R.I.V.		Insulator Dept. General Electric	
Paper (2)	CORONA AND RIV INVESTIGATION ON INSULATORS AND RELATED CONDUCTOR SUPPORT ACCESSORIES	J. Kaminski, Jr.	Insulator Dept. General Electric	
Paper	DEVELOPMENT OF CORONA SHIELDS FOR SUSPENSION ASSEMBLIES OF BUNDLED CONDUCTOR TRANSMISSION LINES	J. Kaminski, Jr.	Insulator Dept. General Electric	
Paper - AIEE	CONTROL OF CORONA AND RADIO INFLUENCE VOLTAGE ON DISCONNECTING SWITCHES FOR 330 KV	JB Owens	AIEE Member Westinghouse Corp.	
DF51GL103	RADIO NOISE REDUCTION WORK ON D-C MACHINES	PC Gardiner	General Electric Schenectady, NY	June 12, 1951
Booklet	TELEVISION INTERFERENCE IN RURAL AREAS		US Dept of Agriculture Rural Electrification Adm	Dec 1951
DF55GL80	BIBLIOGRAPHY ON CORONA	JW Ryan	General Electric	Feb. 10, 1955
R55GL294	PULSE DEISTRIBUTION ANALYZER FOR CORONA ANALYSIS	WT Starr LW Johnston	General Electric Schenectady, NY	Oct. 10, 1955
DF56GL47	SUPPLEMENT TO BIBLIOGRAPHY ON CORONA	JE Doolittle	General Electric Schenectady, NY	Feb. 1, 1956
59GL11	CORONA	BV Bhimani	General Electric Schenectady, NY	Jan. 13, 1959
R56GL180	RECENT RADIO INTERFERENCE INVESTIGATIONS - HIGH VOLTAGE TRANSMISSION LINES TEST METHODS FOR CORONA, ARCING AND TRACKING INTERACTIONS WITH INSULATING MATERIALS	GE Adams WT Starr JJ Hinchen HS Endicott MW Albright	General Electric Schenectady, NY	1956 Sept 26, 1956

Number	Title	Author	Company	Date
Insulation Magazine excerpt aper 57-711	PART I: CORONA AND ITS EFFECT ON INSULATION -- A Resume	TW Liao	General Electric Pittsfield, MA	March 1957
PT137	INTERNAL CORONA SPACES IN CABLES Manometric Detection of Internal Corona and Auto-graphic Mapping of Corona Spaces	DW Kitchen OS Pratt	AIEE Member Nonmember AIEE	April 26, 1957
JF58AD-11	RADIO NOISE TESTS ON STANDARD AND PLASTIC ROD SUSPENSION INSULATOR STRINGS	VR Mulhall	General Electric Pittsfield, MA	July 9, 1959
01. 11, No. 1 Research News"	ACTIVITIES IN CORONA STUDIES, MEASUREMENT AND DEVELOPMENT SINCE JANUARY 1957	JH Maghorne DE Jones JR Leslie O. Nigol A. Elek C. Nigol	Canadian GE Ltd.	June 12, 1958
K-659-DR	POWER TRANSMISSION AT EXTRA HIGH VOLTAGE (EHV) - Pg 1 RADIO-INTERFERENCE PROBLEMS AT EXTRA HIGH VOLTAGE -pg18	J. Kaminski, Jr.	Hydro Elec Power Co	Jan-March 1959
andwritten Notes K-665-DR	THE CORONA LOSS PROBLEM THE INSULATOR LOSS PROBLEM Etc.			
PT150	CORONA AND RIV TESTS ON BUNDLED CONDUCTOR ASSEMBLIES	J. Kaminski, Jr.	General Electric Insulator Dept.	Sept. 29, 1959
K-671-DR	CORONA			Jan 13, 1960
PT155	VISUAL CORONA AND RIV TESTS ON BUNDLED CONDUCTOR ASSEMBLIES EFFECT OF GREASE AND ARTIFICIAL AGING ON THE CORONA START AND RADIO NOISE FROM CUREW TRANSMISSION LINE CONDUCTORS	L. Graham	General Electric Pittsfield, MA	May 23, 1960
	VISUAL CORONA AND RIV TESTS ON 460 KV SINGLE AND BUNDLED CONDUCTOR ASSEMBLIES	J. Kaminski, Jr.	General Electric Insulator Dept.	July 28, 1960
	RADIO NOISE & LEAKAGE CURRENT INVESTIGATION OF WOODEN & CONCRETE TRANSMISSION LINE TOWER MEMBERS & THEIR ASSOCIATED HARDWARE	LF Jandran	General Electric Pittsfield, MA	August 8, 1960
				Sept 19, 1960

INDEX FOR: CORONA -- RIV

Pg #3

Number	Title	Author	Company	Date
K-671-DR	VISUAL CORONA & RIV TESTS ON 460 KV SINGLE & BUNDLED CONDUCTOR ASSEMBLIES	J. Kaminski, Jr.	General Electric Insulator Dept.	August 8, 1960
P #60-1273 (2)	EFFECT OF BUNDLED CONDUCTOR FIELD INFLUENCE ON EHV TRANSMISSION LINE DESIGN	RW Harmon	Ohio Brass Co. Barberton, OH	Oct 12, 1960
app Info.	LAPP CORONA SHILED INFORMATION TEST OF MARCH 1 & Feb. 28, 1961		Lapp HV Lab.	Feb. 27, 1961
K-683-DR	CORONA & RIV TESTS ON BUNDLED KAISER ACSR CONDUCTORS	BE Kingsbury	General Electric Insulator Dept.	June 14, 1961
K-684-DR (2)	CORONA & RIV TESTS ON BUNDLED CONDUCTOR ASSEMBLIES	BE Kingsbury	General Electric Insulator Dept.	June 14, 1961
1-GC-188	RESEARCH & DEVELOPMENT ON CORONA-RESISTANT MATERIALS Quarterly Progress Report #4 to: Wright Air Development Division	JC Devins HL Greenhaus DR Johnston DL Harms FY DuPont AL Lynn A. Pletenik HG Pfeiffer	General Electric	July 1961
K-689-DR (2)	CORONA & RIV TESTS ON BUNDLED REYNOLDS ACSR CONDUCTORS	BE Kingsbury	General Electric Insulator Dept.	Sept. 11, 1961
62FL10	THE DEVELOPMENT OF A METHOD TO DETECT GROUND INSULATOR DEFECTS	HH Richardson	General Electric Ft. Wayne, Indiana	April 12, 1962
K-707-DR (2)	VISUAL CORONA & RIV TESTS ON SUSPENSION INSULATOR ASSEMBLIES FOR PACIFIC GAS & ELECTRIC -- 500 KV System	BE Kingsbury	General Electric Insulator Dept.	May 11, 1962
K-708-DR	VISUAL CORONA & RIV TESTS ON SUSPENSION INSULATOR ASSEMBLIES FOR HOUSTON LIGHTING & POWER CO. - 345 KV	BE Kingsbury	General Electric	1962
K-712-DR	VISUAL CORONA & RIV TESTS ON SUSPENSION INSULATOR ASSEMBLIES FOR PACIFIC GAS & ELECTRIC - 500 KV System	BE Kingsbury	General Electric Insulator Dept	Dec. 11, 1962
F-62-AD-43	UNIFORM & DISCRETE DISTRIBUTION OF CORONA DISCHARGES ON A LINE	JJ LaForest	General Electric Pittsfield, MA	Dec. 17, 1962
3-GC-0234 C	RESEARCH & DEVELOPMENT ON CORONA-RESISTANT MATERIALS Quarterly Progress Report #1 to Wright Air Development	JC Devins HL Greenhaus DR Johnston A Pletenik HG Pfeiffer	General Electric Schenectady, NY	April 9 1963

Number	Title	Author	Company	Date
GC-0254-C	RESEARCH & DEVELOPMENT ON CORONA-RESISTANT MATERIALS Quarterly Report No. 3 to Wright Air Development Center	FF Carnini JC Devins HL Greenhaus DR Johnston A. Pletenik HG Pfeiffer BE Kingsbury	General Electric Schenectady, NY	October 1963
722-Dr	RIV & VISUAL CORONA TESTS ON P.G. & E. 500 KV ASSEMBLIES MADE IN PITTSFIELD HIGH VOLTAGE LABORATORY		General Electric Insulator Depart.	May 27, 1963
07 (2)	CORONA LOSSES, RADIO INTERFERENCE & INSULATOR REQUIREMENTS FOR H.V.D.C. LINES. STUDIES REGARDING INSULATOR INTERFERENCE FOR FREQUENCIES BETWEEN 30 & 1500 MHZ	N. Hylden-Cavallius S. Anestrand JL Maksiejewski J. Ellder N. Knudsen	ASEA Ludvika, (Sweden) Warsaw, Poland Gothenburg, Sweden Chalmers Univ of Tech Sweden	1964
11 (2)	CORONA LOSS & RADIO INTERFERENCE MEASUREMENTS AT HIGH VOLTAGE A.C. ON TEST LINES IN SWEDEN	RM Morris B. Rakoshdas	IEEE Member IEEE Member	Dec 3, 1962
per #63-84	AN INVESTIGATION OF CORONA LOSS & RADIO INTERFERENCE FROM TRANSMISSION LINE CONDUCTORS AT HIGH DIRECT VOLTAGES	RL McCoy	General Electric Insulator Dept	April 3, 1964
per	RADIO INTERFERENCE FROM EHV TRANSMISSION LINES AND SUBSTATIONS	J. Kaminski, Jr. M. Betha, Jr.	GE-Insulator Dept Betha - Ala.	January 1967
print from electric Power Light	EHV INSULATOR ASSEMBLIES CAN BE CORONAPROOF	JJ LaForest	General Electric Schenectady, NY	March 3, 1967
S-67EU-03	CHOICE OF 1000-KV CONDUCTOR CONFIGURATIONS AND UHV CAGE DESIGN	WT Starr	General Electric Schenectady, NY	March 1967
-C-082	CORONA TESTS ON VARIOUS COMPONENTS	M. Olyphant, Jr	Dielectric Mat & Sys St. Paul, MN	June 28, 1967
cerpt per 31 PP 66-500	INTERNAL CORONA TESTING OF CASTING RESINS	G. Grueneich	Houston Ltg & Pwr Houston, TX	April 1968
cerpt from & D	RADIO INFLUENCE OF A 345-KV TRANSMISSION LINE	LE Zaffanello	General Electric Pittsfield, MA	March 26, 1970
per	CAGE TESTING INVESTIGATION OF AUDIBLE NOISE OF EHV & UHV TRANSMISSION LINE CONDUCTORS			

GENERAL  ELECTRIC

SUBJECT

Corona

COPIES: H. A. Frey, Baltimore
J. Kawinski, Baltimore
C. H. Titus, 10-7
R. L. Williams, 21-1

Mr. King

LABORATORIES DEPARTMENT - PHILADELPHIA
April 16, 1959

RECEIVED

APR 20 1959

ENG. DEPT.

F. Vose

Mr. F. Vose
General Electric Company
BALTIMORE WORKS

The enclosed discussion by Dr. A. S. Denholm of the National Research Council of Canada might be of interest to you, particularly in the section pertaining to insulator noise.

T. W. Liao

T. W. Liao
PLANNING ENGINEER
SWITCHGEAR DEVELOPMENT LAB.

TWL:pcs

Attachment

ON PROCEDURES FOR RELIABILITY EVALUATIONS OF TRANSMISSION SYSTEMS

R.J. Ringlee S.D. Goode
General Electric Company
Schenectady, New York

ABSTRACT

A step-by-step procedure for reliability evaluations of transmission systems is described in this paper. Simple algebraic results for prediction of frequency and duration of transmission contingencies are obtained with the use of renewal process theory.

INTRODUCTION

A continuing interest in quantitative reliability evaluations of transmission systems has prompted the preparation of this paper. With the substantial progress that has been made in the perfection of methods for simulating network power flows by fast methods on digital computing machines, the time for the general realization of quantitative transmission system reliability evaluations may be near. One limiting area appears to be the practical, rapid evaluation of stability limits. Techniques for predicting the frequency with which certain transmission contingencies will occur have been known for some time. The combination of rapid simulation methods with event prediction techniques may offer a practical method for carrying out transmission system reliability evaluations. To the already substantial body of technique published on the subject of transmission system reliability, this paper offers a generalization of the concepts of the component run-fail-repair "life cycle" and describes a step-by-step procedure for performing reliability evaluations. Component reliability/availability models have been investigated using renewal processes. The techniques described have proved quite feasible for hand as well as machine computations.

RESUME OF RECENT EFFORTS

Suggestions of numerical reliability criteria for transmission and distribution systems extend back at least three decades to Dean¹ who reported on interruption frequency and duration measures as an aid in decisions to modify circuit protection arrangements. Frequency and probability measures were suggested for generation and transmission systems nearly four decades ago by Lyman² and Smith.³

Cohn⁴ suggested a criterion for generation and transmission reliability based upon the risk of overlapping transmission and generation outages. Todd⁵ developed a probabilistic approach for transmission and distribution circuits. Treating circuit and component outages as independent events, he developed expressions for the probability of outage of one or more series-connected components and the probability of overlapping outage of parallel paths. Todd's criteria

was based upon each outage lasting 24 hours, or conversely, counting "one day" interruption for an outage event. Two outages overlapped if they occurred within the same 24-hour span. It is interesting to note that the component failure rate expressed in failures per day will be very closely estimated by Todd's component probability-of-outage. Parallel paths were assumed to be fully redundant such that the criterion of success could be measured by the existence of a path from the source to the load.

Modeling of repairable systems was greatly enhanced by the use of the Markov Chain with continuous time parameter. Barlow and Hunter⁶ gave a brief analysis of such an approach, and DeSieno and Stine⁷ presented a state-description approach which employed Boolean Algebra and Markov Chains for the analysis of system reliability problems. The Boolean Algebra approach has been applied by Esser, Wasilew, and Egly.⁸ Effects of less than full redundancy in parallel circuits, effects of environmental states and of scheduled outages were investigated by Gaver, et al⁹ and Montmeat et al.¹⁰ Formulas were developed for the prediction of the frequency and duration of outages in series and parallel paths. This work was extended by Mallard and Thomas¹¹ to multiple path transmission circuits. Expressions were developed for the probability of path overload given that specified paths were out of service. Path overload contingency curves were developed for cases of single and multiple path forced outages. Patton, in a discussion of the paper, questioned the method employed to estimate the risk of cascading outages, of overload outages precipitated by other overload outages. The essential point in question was the degree of correlation between loads at various points in the system and upon various components. It was Patton's observation that there was a definite correlation between loads which must be accounted for in probabilistic models of overload occurrence.

Methods of analysis and criteria discussed so far were directed to the prediction of interruptions at specific points in a network. While the methods are readily adaptable to predictions of broader scope, the preparation of numbers of individual "reliability diagrams" or diagrams of paths between sources and load points appears to be needlessly repetitive. An alternative approach, long used in reliability predictions, literally a state-enumeration technique, offers an alternative for developing predictions of system effect rather than load-point effect.

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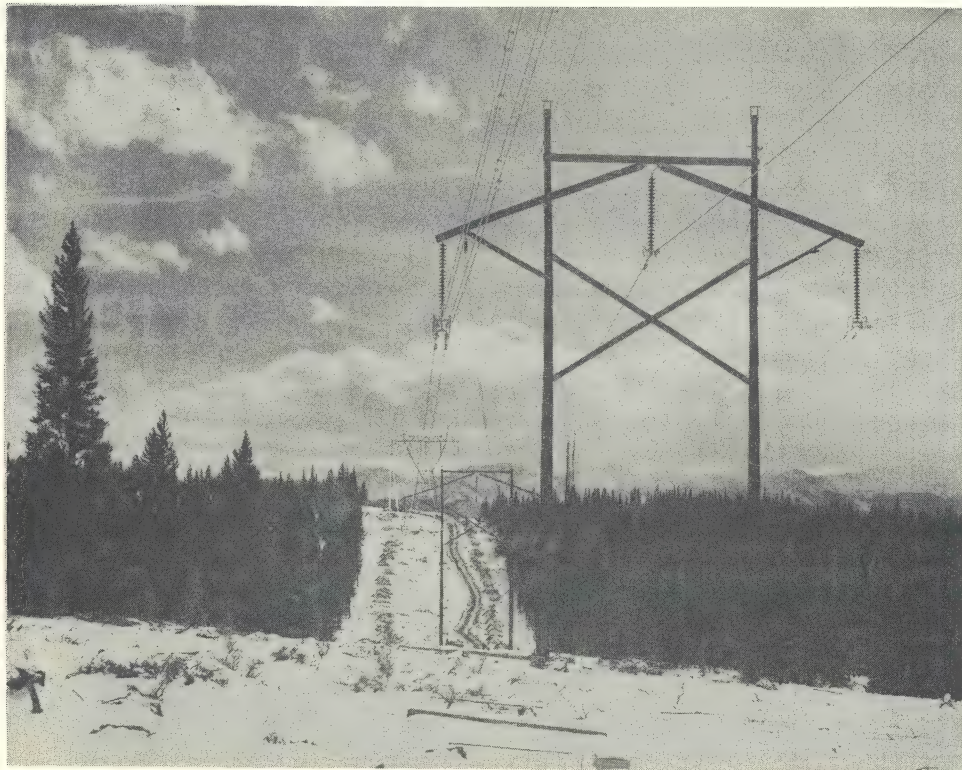


PHOTO BY BILL DANFORD

CORONA AND RIV INVESTIGATION ON INSULATORS
AND RELATED CONDUCTOR SUPPORT ACCESSORIES

J. Kaminski, Jr.

The purpose of this paper is to publish results of RIV investigations on insulators and related hardware carried out at the High Voltage Laboratory in Baltimore.

The general area covered by this report is:

RIV and Corona Performance of Long Insulator Strings

Comparison of RIV and Corona Performance Between Rod Type and Suspension Insulators

Comparison of Single and Bundled Conductor Shielded and Unshielded Arrangements for 460 kv Operation.

Comparison of Shielded V String Assemblies for 345 kv and 460 kv Operation

PERFORMANCE OF LONG INSULATOR STRINGS

Investigations were carried out on long strings of insulators using conventional 5-3/4 x 10 inch standard suspension insulators in single and quadruple strings of 34 units per string. Independent measurements of the test equipment were made including readings with the 600 mmf capacitor located in several different locations in the laboratory, to obtain the minimum of RIV background noise in order to obtain the lowest possible effect on subsequent tests. A 4-1/2 inch O.D. aluminum conductor was attached to the capacitor and supported from overhead by a glass rope. A control ring was used to suppress the possible corona effects of the supporting hardware. An attempt was made to place the ring in such a position that its influence on the lower units would be minimized. Background noise measurements were made with the test arrangement as just described.

The RIV general characteristics of long insulator strings is shown on Figure 1 as gradual ascending RIV levels with major distortions to the pattern occurring at corona onset points. Observations show that the highest stressed area occurred on the bottom insulators at the base of the cap. The presence of glow type corona was readily detectable at the values shown on the curve. The variation in corona readings, as well as RIV values between single and quadruple strings, can be attributed to a difference in grading effect provided by the control ring used to shield cable support hardware.

In order to minimize the effect of the insulator string as a source of RIV, further investigations were made with quadruple strings of insulators to determine the appropriate shielding required for improvement of corona onset voltages. Subsequent tests made with variations in shielding positions resulted in corona starting voltage of 396 kv for a quadruple string as compared to 214 kv without insulator shields.

COMPARISON BETWEEN SPECIAL ROD TYPE INSULATORS
AND STANDARD SUSPENSION INSULATORS

Special rod type insulators each having a dry arcing distance of 20 inches and a leakage distance of 37 inches were used in the following test. Each rod type insulator was substantially equivalent to a string of three standard suspension insulators having a 5-3/4 inch spacing.

Corona

DEVELOPMENT OF CORONA SHIELDS
FOR
SUSPENSION ASSEMBLIES OF BUNDLED CONDUCTOR TRANSMISSION LINES

Joseph Kaminski, Jr.

The task of keeping pace with consumer electrical power requirements has required the development of power stations with single unit capacities in excess of 250,000 kw. These huge concentrations of generating capacity must be located in areas where the economic feasibility will justify their investment. Often times each plant location will not be properly disposed with respect to load centers, therefore, the transmission of large blocks of power economically, and the need of firming up transmission systems has led to the employment of extremely high voltage transmission lines.

Accompanying the increased voltage is the further necessity of determining proper size conductor for use with these higher voltages.

There are many problems to be considered and evaluated in the determination of the conductor to be selected. The problem includes both mechanical and electrical characteristics of the conductors. Proper sags and tensions, terrain and topographic features, structure design, and size all have an important bearing on the most economical conductor to be employed. Having even greater influence, however, may be load carrying capabilities, line reactance, stability considerations, and the corona power loss with disturbing radio and television interferences.

In order to successfully design transmission lines and adequately solve the problems with which he is confronted, the design engineer may find the use of single conductors in steadily increasing diameters reaching a practical limit. Consequently, a multiple number of smaller conductors per phase, spaced short distances apart, but metallically connected is gaining increasing prominence. This arrangement, popularly referred to as bundling, offers many advantages over single conductor per phase arrangements. The application of bundled conductors to transmission lines was first introduced in this country by Mr. Percy H. Thomas nearly fifty years ago.¹ A more complete consideration of the electrical characteristics of bundling was discussed in a paper presented at the Northeastern District Meeting of A.I.E.E. in May 1932, by Edith Clark entitled "Three Phase Multiple Conductor Circuits".² More recently analyses and investigations of the relationship between bundled conductor assemblies and radio interference has been made. This is reported in A.I.E.E. Transaction Paper "Colorado High Altitude Corona Tests, Part II, Insulators and Associated Hardware" by L. M. Robertson and A. D. Lantz.³ This latter paper deals primarily with a comparison between the R.L.V. and corona performance of shielded bundled assemblies and that arising from line conductors.

It is the purpose of this paper, however, to make investigations, studies and comparisons of corona onset voltages and radio influence voltages on various appurtenances for supporting bundled conductors on suspension assemblies and to develop methods for improving these characteristics.

EQUIPMENT AND MEASUREMENTS

Dictated by practical considerations, the scope of this study has been limited to a conductor suspension bundled arrangement with a sixteen inch horizontal displacement conductor center lines. The investigations feature the characteristic behavior of a 16 inch Iron Pipe Size thin wall aluminum (tubing) conductor having a 1.9" outside diameter. This selection was made to conform as nearly as possible to the diameters of transmission line conductors including armor rods presently being considered for use in bundled arrangements.

Mr. Kungstman

GENERAL ENGINEERING LABORATORY

SUPPLEMENT TO BIBLIOGRAPHY ON CORONA

by

J. E. Doolittle

Report No. DF56GL47

February 1, 1956

GENERAL  ELECTRIC



GENERAL ENGINEERING LABORATORY

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR Doolittle, J.E.		SUBJECT CLASSIFICATION Bibliography-Corona		NO. DF56GL47
				DATE 2/1/56
TITLE SUPPLEMENT TO BIBLIOGRAPHY ON CORONA				
ABSTRACT Approximately 200 open literature references on corona have been accumulated. The references have been divided into eight subject classifications, and are listed chronologically in each classification. These references are a supplement to DF55GL80 entitled, "Bibliography on Corona" by J. W. Ryan.				
G.E. CLASS I		REPRODUCIBLE COPY FILED AT General Engineering Laboratory Library Schenectady, N.Y.		NO. PAGES 36
GOV. CLASS. None				
CONCLUSIONS				

For list of contents—drawings, photos, etc. and for distribution see next page (FN-610-2).

INFORMATION PREPARED FOR W. T. Starr

TESTS MADE BY _____

AUTHOR J. E. Doolittle

COUNTERSIGNED Aaron Cohen *Aaron Cohen* 2/10/56

SECTION Technical Literature Comp. LOCATION Schenectady, N.Y.

GL-16-B (4-52)

TELEVISION INTERFERENCE IN RURAL AREAS



U. S. DEPARTMENT OF AGRICULTURE RURAL ELECTRIFICATION ADMINISTRATION

DEC. 1951

GENERAL ENGINEERING LABORATORY

CORONA

By

B. V. Bhimani

Report No. 59GL11

January 13, 1959

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Recent Radio Interference Investigations
High Voltage Transmission Lines

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General Electric Company
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Mr. Kingsbury

Corona

TEST METHODS FOR CORONA, ARCING AND TRACKING INTERACTIONS WITH INSULATING MATERIALS

By

W. T. Starr
J. J. Hinchey
H. S. Endicott
M. W. Albright

Report No. R56GL180

September 26, 1956

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General Engineering Laboratory

SCHENECTADY, NEW YORK

TECHNICAL INFORMATION SERIES

TRACKING
RESISTANCE

CORONA
TESTING

CORONA
RESISTANCE

ARC
RESISTANCE

AUTHOR W.T. Starr J.J. Hinchon H.S. Endicott M.W. Albright		SUBJECT CLASSIFICATION Dielectric - Tab 8	NO. R56GL180 DATE Sept. 26, 1956
TITLE Test Methods for Corona, Arcing and Tracking Interactions with Insulating Materials			
ABSTRACT This report contains three formalized test methods and one descriptive report intended for submission to the Corona Resistance and Arc Resistance Sections of the "American Society for Testing Materials".			
G.E. CLASS I	REPRODUCIBLE COPY FILED AT LIBRARY OF GENERAL ENGINEERING LABORATORY SCHENECTADY, NEW YORK		NO. PAGES
GOV. CLASS. None			
CONCLUSIONS The "Dust and Fog" test rates electrical insulations with respect to their suitability for use in wet, contaminated atmospheres. The method was developed in the Lynn Measurements Laboratory and it belongs in ASTM. The test methods for measuring the resistance of insulations to corona grew out of our work on a Navy contract with the development of ASTM methods as one of its objectives. The test method for corona measurements is not new to GE engineers except in a few details. E.B. Curdts and C.W. Ross of Biddle Company are the original authors. An arc resistance test method which provides a better measure of insulation quality in certain arcing conditions than ASTM D-495-48T is also included.			

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 HOR W. T. Starr *W.T. Starr* H. S. Endicott *H. S. Endicott* M. W. Albright *M. W. Albright* J. J. Hinchon *J. J. Hinchon*

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MPONENT _____
 Insulation Properties - Chemistry and Metallurgy

Part I

Corona

and its Effect on Insulation —a Résumé

By T. W. Liao, Consulting Engineer, High Voltage Laboratory, Transformer Division, General Electric Company, Pittsfield, Mass.

Foreword: This article tells what corona is and how it occurs, as well as covering its inception and effect on insulation. Corona in electrical equipment is also discussed. The paper reviews the subject of corona and its effects based on some of the pertinent published articles in this field. The references cited give leads to many findings which broaden what is briefly discussed here. This article is of a comprehensive nature primarily written for the users and manufacturers of electrical and electronic equipment who are not very familiar with the subject.

What Corona Is

Once, a questionnaire was sent to several people asking them to give their description of what "corona" is. There were a variety of answers such as: (1) corona gives a hissing sound and an ozone smell; (2) corona is a bluish glow discharge in air; (3) corona is an electromagnetic phenomenon causing radio interference; (4) corona is a form of ionization in a piece of electrical equipment sometimes causing damage to its insulation; and (5) corona is the luminous envelope surrounding the sun, seen only during a total eclipse. Apparently the last statement came from an astronomer. All of these answers are right and strangely, there are many more right answers, each signifying a method of sensing or detecting the phenomenon known as "corona." However, this article will deal primarily with the subject matter of the fourth answer—

corona is a deadly enemy to electrical insulation.

How Corona Occurs

Corona can occur only in insulating media such as air or other gases, oil or other liquids, and paper or other insulating materials. Under normal conditions, all such substances consist of myriads of neutral molecules and a relatively small number of free harmless electrons bearing negative electric charges. However, under high electric stress, the electrons are accelerated to such high speeds that by virtue of collision, they can break up the neighboring neutral molecules into two types of charged particles—positive ions and more free electrons which in turn can break up more neutral molecules. This chain reaction gives rise to millions of

free ions and electrons existing in a turbulent condition, called corona, which manifests itself in many different ways.

Corona Inception

The question of how high an electric stress this chain reaction will start is of great importance to the design of an electrical system. For instance, the critical voltage (V_c) for a transmission line of smooth conductors in terms of the spacing between conductors (S), the radius (r), and the air density (d) is given by¹:

$$V_c \text{ (KV rms to neutral)} = 123 \text{ rd log } \frac{S}{r}$$

For a more complicated system, in which corona may occur in an air gap between solid insulating materials, the corona starting voltage can be determined by means of a graph^{2,3} as shown in Figure 1. For an electrode system consisting of two 1/2-inch diameter square edge electrodes on opposite sides of a sheet of insulation, the voltage (V_c) at which corona starts on the surface of the insulating materials is given by⁴:

$$V_c \text{ (V-rms)} = 720 \left(\frac{t}{k} \right) 0.46$$

Internal Corona Spaces in Cables

Manometric Detection of Internal Corona and Autographic Mapping of Corona Spaces

D. W. KITCHIN
ASSOCIATE MEMBER AIEE

O. S. PRATT
NONMEMBER AIEE

Synopsis: This paper describes two methods of studying corona spaces in cables between insulation and conductor. The manometric method makes it possible to determine the internal corona level unambiguously. Effects of outside electrical disturbances are excluded. There appears to be no upper voltage limit to the applicability of this test. It is performed by observing on a sensitive manometer the pressure decrease inside the cable that results from absorption of oxygen activated by corona discharge. These studies have been carried out principally with polyethylene, but also with rubber, polyvinyl chloride, silicone, Teflon, and glass. In the autographic method silver is deposited on all copper surfaces accessible to the silver cyanide solution. This clearly maps the projection of the corona spaces on the conductor. The method is extremely simple and the results are direct and conclusive.

IN THE MANUFACTURE, and especially in the development of high-voltage cables, it is necessary to be able to measure the voltage at which corona, or ionization, occurs. Discharges can take place outside the insulation, in voids entirely within the insulation, or between insulation and conductor. If there is strand shielding, corona may exist between this and the insulation wherever they are separated, for example, by severe bending.

Much interest is attached to the problem of eliminating internal corona spaces between insulation and conductor. The conventional method at present is to use semiconducting strand shielding. This is done on the theory that the insulation is not sufficiently tight on the conductor, or at any rate may become so loosened during installation that corona spaces are formed. The other approach to this problem is to try to apply the insulation in such a way that it remains tight even

after bending to at least as severe as any likely to occur during installation. Whether or not this has been accomplished in any particular case seems at present to be a matter of conjecture based on results of indirect tests. If real progress is to be made it is necessary to have an unambiguous means of detecting this type of corona and distinguishing it from corona in other regions of the cable, or even from corona in the test equipment. The manometric test accomplishes this.

The autographic mapping applies only to cable without strand shielding. It marks distinctly those regions where there are gaps between conductor and insulation in which corona will occur above some threshold stress. It is a destructive test, but it requires only a few feet of sample, and it appears to be more sensitive than the manometric test. As evidence of presence or absence of corona spaces around the conductor it is conclusive. This paper is concerned exclusively with the detection of this type of internal corona, and with mapping the spaces where it can occur. All ratings and test voltages in this study are 60-cycle rms.

Principle of the Manometric Method

The manometric method differs from the customary corona tests in that it depends on chemical rather than electrical effects. The only electric equipment involved is the source of voltage.

When corona occurs in air spaces between conductor and insulation there is an immediate and irreversible decrease in internal gas pressure. It is convenient to call this "corona absorption." The rate of pressure drop increases rapidly as the voltage is raised above the onset value. If a stopcock is connected at one end of a cable and a sensitive manometer at the other, the pressure changes observed at various stresses can be used as a criterion of existence of internal corona.

Corona absorption is a result of the action of electrical discharges on the oxygen present in the corona spaces.

If the air is replaced by pure nitrogen there is no absorption even though severe corona is present. Traces of oxygen, whether residual oxygen, or oxygen that diffuses in through the wall, produce a detectable pressure drop as soon as there is internal corona. Two mechanisms can contribute to this pressure decrease: (1) chemical reaction of activated oxygen with the insulation, and (2) contraction resulting from the reaction $3O_2 \rightarrow 2O_3$. In cables with the usual organic insulation both actions probably occur, with chemical absorption the predominant one. Fortunately, an exact understanding of the chemistry is not necessary in order to take advantage of the phenomenon.

Whatever the mechanism, the manometric test provides an unambiguous criterion of internal corona. This method has been used successfully up to 120 kv on cables with polyethylene insulation. The upper limit is set only by the breakdown strength of the test sample or the power of the voltage supply. Cables insulated with polyethylene, rubber, silicone and polyvinyl chloride have been tested.

This test can reveal whether the insulation is originally tight, or the strand shielding effective, and how much bending a cable can tolerate without suffering a dangerous lowering of the internal corona level.

Principle of Autographic Mapping

Since corona in the spaces involved in this study manifests itself by a change in the manometer reading, these spaces must be connected by channels, so that they are accessible to a liquid. Wherever silver cyanide solution can contact the copper conductor a bright silver coating deposits. Thus gaps between insulation and the outside surfaces of a stranded conductor can be mapped, so that they can be examined or photographed after removal of the insulation. To make certain that the solution reaches the voids one end of the sample is connected to a vacuum pump while the other dips in the solution.

This method of detecting corona spaces is more searching than the manometric test. If in a given cable the amount of corona space is very small the pressure change resulting from corona absorption may be masked by fluctuations caused by variations in ambient temperature or pressure. The silver mapping method is free of these troubles. It can serve equally well where insulation having high dielectric loss would develop too much heat to permit use of the manometric test.

Paper 57-711, recommended by the AIEE Dielectrics Committee of the Communication and Electronics Division and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Manuscript submitted March 25, 1957; made available for printing April 26, 1957.

D. W. KITCHIN and O. S. PRATT are with the Simplex Wire and Cable Company, Cambridge, Mass.

Carona

~~Fred Vase~~

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>JL Wiesztort</i> JL Wiesztort	SUBJECT CLASSIFICATION 1. Insulators, Suspension 2. Radio Interference 3. Noise, Radio	NO. 59PT137 DATE 7/9/59
TITLE RADIO NOISE TESTS ON STANDARD AND PLASTIC ROD SUSPENSION INSULATOR STRINGS		

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TRANSFORMER DIVISION



TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>JL Wiesztort</i> JL Wiesztort		SUBJECT CLASSIFICATION 1. Insulators, Suspension 2. Radio Interference 3. Noise, Radio		NO. 59PT137
				DATE 7/9/59
TITLE RADIO NOISE TESTS ON STANDARD AND PLASTIC ROD SUSPENSION INSULATOR STRINGS				
ABSTRACT Reported are results of dry tests on 22 and 30 unit porcelain insulator strings and also on comparative lengths of new type plastic rod insulators. Incidental data on 34 and 45 standard unit strings are also included.				
G.E. CLASS IV M		REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS		NO. PAGES
GOV. CLASS None		Pittsfield, Works		10
CONCLUSION Listed below are radio noise results on the various configurations for 460 kv line-to-line (265 kv line-to-ground) and 650 kv line-to-line (375 kv line-to-ground)				
Type Units		Radio Noise (μvolts)		
		265 kv applied	375 kv applied	
22 - 15,000 lb.		200	580	
22 - 36,000 lb.		140	500	
30 - 15,000 lb.		150	340	
30 - 36,000 lb.		75	250	
4 - plastic rod		65	7500	
5 - plastic rod		65	80-3500	
6 - plastic rod		90	105	

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR EHV / J. J. LaForest

TESTS MADE BY JL Wiesztort, J. Stevens Tests Completed: 4/24/59

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Corona

ACTIVITIES IN CORONA STUDIES,
MEASUREMENT AND DEVELOPMENT SINCE JANUARY 1957

BY

V.R. MULHALL

DQF58AD-11

12 JUNE 1958

CANADIAN GENERAL ELECTRIC COMPANY LIMITED
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AUTHOR V.R. MULHALL	SUBJECT CLASSIFICATION INSULATION CORONA TESTING	NO. DQF58AD-11
		DATE 12 JUNE 58
TITLE ACTIVITIES IN CORONA STUDIES, MEASUREMENT AND DEVELOPMENT SINCE JANUARY 1957		
ABSTRACT THIS REPORT SUMMARIZES ACTIVITIES IN CORONA STUDIES - MEASUREMENT AND DEVELOPMENT SINCE JANUARY 1957, AS A CONTINUATION OF THAT REPORTED IN DQF57AD-5, DATED 30 JANUARY 1957. THESE ACTIVITIES INCLUDE REVISION AND MODIFICATION OF		
CGE CLASS II	REPRODUCIBLE COPY FILED AT ENGINEERING LABORATORY PETERBOROUGH WORKS CANADIAN GENERAL ELECTRIC CO LTD	NO. PAGES 43
GOV. CLASS NONE		
XXXXXXXXXX LABORATORY TEST EQUIPMENT, EXPERIMENTAL EVALUATION OF CORONA IN A NUMBER OF SYSTEMS AND PRODUCTS, STUDY OF CORONA LITERATURE AT MORE DEPTH, AND LIAISON WITH ACTIVITIES WITHIN THE COMPANY, AND IN ORGANIZATIONS SUCH AS A.S.T.M., A.I.E.E., C.E.M.A., ETC. OSCILLOGRAMS ARE INCLUDED AND DESCRIBED, AND FUTURE PLANS INDICATED.		

For list of contents — drawings, photos, etc., see next page.

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DE BY R.E. TURNER, S.A. SAGE, V.R. MULHALL

V.R. MULHALL *V.R. Mulhall*

SIGNED V.R. MULHALL

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Corona

PULSE DISTRIBUTION ANALYZER FOR CORONA ANALYSIS

by

W. T. Starr

L. W. Johnston

Report No. R55GL294

October 10, 1955

GENERAL  ELECTRIC

PULSE DISTRIBUTION ANALYZER FOR CORONA ANALYSIS

ABSTRACT

This report describes a new instrument which can determine the amplitude distribution of electrical pulses generated by corona discharges. The corona signal is fed from a wide band amplifier to the "Pulse Distribution Analyzer" which counts the number of pulses that fall within a specified band width. This band (or window) can be continuously moved from 0 until the largest pulse amplitude has been reached, counting only those pulses whose amplitudes fall at any voltage in this range. The pulse distribution is displayed on an oscilloscope. The amplitude of the pulses being counted positions the trace on the X axis of the oscilloscope. A count rate voltage, proportional to the number of pulses whose amplitudes fall within the window, positions the trace on the Y axis of the oscilloscope. Photographs are shown of the pulse distribution of corona produced using melamine glass laminate stressed at 8,400 volts and of corona produced using polyethylene stressed at 7,000 volts.

CONTROL OF CORONA AND RADIO
INFLUENCE VOLTAGE ON DISCONNECTING
SWITCHES FOR 330 KV

J. B. OWENS*
MEMBER AIEE

INTRODUCTION

The development of electrical equipment for operation at 330,000 volts has placed new emphasis on the problem of control of visual corona particularly as it relates to radio influence. The close relation between the start of corona and the threshold of radio influence has been demonstrated, 1, 2 and the maintenance of satisfactory levels of radio noise depends upon proper attention to corona control in apparatus design. The widespread use of television receivers in fringe areas has intensified this problem.

This design of disconnecting switches to operate at this voltage required the development of several new shielding techniques for various switch components. A new switch has been tested which demonstrates a high corona starting voltage and an exceptionally low level of radio influence at normal operating voltages. The data gathered on effective shield sizes, and the techniques employed, may well find application on other high voltage apparatus.

PRELIMINARY TESTS

Work by Pakala and Fahrnkopf in the Trafford laboratory of the Westinghouse Electric Corporation to determine the radio influence threshold voltage for conductors of various diameters was of great value in determining the design specification for a switch to operate at 330 kv. Their work indicated that a stranded dry conductor requires a 1/2 inch minimum radius to achieve an r.i. threshold of 330 kv. To allow for adverse effects of rain and field discontinuities in practical switch design a one inch minimum radius was established for all unshielded parts.

To determine the proper termination of a tubular switch blade standing vertically in the open position, a test was made using a 3-inch outside diameter tube 13 feet in length mounted on an insulator column of seven 14-1/2 inch high insulator units. The tube was vertical and its upper end was approximately 30 feet below the ceiling beams in a shielded room. Spun brass spheres of various diameters were attached to the end of the tube and the start of visual corona determined with the following results:

SPHERE DIAMETER INCHES	CORONA STARTING VOLTAGE KV
3	175
5	227
6	285

* Westinghouse Electric Corporation, East Pittsburgh, Pa.

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Corona

General Engineering Laboratory

RADIO NOISE REDUCTION WORK ON D-C MACHINES

P. C. Gardiner

June 12, 1951

SCHENECTADY, NEW YORK

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR Gardiner, P.C.	SUBJECT CLASSIFICATION Radio Noise in D-c Machines	NO. DF51GL103 DATE June 12, 1951
TITLE Radio Noise Reduction Work on D-c Machines		
ABSTRACT Radio noise is broadly discussed in the introduction. Present technical knowledge in coordination with representative results from recent work is presented. Probable effective means of future basic radio noise reduction are suggested and discussed. A list of references is included.		
G.E. CLASS III	REPRODUCIBLE COPY FILED AT General Engineering Laboratory Library, Schenectady, N.Y.	NO. PAGES 12
GOV. CLASS. None		
CONCLUSIONS Information given is basic for definite gradual design changes that will result in substantial radio noise reduction in d-c machines.		

For list of contents—drawings, photos, etc. and for distribution see next page (FN-610-2).

INFORMATION PREPARED FOR High Voltage & Nucleonics Division

TESTS MADE BY T.J. Perkins, K.L. Scofield, P.C. Gardiner and others.

AUTHOR P. C. Gardiner

COUNTERSIGNED G. W. Dunlap

DIVISIONS High Voltage & Nucleonics

LOCATION Schenectady, New York

C. W. F.

*Mr. J. W. Ryan
c. 1955
File
Kerr*

GENERAL ENGINEERING LABORATORY

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BIBLIOGRAPHY ON CORONA

by

J. W. Ryan

Data Folder No. DF55GL80

February 10, 1955

GENERAL  ELECTRIC



GENERAL ENGINEERING LABORATORY

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR Ryan, J.W.	SUBJECT CLASSIFICATION Bibliography- Corona	NO. 55GL80 DATE 2/10/55
TITLE Bibliography on Corona		
ABSTRACT Approximately 500 references on Corona have been accumulated. The references are listed chronologically in sections. An author index is included. The references listed here are a composite of the bibliographies of Dr. Cobine and P. Elson. (DF-53GL116)		
G.E. CLASS II GOV. CLASS.	REPRODUCIBLE COPY FILED AT General Engineering Laboratory Library	NO. PAGES 73
CONCLUSIONS		

For list of contents—drawings, photos, etc. and for distribution see next page (FN-610-2).

INFORMATION PREPARED FOR W. T. Starr

TESTS MADE BY Elson, Cobine

AUTHOR Ryan, J.W.

COUNTERSIGNED R. L. Francisco *R. L. Francisco*

SECTION _____ LOCATION _____



ts at the Coldwater ehv test
n up to 350 kv to ground, the
measurement on each phase.

Carson
Fred C. Vore

ONTARIO HYDRO

Research News

Vol. 11

No. 1

JANUARY - MARCH, 1959



Coupling capacitor for radio-noise measurements at the Coldwater ehv test project, in assembly stage. Designed for operation up to 350 kv to ground, the capacitor will be movable for convenience of measurement on each phase.

GENERAL ELECTRIC COMPANY

INSULATOR DEPARTMENT

Technical Report No. IK-659-DR

September 29, 1959

SUBJECT

CORONA AND RIV TESTS ON BUNDLED CONDUCTOR ASSEMBLIES

Joseph Kaminski, Jr.

This report contains:

5 typewritten pages

7 curves

3 drawings

Baltimore, Maryland

Signed

Joseph Kaminski, Jr.

Approved

Fred C. Vase

Corona

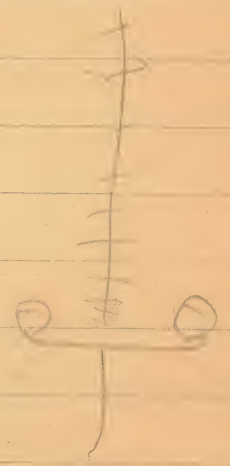
1-18-60

- 1- Caps. near Oil Tank - 383 KV. - 65 yv.
- 2- " away (5'') fin " " - 396 KV. - 65 yv.
- 3- with extension tube for caps. supported with rope - 347 KV. 35 yv.
- 4- Glass rope away from sphere - camera off end of sphere @ 343 KV. -
- 340 KV. - 30 yv.
- 5- Sphere removed, and large shield used. - Glass rope supporting for time
Ferris - -75 to 90 yv. @ 402 KV.
Stod. - -20 to 85 yv. @ 402 KV.

Background N.L. curve, set up same as (5)

Ferris Stod.

KV.	Block (yv.) code	Rdg. (yv.)	x
801	35	40	1
351	40	50	1
361	45	55	1
370	60	65	1
380	65	70	1
389	70	75	1
402	80-100	7 to 9	10



6- Setting No. 1 - 34-1840 S - 300KV. - 80-100 yv. @ 402 KV. - 50 yv.

31	47	63	78	93	108	116	124	(Ring up)
100	131	201	280	301	351	379	402	Vertical
12	22	27	35	100	275	350	375	
35	40	45	45	7-9 ¹⁰	18-20 ¹⁰	20 ¹⁰	23 ¹⁰	
100	201	301					402	(Ring down)
100 yv.	30	100					530	
100 yv.	50	20 ¹⁰					50 ¹⁰	

Corona

GENERAL ELECTRIC COMPANY

INSULATOR DEPARTMENT

Technical Report No. LK-665-DR

May 23, 1960

SUBJECT

Visual Corona and RIV Tests
On Bundled Conductor Assemblies

Joseph Kaminski, Jr.

This report contains:

3 typewritten pages
2 curves
1 test result

Baltimore Maryland

Signed

Joseph Kaminski Jr.

Approved

Fred C. Vore

GENERAL ELECTRIC

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>L. Graham</i> L. Graham	SUBJECT CLASSIFICATION 1. Radio Interference 2. Corona 3. Conductors, Elect.	NO. 60PT150 DATE 7/28/60
TITLE EFFECT OF GREASE AND ARTIFICIAL AGING ON THE CORONA START AND RADIO NOISE FROM CURLEW TRANSMISSION LINE CONDUCTORS		
ABSTRACT Corona start and radio noise tests were made on a 1.246" dia. solid aluminum conductor and on Curlew (1.246" dia.) ACSR transmission line conductors with their surface conditions either clean, artificially aged, greased or organic material applied over grease coat.		
G.E. CLASS IV	FILE COPY AVAILABLE IN THE WILLIAM STANLEY LIBRARY, PITTSFIELD	NO. PAGES
GOV. CLASS None	Pittsfield Works	10
CONCLUSION 1. In general, all aging operations performed on the conductors reduced the corona start voltages. 2. The greatest reduction in corona start voltage was obtained when organic material was applied over a grease coated conductor.		

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR PROJECT EHV / J.J. LAFOREST

TESTS MADE BY C. Reilly, L. Graham Tests Completed: 4/21/60

COUNTERSIGNED H.E. Fiegel *H.E. Fiegel* SECTION High Voltage Laboratory

BUILDING and ROOM No. 9-102 LOCATION Pittsfield, Mass.

-mjb

B. E. Kingsbury
Corona

GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT

August 8, 1960

Technical Report No. LK-671-DR

SUBJECT

VISUAL CORONA AND RIV TESTS
ON
460 KV SINGLE AND BUNDLED CONDUCTOR ASSEMBLIES

This report contains:

4 Typewritten Pages
1 Data Sheet
5 Curve Sheets

Baltimore, Maryland

Signed

Joseph Kaminski Jr

Approved

Fred C. Vane

FOR USE OF G-E EMPLOYEES ONLY

GENERAL  ELECTRIC

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>L. L. Jandran</i> LF Jandran	SUBJECT CLASSIFICATION 1. Transmission Lines 2. Noise, Radio	NO. 60PT155 DATE 9/19/60
TITLE Radio Noise and Leakage Current Investigation of Wooden and Concrete Transmission Line Tower Members and their Associated Hardware		
ABSTRACT Reported are the results of radio noise and leakage current measurements made on wooden and concrete tower members with a ground wire and various combinations of hardware.		
G.E. CLASS IV M GOV. CLASS None	FILE COPY AVAILABLE IN THE WILLIAM STANLEY LIBRARY, PITTSFIELD Pittsfield Works	NO. PAGES 16
CONCLUSION The results of these tests are presented in the tables of the report.		

By cutting out this rectangle and folding on the center line, the above information can be fitted
 into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

 INFORMATION PREPARED FOR Project EHV / J.J. LaForest

 TESTS MADE BY LF Jandran, LJ Wiesztort

 Tests Completed: 1/4/60

 COUNTERSIGNED HE Fiegel *H E Fiegel*

 SECTION High Voltage Laboratory

 BUILDING and ROOM No. 9-102

 LOCATION Pittsfield, Massachusetts

-mfw

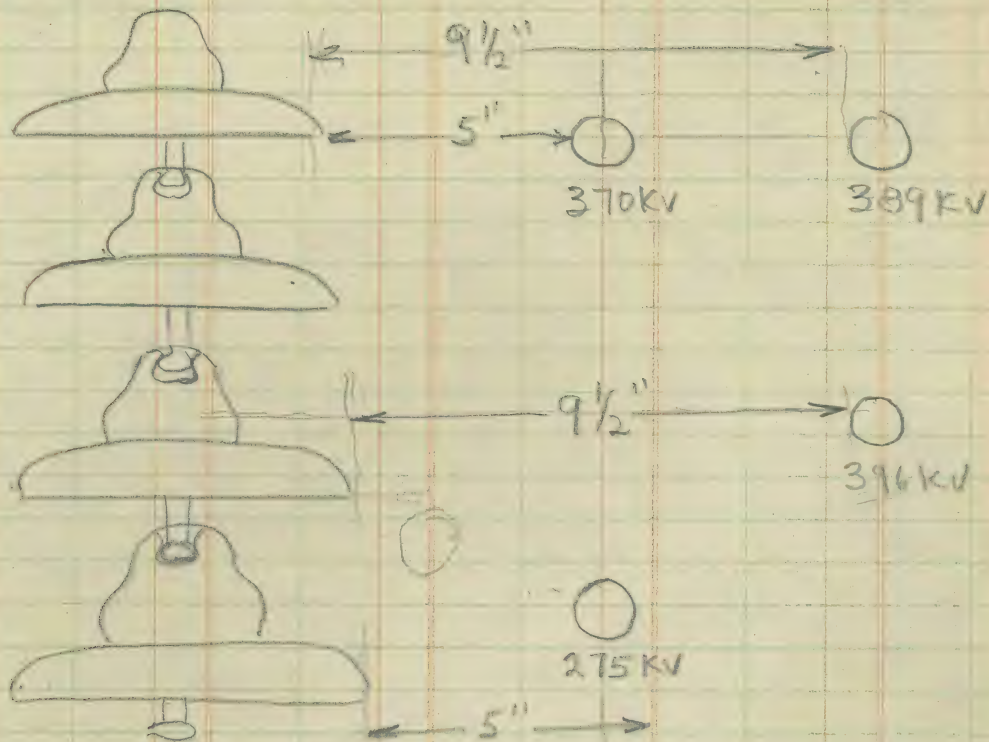
Corona

47

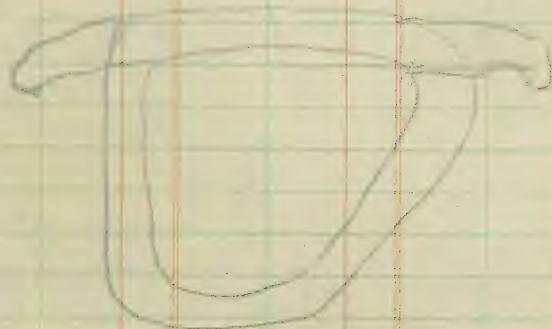
38

19

4-Strings
outside string



11 1/2
3 1/2
14 1/2



GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT

August 8, 1960

Technical Report No. LK-671-DR

SUBJECT

VISUAL CORONA AND RIV TESTS
ON
460 KV SINGLE AND BUNDLED CONDUCTOR ASSEMBLIES

This report contains:

4 Typewritten Pages
1 Data Sheet
5 Curve Sheets

Baltimore, Maryland

Signed

Joseph Kaminski Jr

Approved

Fred C. Vore

GENERAL ELECTRIC COMPANY

INSULATOR DEPARTMENT

Technical Report No. LK-659-DR

September 29, 1959

SUBJECT

CORONA AND RIV TESTS ON BUNDLED CONDUCTOR ASSEMBLIES

Joseph Kaminski, Jr.

This report contains:

- ✓ 5 typewritten pages
- ✓ 7 curves
- 3 drawings

Baltimore, Maryland

Signed

Joseph Kaminski, Jr.

Approved

Fred C. Vase

DISCUSSION OF CONFERENCE PAPER NO. 60-1273

"EFFECT OF BUNDLED CONDUCTOR FIELD

INFLUENCE ON E. H. V. TRANSMISSION

LINE DESIGN"

BY

R. W. HARMON
THE OHIO BRASS COMPANY
BARBERTON, OHIO

DISCUSSION BY:

R. L. MC COY
AND
J. KAMINSKI
INSULATOR DEPARTMENT GENERAL ELECTRIC COMPANY
BALTIMORE, MARYLAND

OCTOBER 12, 1960

INDEX FOR: CONDUCTORS (Trans. & Distrib) (See Corona)

Number	Title	Author	Company	Date
-6307-17	CONDUCTOR SPACERS FOR HIGH AND EXTRA HIGH TWIN OR MULTIPLE CONDUCTOR TRANSMISSION LINES		A. Salvia & Co. Milano, Italy	
	HIGH VOLTAGE TEST REPORT - 500 KV THREE CONDUCTOR SUSPENSION ASSEMBLIES		Betha Co. Birmingham, AL	
(2)	BUNDLED CONDUCTORS		General Electric Baltimore, MD	
	EHV BUNDLED CONDUCTOR SPACER		Clevite Corp. Milan, Ohio	
IEEE 51-195 (2)	COMPARISON OF HEATING EFFECTS & POWER LOSSES BETWEEN FORGED STEEL & FORGED ALUMINUM (MPL) SUSPENSION CLAMPS	Rensselaer Poly. Inst.		
IEEE 51-294	CURRENT CARRYING CAPACITY OF ACSR CONDUCTORS	JH Wagborne VE Ogorodnikov	Hydro-Elec Power Co	5/11/51
IEEE 52-252	INCREMENTAL METHOD FOR SAG-TENSION CALCULATIONS	M. Landau	Dept of Water & Power Los Angeles, CA	7/6/51
IEEE 55-98	STRUCTURE LIMITATION CHARTS FOR TRANSMISSION LINES	TM Austin	Bur of Reclamation Denver, CO	7/7/52
IEEE 55-153	MEASUREMENT OF RESISTANCE AND REACTANCE OF EXPANDED ACSR	J. Tompkins BL Jones PD Tuttle	Aluminum Co of Am Massena, NY	2/16/55
IEEE 55-159	JOINT TESTING FOR HIGH VOLTAGE TRANSMISSION LINES	AS Runciman H. Westman	Shawinigan Water Montreal, Canada	2/16/55
	A METHOD FOR DETERMINING ECONOMICAL ACSR CONDUCTOR SIZES FOR DISTRIBUTION SYSTEMS	AW Funkhouser RP Huber	Indianapolis P & L Indianapolis, In	2/16/55
	THE USE OF AND EXPERIENCE WITH BUNDLED CONDUCTOR LINES	NH Erlandson	Carolina P & L Raleigh, NC	4/7/55
	BUNDLED CONDUCTORS FOR TRANSMISSION CAPACITY INCREASE	HL Deloney WL Rush	LA P & L Co New Orleans, LA	1955

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Number	Title	Author	Company	Date
IEE CP	RELATIONSHIP BETWEEN CORONA AND RADIO NOISE ON TRANSMISSION LINES, LABORATORY STUDIES PART I - POINT AND CONDUCTOR CORONA	TW Liao	AIEE	2/3/56
IEE 56-213	PROGRESS REPORT ON THE INVESTIGATION OF GALLOPING OF TRANSMISSION LINE CONDUCTORS	AT Edwards A. Madeyski	Hydro-Elec Pow Com Toronto, Ont. Canada	2/15/56
IEE 56-222	THE CALCULATION OF THE RADIO INTERFERENCE LEVELS OF TRANSMISSION LINES CAUSED BY CORONA DISCHARGES	GE Adams	General Electric Schenectady, NY	2/15/56
IEE 56-706	PRESENT PRACTICES IN ELECTRICAL AND MECHANICAL DESIGN OF BUSES FOR EXTRA HIGH VOLTAGE SUBSTATIONS	Work Group Project 53.1	AIEE	7/11/56
IEE 57-156	CONDUCTOR ECONOMICS ON HIGH-VOLTAGE TRANSMISSION SYSTEMS	JM Henderson AJ Wood	General Electric Schenectady, NY	2/6/57
IEE 57-533 DP	SOME ASPECTS OF SURFACE VOLTAGE GRADIENT ON POWER TRANSMISSION LINES	HB Dwight	MIT Lexington, MA	3/14/57
ELECTRICAL Design News	GUIDE TO RG-/U CABLES	M Goldstein	American TV, Inc Chicago, IL	Sept 1957
IEE 58-57	BUNDLED CONDUCTORS	J. Kaminski	General Electric Baltimore, MD	7/13/56
IEE 58-191 CP	DEVELOPMENT OF CORONA SHIELDS FOR SUSPENSION ASSEMBLIES OF BUNDLED CONDUCTOR TRANSMISSION LINES	J. Kaminski	General Electric Baltimore, MD	2/19/58
IEE 58-191 CP	THE RESISTANCE & REACTANCE OF ALUMINUM CONDUCTORS, STEEL REINFORCED	WA Lewis PD Tuttle	IL Inst of Tech ALCOA Research Lab	11/18/57
IEE 58-191 CP	SUPPLEMENT	LM Matsch WA Lewis	Univ of Arizona IL Inst of Tech	2/7/58
IEE 58-360	THE MAGNETIC PROPERTIES OF ACSR CORE WIRE	WA Keen, Jr. AJ Damasco	General Electric Pittsfield, MA	4/23/58
8PT228	ELECTROLYTIC FIELD ANALYSIS OF BUNDLED CONDUCTORS IN A CYLINDRICAL CONDUCTOR			

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Number	Title	Author	Company	Date
AIEE 58-110 Reprint	SURGE MEASUREMENT ERRORS INTRODUCED BY COAXIAL CABLES	JH Park	AIEE	7/1958
AIEE	TOWERS, POLES, & CONDUCTORS SUBCOMTEE, AIEE QUESTIONNAIRE-- PARTS I & II		AIEE	1/19/59
AIEE 59-82	BUNDLED CONDUCTOR VOLTAGE GRADIENT CALCULATIONS	J. Reichman	Hydro-Elec Power Comm Tornoto, Ont, Canada	2/20/59
AIEE 59-98	RELATIONSHIP BETWEEN CORONA & RADIO NOISE ON TRANS- MISSION LINES PART II - CONDUCTOR & INSULATOR CORONA	TW Liao JJ LaForest	General Electric Pittsfield, MA	2/20/59
AIEE 59-643	RADIO INFLUENCE VOLTAGES CAUSED BY SURFACE IMPERFECT- ions ON SINGLE & BUNDLE CONDUCTORS	TW Liao	General Electric Philadelphia, PA	6/4/59
AIEE 59-898 CP	SHORT-TIME ANNEALING CHARACTERISTIC OF ELECTRICAL CONDUCTORS	LF Roehmann	Kaiser Alum Spokane, WA	4/29/59
AIEE 59-899	LABORATORY & FIELD EVALUATION OF CONNECTORS & OTHER ACCESSORIES FOR ALUMINUM CONDUCTORS IN SEVERE MARINE ENVIRONMENTS	WJ Sanders	Kaiser Alum Co Spokane, WA	7/10/59
AIEE 59-1122 (2)	ICE BUILD-UP ON CONDUCTORS OF DIFFERENT DIAMETER	EK Lancot HE House EL Peterson ES Zobel	ALCOA Massena, NY Am Elec & Power New York, NY	10/30/59
Prog Report #1	RESEARCH STUDY ON GALLOPING OF ELECTRIC POWER TRANS- MISSION LINES	AS Richardson JR Martuccelli	MIT	12/1/59
CP #2	" " " " "	"	"	2/1/60
AIEE 60-840	EMISSIVITY OF WEATHERED CONDUCTORS AFTER SERVICE IN RURAL & INDUSTRIAL ENVIRONMENTS	WS Rigdon RJ Grosh HE House WB Cottingham	Purdue Univ Lafayette, Indiana Alcoa -Massena, NY Purdue Univ	5/12/60

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Number	Title	Author	Company	Date
10-1273	DISCUSSION OF CONFERENCE PAPER 60-1273 EFFECT OF BUNDLED CONDUCTOR FIELD INFLUENCE ON EHV TRANSMISSION LINE DESIGN	RW Harmon by RL McCoy & J. Kaminski	Ohio Brass Co. General Electric Baltimore, MD	10/12/60
IEE 61-234 CP	TEMPERATURE, CURRENT, & RESISTANCE CHARACTERISTICS OF BARE ALUMINUM DISTRIBUTION CONDUCTORS	E. Hazan	Kaiser Alum & Chem Spokane, WA	12/27/60
IEE 61-496 DP	FIRST REPORT ON FIELD INVESTIGATION OF THE EFFECTS OF CONDUCTORS AGING & CLEANING ON ELECTRICAL CONNECTIONS	OA Boyer J. Hus	Central P & L Burndy Corp	2/10/61
IEE 61-823 CP	THERMAL LIMITS OF OVERHEAD CONDUCTORS AT VARIOUS METEOROLOGICAL CONDITIONS	JA McEllyea	Illinois Power Co Decatur, IL	4/24/61
IEE 61-813 CP	THE ELECTRICAL PROPERTIES OF SINGLE-LAYER ALUMINUM CONDUCTORS, STEEL-REINFORCED (ACSR), HAVING SINGLE STEEL CORE WIRES WITH HEAVY ALUMINUM COATING	CH Jensen RE demuth RW Mowery	Copperweld Steel Battelle Mem Inst Columbus, OH	4/25/61
IEE 61-1090 CP	CONDUCTOR VIBRATION - A STUDY OF FIELD EXPERIENCE	CB Rawlins KR Greathouse RE Larson	ALCOA Massena, NY	8/18/61
ELECTRICAL WORLD	CHART FINDS TRANSMISSION GRADIENT FACTOR	KW Schmidt	Winnipeg, Manitoba Canada	5/14/62
IEE 62-107 CP	SAG & TENSION CALCULATIONS BY THE NOMOGRAPHIC METHOD	RH Sarikas	Illinois Power Co	12/20/61
IEE 62-284 CP	FAULT & LOAD CURRENT TESTING OF A BUNDLE CONDUCTOR SPACER	RL Retallack TR Fry CA Popeck	Am Elec & Power AB Chance Centralia, MO	12/11/61
IEE 62-251 CP	RADIO NOISE AGING CHARACTERISTICS OF SMALL ALUMINUM CONDUCTORS	JJ LaForest EA Whepley	General Electric Pittsfield, MA	12/8/61
IEE 62-1369	EQUIGRADIENT LINES IN THE VICINITY OF BUNDLE CONDUCTORS	AS Timascheff	Alum Co of Canada	10/26/62

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CONDUCTORS

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IEE 63-88	ELECTRODYNAMIC STUDIES OF BUNDLED CONDUCTOR SPACERS	JR Ruhlmann RA Eucker RL Swart	Preformed Line Products Cleveland, OH	12/17/62
CP IEE 63-657	DESIGN CHARACTERISTICS OF THE 5005 ALL-ALUMINUM ALLOY CONDUCTOR FOR THE VEP CO 500 KV PROJECT	HW Adams J. Shaw	Reynolds Metals Co Va Elec & Power	4/25/63
DP IEE 63-783	APPLICATION OF COMPUTER TO THERMAL RATING OF OVERHEAD CONDUCTORS	T. Hunter KE Voight	Duquesne Light Co Pittsburgh, PA	3/21/63
CP IEE 63-1075 (2)	ON THE DESIGN OF BUNDLE CONDUCTOR SPACERS	AT Edwards JM Boyd	Hydro-Elec Power Toronto, Ont. Canada	4/19/63
Report #2	CONDUCTOR CHARACTERISTICS FOR 1000/1100-KV A-C TRANSMISSION	LO Barthold	General Electric	8/20/63
IEE 31 PP 66-307	A PROPOSED FRICTION DAMPER FOR GALLOPING CONDUCTOR WAVES	AH Kidder	Phila Electric Co Philadelphia, PA	3/22/66
IEE 69 CP 8- PMR	EVALUATION OF SPACERS FOR BUNDLED CONDUCTOR TRANSMISSION LINES	RA Krahn MB Bessler	US Dept Interior Bureau of Reclamation Denver, Colorado	10/13/68

ALUMINUM COMPANY OF CANADA LIMITED
MONTREAL

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A. SALVI & C.
C.C.I.A. Milano N. 75138Via Cosenz, 32
Telef.: 97.05.61 - 97.05.95

MILANO

Telegr.: SALVIFI
Raccordo Ferr.: BOVISTA-NORDCONDUCTOR SPACERS FOR HIGH AND EXTRA HIGH TWIN OR MULTIPLECONDUCTOR TRANSMISSION LINES.CONSIDERATIONS.

- 1 - The problem of Spacers for multiple conductor installation for high and extra high transmission Systems is certainly of equal if not of superior importance in the choice of fittings.
- 2 - The experience about Spacers in the international field is still limited and so little known, and the opinion so contradicting among electrical line Engineers, that it is not possible to draw statistical data, which might be taken as a basis for the projecting and the choice of Spacers, which may give ample certainty of dependable service operation, also under the most precarious climatic conditions.
- 3 - The report of an experienced French Engineer, after the tests carried out on a twin experimental horizontal line, is really not very encouraging, and its conclusions give once more great evidence to the above problem.
- 4 - It is believed that the pessimism of many well known Engineers, specialized in the construction of high transmission lines, is due to the fact that they have not been able, so far, to dispose of Spacers summarizing all the necessary requirements.

The troubles which have been disclosed in those countries where multiple conductor lines have been built, have however permitted to determinate the characteristics a dependable Spacer should have to embody.

- 5 - Our own experience in this field has led us to the conviction that a reliable Spacer should summarize the following main requirements:
 - a) - The clamps connected with the conductors must absolutely avoid any slipping, also under the action of most violent wind, irregular snow and ice overloads.

BETHEA COMPANY, INC.
BIRMINGHAM, ALABAMA

HIGH VOLTAGE TEST REPORT
500 KV THREE CONDUCTOR
SUSPENSION ASSEMBLIES

REPORT NO. T-6307-17

NO. _____

BETHEA COMPANY, INC.
BIRMINGHAM, ALABAMA

HIGH VOLTAGE TEST REPORT
500 KV THREE CONDUCTOR
SUSPENSION ASSEMBLIES

REPORT NO. T-6307-17

FOR: _____

Corona

Insulator Department

BUNDLED
CONDUCTORS

General Electric Co.

GENERAL  ELECTRIC

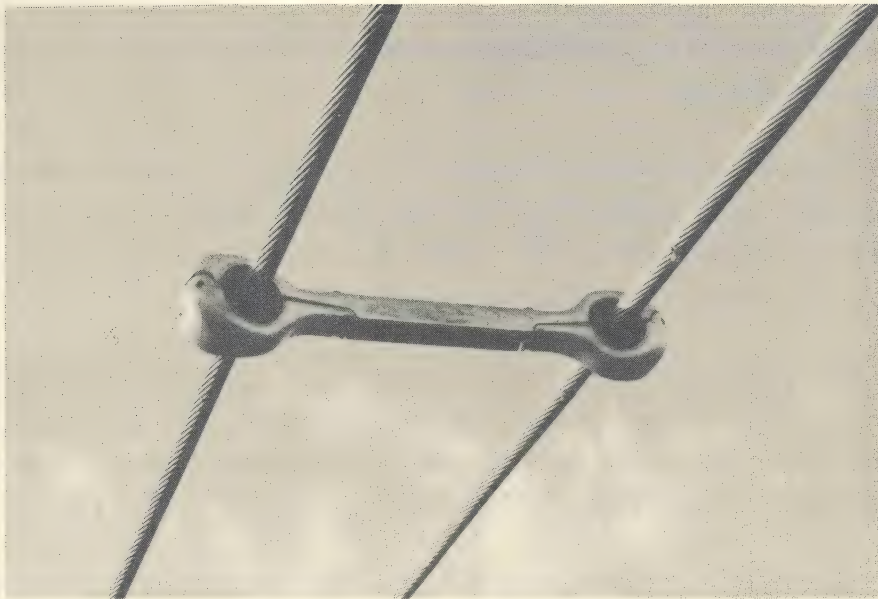
BUNDLED CONDUCTORS

GENERAL  ELECTRIC

CLEVITE
CORPORATION

HARRIS DIVISION

LOCKWOOD ROAD / MILAN, OHIO 44846 / AREA CODE 419-499-2751



EHV BUNDLED CONDUCTOR SPACER

COMPARISON OF HEATING EFFECTS & POWER
LOSSES BETWEEN FORGED STEEL & FORGED
ALUMINUM (MPL) SUSPENSION CLAMPS.

May 1951
Litho in USA



CURRENT CARRYING CAPACITY OF ACSR CONDUCTORS

J. H. Waghorne
Normmember AIEE

V. E. Ogorodnikov
Normmember AIEE

Both of:
The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ont., Canada, June 25-29, 1951. Manuscript submitted March 27, 1951; made available for printing May 11, 1951.

PRICE: 30¢ To Members
60¢ To Normmembers

Return To R. W. McCoy

May 1951
Litho in USA



CURRENT CARRYING CAPACITY OF ACSR CONDUCTORS

J. H. Waghorne
Normmember AIEE

V. E. Ogorodnikov
Normmember AIEE

Both of:
The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

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AUG 4 1952
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STRUCTURE LIMITATION CHARTS FOR TRANSMISSION LINES

Thomas M. Austin
Member AIEE
Bureau of Reclamation,
Denver, Colo.

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Phoenix, Ariz., August 19-22, 1952. Manuscript submitted October 9, 1951; made available for printing July 7, 1952.

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Transactions Paper

(Reviewed and Accepted for Publication)

Conductions



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MEASUREMENT OF RESISTANCE AND REACTANCE OF EXPANDED ACSR

Joel Tompkins
Member AIEE

B. L. Jones
Associate Member AIEE

P. D. Tuttle
Associate Member AIEE

All of:
Aluminum Co. of America
Massena, N. Y.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Manuscript submitted October 20, 1954; made available for printing November 19, 1954.

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Paper No.

55-98

Discussion in Duplicate Due February 16, 1955.

Conference Paper

Conductor



JOINT TESTING FOR HIGH VOLTAGE TRANSMISSION LINES

A. S. Runciman
Member AIEE

H. Westman
Associate Member AIEE

Both of:
The Shawinigan Water and Power Co.
Montreal, Que., Canada

Submitted in abstract or outline form only to AIEE Committee on Transmission and Distribution for the AIEE Winter General Meeting, New York, N.Y., January 31-February 4, 1955. Manuscript submitted November 16, 1954; made available for printing December 6, 1954.

Price: 30¢ To Members
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Paper No. **CP**

55-153

Discussion in Duplicate Due February 16, 1955.

Transactions Paper

(Reviewed and Accepted for Publication)



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ENG. DEPT.

A METHOD FOR DETERMINING ECONOMICAL ACSR CONDUCTOR SIZES FOR DISTRIBUTION SYSTEMS

A. W. Funkhouser
Associate Member AIEE

R. P. Huber
Nonmember AIEE

Both of:
Indianapolis Power & Light Co.
Indianapolis, Ind.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Manuscript submitted October 13, 1954; made available for printing December 15, 1954.

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Paper No.

55-159

Discussion in Duplicate Due February 16, 1955.

THE USE OF AND EXPERIENCE WITH BUNDLED CONDUCTOR LINES

By

N. H. Erlandson, Transmission Engineer
Carolina Power & Light Company
Raleigh, North Carolina

Before Transmission & Large Substation Committee Meeting,
Engineering & Operation Section, Southeastern Electric
Exchange, New Orleans, Louisiana, April 7 & 8, 1955

GENERAL

Although bundled conductors are usually associated with transmission lines of 230 KV and above, our Company has made use of this type of construction as an economical means of handling increased loads on two existing transmission lines in the lower voltage class.

This paper will outline the reasons for the selection of bundled conductors on two of Carolina Power & Light Company's 110 KV transmission lines; some of the problems involved, which are common to bundled conductor lines irrespective of whether or not they are used in the high voltage class or as we made use of this type of construction; and our operating experience with these two lines.

ADVANTAGES OF BUNDLED CONDUCTORS

Some of the advantages offered by the use of bundled conductors as a means of handling increased loads on these two lines, as compared to other plans which were considered, all of which were the single-conductor type of construction, are as follows:

1. Lower construction cost.
2. The reuse of the existing conductor fittings and other accessories. This advantage was of real importance as it eliminated the return of these items to the Warehouse and the possibility of a slow turnover, and possible junking of the fittings and accessories.
3. A reduction in reactance in the order of 25%. Although this factor is of greater importance in the high voltage lines, it was still a very important factor in our application.

In addition to the above major factors, bundling offered the following advantages:

1. A reduction in conductor temperature for a given current value due to the increased surface area of multiple conductors.
2. An increase in capacitance to neutral.

BUNDLED CONDUCTORS FOR
TRANSMISSION CAPACITY INCREASE

By

H. L. Deloney

&

W. L. Rush

Louisiana Power & Light Company
New Orleans, Louisiana

The possibilities of using "Bundled Conductors" for increasing transmission line capacity had long intrigued us as being a means of augmenting capacity of some 2000 miles of 115 KV Transmission lines already in service and on new lines to be built in the future. So in the spring of 1951 we started an investigation to determine its feasibility. We had as a starting point, certain information available concerning some "Super-Voltage" applications in foreign countries where bundling of three or more conductors per phase had been employed to solve the corona problem, but had no information as to the use of "bundling" on lower voltage transmission for capacity purposes.

Determining electrical performance data for comparison with single conductor per phase construction was a matter of mathematics. The following tabulation will illustrate some of the electrical data for 115 KV "H" frame construction using different combinations of ACSR conductor sizes:

Type of Line	Weight Lbs/mile	Resistance Ohms/Mile 25°C	Reactance Ohms/Mile 0 Amps	Charging Micromhos per Mile	Approx. Current Carrying Capacity Amperes
Bundle 2-2/0	5820	.353	.685	6.90	540
Bundle 2-4/0	9252	.223	.657	7.07	680
Bundle 2-336.4 MCM	14652	.139	.591	7.24	1060
Bundle 1-2/0 1-336.4 MCM	10236	.219	.632	7.07	790
Bundle 1-4/0 1-336.4 MCM	11952	.185	.619	7.11	845
Standard 2/0 Line	2910	.706	.902	4.93	270
Standard 4/0 Line	4626	.445	.872	5.09	340
Standard 336.4 MCM Line	7326	.278	.799	5.30	530
Standard 666.6 MCM Line	13581	.147	.760	5.58	800

Note: (A) All bundle conductor lines use a 9" subconductor spacing
(B) Equivalent phase conductor spacing is 17.6 ft.

To determine some of the mechanical and magneto-motive effects, we decided to build about three spans of bundled constructions using 336,400 CM ACSR conductors for tests. Test conductors were pulled in on a section of readily accessible transmission circuit having span lengths of approximately 510'. Tests consisted of various current values with phase conductor spacings of 6, 9 and 12 inches with both horizontal and vertical conductor arrangements. The following Curves show the values at which conductors pulled together, or just held, after being brought together:

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RELATIONSHIP BETWEEN CORONA AND
RADIO NOISE ON TRANSMISSION LINES, LABORATORY STUDIES
PART I - POINT AND CONDUCTOR CORONA

T. W. Liao
Member

For Presentation as a Conference Paper at the 1956
General Winter Meeting of the AIEE

February 3, 1956

Conductors

Transactions Paper

(Reviewed and Accepted for Publication)



PROGRESS REPORT ON THE INVESTIGATION OF GALLOPING OF TRANSMISSION LINE CONDUCTORS

A. T. Edwards
Nonmember AIEE

A. Madeyski
Nonmember AIEE

Both of:
The Hydro-Electric Pwr. Com. of Ont.
Toronto, Ont., Canada

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Paper No.

56-213

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Transactions Paper

(Reviewed and Accepted for Publication)



THE CALCULATION OF THE RADIO INTERFERENCE LEVEL OF TRANSMISSION LINES CAUSED BY CORONA DISCHARGES

G. E. Adams
Associate Member AIEE
General Electric Company
Schenectady, N. Y.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted October 20, 1955; made available for printing December 20, 1955.

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Conductor

PRESENT PRACTICES IN ELECTRICAL AND MECHANICAL DESIGN OF BUSES FOR EXTRA HIGH VOLTAGE SUBSTATIONS

Working Group on Project 53. 1
of the
AIEE Committee on Substations

A paper recommended by the AIEE Committee on Substations and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25-29, 1956. Manuscript submitted March 28, 1956; made available for printing April 30, 1956.

The following are members of the Working Group on Project 53. 1:
F. C. Vose, Chairman; J. W. Erven, W. H. Fong, R. F. Gibbons, R. A. Harvie, S. C. Killian, A. H. Powell, J. A. Smith, R. F. Stevens, D. W. Taylor, C. P. Zimmerman.

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(Reviewed and Accepted for Publication)



*Vose
Kingsbury
Kaminishi
Weller
Jeatho
Walter
Weaver*

CONDUCTOR ECONOMICS ON HIGH-VOLTAGE TRANSMISSION SYSTEMS

J. M. Henderson
Associate Member AIEE

A. J. Wood
Associate Member AIEE

Both of:
General Electric Company
Schenectady, N. Y.

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District Conference Paper



SOME ASPECTS OF SURFACE VOLTAGE GRADIENT ON POWER TRANSMISSION LINES

H. B. Dwight
Fellow AIEE
Massachusetts Institute of Technology
Lexington, Mass.

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Paper No. **DP**
57-533

Insulator Department

BUNDLED
CONDUCTORS

General Electric Co.

GENERAL  ELECTRIC

BUNDLED CONDUCTORS -- INDEX

Characteristic Sheet No. 1473 - #18360 Suspension Insulator
Characteristic Sheet No. 1479 - #18250 Suspension Insulator
Characteristic Sheet No. 1478 - #18251 Suspension Insulator
Characteristic Sheet No. 1480 - #18252 Suspension Insulator
Dwg. U-93206 - Single Suspension Bundled Conductor with Corona Shield
Dwg. U-93204 - Bundled Conductor Corona Shield
Dwg. U-93205 - Dead End Bundled Conductor
Dwg. U-93207 - Dead End Bundled Conductor
Dwg. V-43659 - Socket Eye
Dwg. V-43668 - Socket Clevis
Dwg. V-43657 - Ball Clevis
Dwg. V-43634 - "Y" Clevis Socket
Dwg. V-43633 - "Y" Clevis Ball
Dwg. U-93152 - Bundled Conductor Spreader
Dwg. U-93153 - Twin Conductor Spacer
Dwg. U-93208 - Bundled Conductor Spreader
Dwg. W-93209 - Dead End Assemblies for Strain Bus Sub-stations
Dwg. V-93210 - Bundled Conductor Assemblies
Record of Tests - Radio Influence Voltage - Bundled Conductor Assemblies - Page 1
Record of Tests - Radio Influence Voltage - Bundled Conductor Assemblies - Page 2
Record of Tests - Radio Influence Voltage - Bundled Conductor Assemblies - Dwg. 1
Record of Tests - Radio Influence Voltage - Bundled Conductor Assemblies - Dwg. 2

Guide to RG-/U Cables

Kahn-Conductors

M. GOLDSTEIN, *Electronics Engineer, American TV, Inc., Chicago, Ill.*

The following tabulation of RG-/U Cable characteristics has been compiled from various manufacturers' literature and presents a cross-section of the values contained therein. For the sake of completeness, all available RG-/U numbers have been listed. Thus, the listings include waveguides and stub or bead supported coaxial lines. For RG-/U waveguide characteristics, the reader is referred to the Rigid Waveguide Standards and Comparisons chart that appeared on p. 51 of the Dec. 1956 issue of ELECTRICAL DESIGN NEWS.

Cable covering and conductor information has been listed in order from outermost covering to innermost conductor. The "Armor" is a metallic (usually aluminum) braid which protects the outer jacket of the cable against abnormally severe abrasion. The "Jacket" protects the cable from moisture, weather abrasion, and other mechanical and electrical effects. Jacket materials, as listed in the tabulation, are:

- C. Tube* Copper tube
- Chloro* Chloroprene
- Fiberglas* Fiberglas braid impregnated with a high temperature silicone varnish for operation to 500F.
- Kel-F* Extruded Trifluorochloroethylene. Operates from -370F to +390F and has a high chemical resistance.
- Lead* Lead sheath.
- L. T., Black* Non-contaminating thermoplastic for use at low temperatures (to -40C).
- Neoprene*
- Nylon* Extruded black nylon.
- Poly* Polyethylene.
- Rubber*
- "Teflon"* Tetrafluoroethylene. Operates from -100F to +500F. Has virtually no water absorption.
- Vinyl, Black* ... Polyvinylchloride (Vinylite) with a non-resinous plasticizer. Migration of the plasticizer may contaminate the dielectric,

thereby increasing attenuation and reducing the breakdown voltage.

Vinyl, Grey Non-contaminating Polyvinylchloride with resinous plasticizer.

The dielectric materials as listed are:

- Copo* Copolene, a combination of polystyrene and polyisobutylene.
- M.O.* Magnesium oxide.
- Poly* Extruded solid polyethylene.
- Rub* Synthetic rubber.
- SS Poly* Semi-solid polyethylene (air-spaced).
- SS "Teflon"* Semi-solid "Teflon".
- "Teflon"* Extruded tetrafluoroethylene. Has low losses, high breakdown voltage and good efficiency at high temperatures. "Teflon" dielectric is usually covered with one or two silver-coated or plain copper shield braids and two wrappings of "Teflon" tape for a moisture seal.
- "Teflon" T* "Teflon" tape.

Abbreviations employed for the inner conductors and the shield braids are as follows:

- C* Copper
- CW* "Copperweld" (copper covered steel wire).
- CWS* Silver coated "Copperweld."
- CWT* Tinned "Copperweld."
- F* Formex F, wound in helix.
- K* "Karma" wire.
- N* Nichrome
- S* Silver coated copper.
- T* Tinned copper.
- T and Galv*
- Steel* Three braid: tinned copper, galvanized steel, tinned copper.

(Continued on page 38)

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Transactions Paper

(Reviewed and Accepted for Publication)



DEVELOPMENT OF CORONA SHIELDS FOR SUSPENSION ASSEMBLIES OF BUNDLED CONDUCTOR TRANSMISSION LINES

J. Kaminski, Jr.
Member AIEE
General Electric Co.
Baltimore, Md.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 14, 1957; made available for printing November 7, 1957.

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Conference Paper



THE RESISTANCE AND REACTANCE OF ALUMINUM CONDUCTORS, STEEL REINFORCED

W. A. Lewis
Fellow AIEE
Illinois Institute of Tech.,
Chicago, Ill.

P. D. Tuttle
Member AIEE
Alcoa Research Laboratories
Massena, N.Y.

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H. A. FREY

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H. A. FREY

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RESISTANCE AND REACTANCE OF

ALUMINUM CONDUCTORS, STEEL REINFORCED

~~R. Heller~~
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~~J. M. Jants~~
~~J. E. Lee~~
~~W. J. Hutton~~
~~B. E. Humphrey~~

W. A. Lewis
Fellow AIEE

P. D. Tuttle
Member AIEE

Please substitute the attached text for pages
29 to 31 inclusive of the original draft and
add APPENDIX IV between APPENDIX III and
REFERENCES.

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H. A. FREY

Conference Paper

Conductors

A
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I

THE MAGNETIC PROPERTIES OF ACSR CORE WIRE

L. W. Matsch
Fellow AIEE

University of Arizona
Tucson, Arizona

W. A. Lewis
Fellow AIEE

Illinois Institute of Technology
Chicago, Illinois

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Transmission and Distribution Committee for the AIEE
Winter General Meeting, New York, N.Y., February 2-7,
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Graduate

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>W.A. Keen, Jr.</i> W.A. Keen, Jr. <i>A.J. Damasca</i> A.J. Damasca	SUBJECT CLASSIFICATION Fields, Electrical Conductors, Electrical	NO. 58PT228 DATE 4-23-58
TITLE Electrolytic Field Analysis of Bundled Conductors In a Cylindrical Conductor		

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>W.A. Keen, Jr.</i> W.A. Keen, Jr. <i>A.J. Damasca</i> A.J. Damasca	SUBJECT CLASSIFICATION Fields, Electrical Conductors, Electrical	NO. 58PT228 DATE 4-23-58
TITLE Electrolytic Field Analysis of Bundled Conductors In a Cylindrical Conductor		
ABSTRACT The electrolytic field analyzer was used to study the field near the conductors enclosed in a grounded cylindrical tank. The gradient distributions were determined for 2, 3, and 4 conductor bundles.		
G.E. CLASS III - M GOV. CLASS None	REPRODUCIBLE COPY FILED TECHNICAL SERVICE DIV. PITTSFIELD Pittsfield, Massachusetts	NO. PAGES 19
CONCLUSIONS 1. Surface gradients are distributed on the periphery of the conductors sinusoidally with the maximum gradients on the front side of the conductors in the area nearest the grounded cylinder. 2. The gradients on the inside of the bundle are not only lower than those on the outside of the bundle, but also decrease at a faster rate as the radial distance from the conductor increases.		

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR Electrical Performance - Systems Research - P.T. Engineering

TESTS MADE BY W. A. Keen, Jr., A. J. Damasca

COUNTERSIGNED T. R. Walters *T.R. Walters* DIV. Electrical Research
High Voltage Laboratory

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PITTSFIELD, Massachusetts

July 1951
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INCREMENTAL METHOD FOR SAG-TENSION CALCULATIONS

Maurice Landau
Member AIEE
Department of Water and Power
The City of Los Angeles
Los Angeles, Calif.

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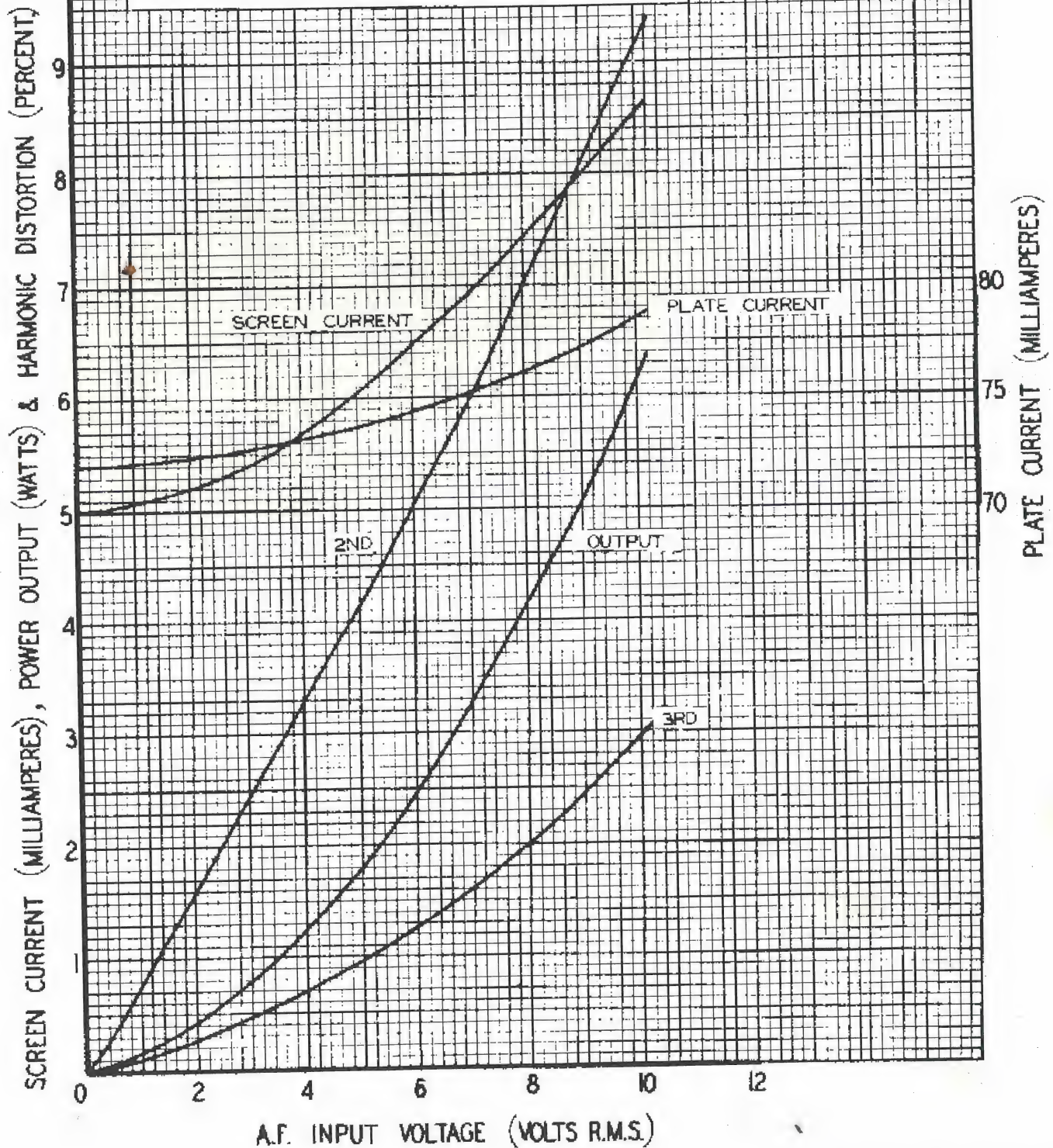
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VALVE TYPE 807
CLASS "A" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE

PLATE VOLTAGE = 250 VOLTS
SCREEN VOLTAGE = 250 VOLTS
CONTROL GRID VOLTAGE = -14 VOLTS
PLATE LOAD = 2,500 OHMS



GENERAL ELECTRIC

INSULATOR DEPARTMENT
2525 Insulator Drive
Baltimore, Md. 21230



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R. Weller
J. Kaminski

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February 3, 1967

Mr. J. J. LaForest
PITTSFIELD

As I discussed with you about ten days ago, we are interested in determining whether or not our standard suspension insulator, as per the attached drawing U-1840, can be designed to be more corona-free than is now the case.

Let me digress for just a moment to give you a little background on the overall problem. As you know, our scope of business covers all types of line hardware, such as clamps, yoke plates, and fittings, as well as insulators. In fact, we are concerned with the entire assembly which supports the power conductor to the tower. Sometimes a customer specification will demand that the assembly, when subjected to a given voltage, will have less than a specified amount of RIV. At other times the specification will demand that there be no corona at the specified test voltage. The third possibility is that both a specified RIV level and no visual corona will be required at the test voltage level.

Generally speaking, it is quite feasible to design an assembly to meet the RIV levels specified, and the hardware parts can also be designed to meet the visual corona requirements. But, it becomes quite impossible to design to eliminate visual corona from the insulators, even when using quite elaborate shielding (grading rings). The amounts of visual corona on the insulators do not usually cause very much noise (RIV), at least in comparison with the noise caused by a brush discharge on a piece of hardware.

See the attached curve sheet which shows a generalized plot of RIV versus Test Voltage. The lower section of the curve will be created solely by insulator noise, and the upper part by corona on hardware parts. Usually, the RIV, as caused by the insulators, is about as shown, increasing linearly with test voltage.

As far as I am concerned, where there is RIV there must be corona (at least 10-15 microvolts). Then, the question arises, can we correlate the visual corona levels on the insulators with the RIV curves? The answer is no. The visual corona levels obtained on the insulators depend upon a variety of things such as how dark the laboratory is, how good the observers vision is, and how long the observer has waited to allow his eyes to adjust to the darkness. This situation has created some

INSULATOR DEPARTMENT
GENERAL ELECTRIC COMPANY

April 3, 1964

RADIO INTERFERENCE FROM E. H. V.
TRANSMISSION LINES AND SUBSTATIONS

ML-9, Tabs L and N

As most of you are by now already aware, the subject of radio noise generated by conductors and insulator assemblies on E. H. V. transmission lines has been one which has been very controversial for some two or three years and there has undoubtedly been a tendency to go way overboard by many utility and consulting engineering organizations in the specification of very severe corona and radio influence voltage requirements on insulator assemblies of all kinds.

This undoubtedly has arisen from the fear that E. H. V. lines may produce tremendous amount of radio interference and thus be a cause of poor public relations between the utility and people living in areas adjacent to or near E. H. V. transmission lines.

The relationship between radio influence voltage on insulator components measured in the laboratory on a directly coupled basis to the radio field intensity which these devices would produce on the line has not been well understood in the past and it now appears that radio noise suppression on insulator assemblies and components has in most cases been greatly overemphasized far beyond the actual needs.

At the inception of E. H. V. work in the early years after World War II, with the almost complete lack of knowledge and understanding about these things, the concept was that insulator assemblies should never show any visible or audible corona at a voltage at least 10% above line to neutral voltage and that the R. I. V. on the components as measured in the laboratory should be held at 50 to 100 microvolts or lower when the assembly was energized at 110% of line to ground voltage. This has resulted in a lot of costly designs with all components made with either large and bulky radii at the edges or else has involved rather complete and thorough shielding.

More recently, these R. I. V. specifications for insulator assemblies for E. H. V. projects have been somewhat liberalized where specifications have permitted the R. I. V. levels to go to 350 to 500 microvolts at voltages applied equal to 110% of the maximum line to ground operating voltage.

It now becomes apparent that these liberalized specifications are requiring much better performance radio interference wise than is actually needed, which is causing the cost of insulator assemblies to be higher than is necessary for the actual performance of the line.

In the final analysis, the utility building an E. H. V. circuit is concerned with what the radio interference field is at the edge of the transmission line right-of-way, usually 100 to 150 ft. from the centerline of the transmission circuit.

*Mr. Joseph Kaminski, Jr.
Insulator Dept.
Baltimore*

Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due February 19, 1965.



THE EFFECT OF STATION RADIO NOISE SOURCES ON TRANSMISSION LINE NOISE LEVELS

J. J. LaForest
Senior Member IEEE
General Electric Company
Schenectady, N. Y.

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JJ LaForest
F Olsen

"CONTRIBUTION TO THE STUDY OF RADIO NOISE GENERATED BY MEDIUM VOLTAGE LINES"

By

MM. C. Gary and M. Moreau

Article from "Revue Générale de L'Électricité", October 1963, pages 503 to 518 Inclusive

Translation by D. D. MacCarthy

Giving account of work showing the possibility of evaluating the radio noise fields created by high frequency currents which are generated by insulators on medium voltage lines. In the first part, the authors analyze the process of forming these currents both in rigid insulators and then in suspension insulators; they show that the spectrum of the disturbing current is characterized by the line geometry and by the capacitance between the two metal parts of the insulator. An equivalent circuit of the insulator and line proves that they behave as a current generator injecting high frequency current in the two halves of the line on each side of the insulator. This current, determined by a series of laboratory tests, is the principal characteristic of insulator noise.

In the second part of the article, the authors reveal the possibility of obtaining correlation between the disturbance field measured under the medium tension line and the disturbance current injected in the line and determined from laboratory tests. A formula is established allowing the prediction of attenuation of the disturbance field in a direction perpendicular to the line as well as the absolute value of the disturbance field.

PART I: STUDY OF INSULATORS

Radio noise disturbances observed under lines of medium voltage cannot be attributed to the conductors, as is the case for high voltage lines, because the gradient to which they are subjected, of the order of 3 to 6 kv/cm, is much too low to generate, except during rain, leakage currents caused by corona. In the present work, we propose to demonstrate the possibility of evaluating the disturbance field of a medium voltage line due to the insulators, basing it on the laboratory measurements of the high frequency currents generated by the latter.

I. THEORETICAL STUDY OF INSULATORS.

Experience shows that the disturbance field of a medium voltage line does not vary in the same way, depending on whether the line is equipped with rigid [pin?] or suspension insulators: in the first case the disturbance field decreases markedly in fog or rain, whereas the opposite occurs beneath lines with suspension insulators. It seems then that insulators are, according to their type, the seat of different phenomena, phenomena that we are going to attempt to explain in what follows:

A. Rigid Insulators [pin type?]: - In the case of rigid insulators, the conductor is simply supported at the insulator neck by a lashing-like attachment, so that, if some portions of the conductor are in intimate contact with the insulator body, others must be separated by small air gaps. Because the insulation resistance is very high, it is justifiable to represent by independent capacitors the lines of force bordering on the zones of intimate contact and the lines of force bordering upon the air spaces. The same representation is valuable in the case of a defective insulator, where air gaps are caused



TECHNICAL INFORMATION SERIES

Title Page

AUTHOR JJ LA FOREST	SUBJECT CLASSIFICATION IV File 6-J	NO. DF-63-AD-51 DATE 12-23-63
TITLE THE EFFECT OF INSULATOR NOISE CURRENTS ON THE RADIO NOISE LEVEL OF A TRANSMISSION LINE		
ABSTRACT An analysis is made to show what the lateral radio noise profile would be for a 3-phase transmission line as a result of noise currents generated solely by the insulator strings. Typical cases for 345-, 500-, and 700-kv lines are examined. At distances generally used to evaluate the RI field from a transmission line, the effect of insulator noise currents is seen to be low.		
G.E. CLASS IV GOV. CLASS.	REPRODUCIBLE COPY FILED AT Pittsfield Works Project EHV	NO. PAGES 19
CONCLUSIONS The use of modal analysis has enabled the computation of the effect of insulator noise on the radio noise performance of a transmission line. The computation is facilitated by using eigen roots, field factors, and attenuation values obtainable from the General Electric Radio Noise Program. Values of insulator noise currents are obtained from laboratory tests. This analysis can also be used to determine the effect on line radio noise performance of point sources other than insulator strings such as station equipments.		

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Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due February 21, 1964.



RADIO NOISE STUDIES ON POWER LINES WITH THE CORONAPHONE

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Toronto, Ont., Canada

A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 1, 1963; made available for printing December 4, 1963.

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Paper No.

64-52

411.—CORONA LOSS AND RADIO INTER-FERENCE MEASUREMENTS AT HIGH VOLTAGE A.C. ON TEST LINES IN SWEDEN

by N. KNUDSEN,

Chalmers University of Technology
(Sweden)

SUMMARY

On a test plant erected by the Swedish State Power Board in connection with the Chalmers University of Technology in Gothenburg comprehensive corona tests have been carried out during the last years. Beside the general intention to broaden the theoretical and practical knowledge about the corona phenomenon there has been a special purpose namely to compare the behaviour of double and triple conductors of the types used in Sweden which contain cables with a diameter of 3,2 cm and a spacing of 45 cm.

The results of the experiment indicate that by use of triple conductors instead of double conductors the yearly losses, apart from ice losses, are reduced from about 1,4 kW/km to about 0,4 kW/km and the radio interference level is reduced by about 8 dB in fair weather, and probably somewhat more in bad weather. Expressed in another way the triple conductor has given approximately the same losses and radio disturbances at 460 kV as the double conductor at 400 kV.

Variations between 40 and 95 % in the humidity in the air did not seem to affect the losses noticeably but a slight decrease in radio interference with increasing humidity was observed. Bad weather has given increasing losses in the following order: fog, dry snow, rain, wet snow, hoar frost.

A method for calculating fair weather losses is proposed and future work is outlined.

SUSPENSION INSULATOR FLASHOVER
UNDER HIGH IMPULSE VOLTAGES

B. E. Kingsbury

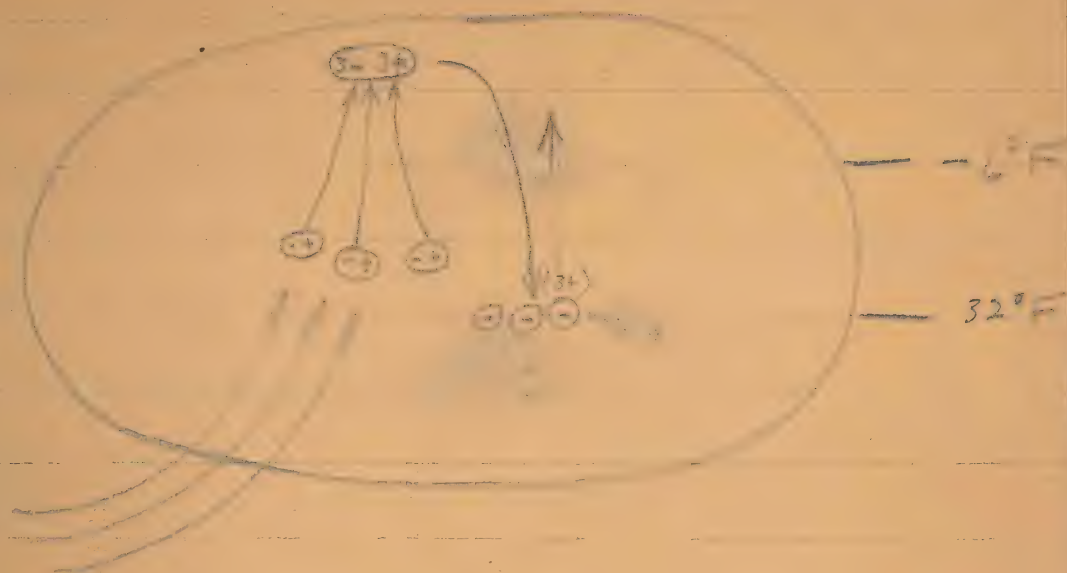
Some of the unpredicted flashovers on high voltage transmission lines which have been experienced during the last few years have raised questions as to the flashover performance of suspension insulators when subjected to impulse voltages considerably higher than the normal critical impulse flashover value. There has been some indication that on some of these circuits the flashovers may have occurred due to very high impulse voltages of very brief duration. These have been commonly spoken of as steep wave front surges.

The rated impulse flashover voltage of a suspension insulator string is based upon the application of a 1-1/2 by 40 microsecond wave applied to the line end of the insulator string with the tower end grounded. This so called critical impulse flashover rating is the voltage at which an insulator string may be expected to flashover on 50% of the applications under standard test conditions.

On transmission structures which are protected by ground wire, it is most likely that the lightning discharge will occur to the tower or the ground wire so that the impulse is applied to the tower end of the insulator string, and, relatively, the conductor end may be considered to be grounded. There is some question as to whether the normal critical flashover voltages which are established in the laboratory by standard test methods properly measure the performance of an insulator string when subjected to this condition.

The curve, Figure 1, shows the normal critical impulse flashover voltage of insulator strings tested under standard laboratory conditions. In this curve, arcing distance is plotted as abscissa, and it is recognized that with a good degree of accuracy the flashover voltage of conventional suspension insulators

Theory of Cloud Charge - Lightning



The air stream moving in from lower left of cloud during a storm creates a strong updraft within the cloud and carries moisture vapor (which carries neutral charge) upward. As the vapor enters the cold stratum, condensation commences and the combination of droplets until they reach such size as their mass overcomes the air stream force and they fall. As the drops fall they may increase in size by recombination until they reach a critical size and split. When by this time they might be back in the warmer cloud stratum and tend to evaporate (which is aided by the updraft). Upon ^{partial} evaporation of a water drop, there is left on the water drop a negative charge and it is probable that there is a positive

Effects of
Gunfire

EFFECTS OF GUNFIRE
ON INSULATING STRUCTURES
FORT MEADE FEB. 13, 1963

Baltimore, March 26, 1963

SUBJECT:

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On February 13, 1963, at Fort Meade, Md., our Engineering Section staged a test to determine the relative resistance of several insulating structures to gunfire. All firing was done by expert riflemen stationed at Ft. Meade. Tests were conducted on each of the following:

1. Lapp Strut Insulator, Cat. No. 73770, a 12 unit equivalent suitable for 230 kv application, 15,000 lb. ultimate tensile strength.
2. Locke Unispar, Cat. No. 18713, a 13 unit strut suitable for 230 kv application, 13,000 lb. ultimate tensile strength.
3. Locke unit-type Polymer suspension insulator (developmental) suitable for 69 kv application, 15,000 lb. ultimate tensile strength.

All shots were made at a distance of 60 feet. The guns and ammunition used were as follows:

1. 22 long rifle - 40 grain lead match bullet, velocity 1300 ft./sec.
2. 45 cal. service pistol - 230 grain lead match bullet, velocity 830 ft./sec.
3. 308 Magnum service rifle - 180 grain lead match bullet, velocity 2650 ft./sec.
4. 30 cal. type M-1 service rifle - 173 grain lead bullet, velocity 2640 ft./sec.

The first firings were made at the bottom of each insulator structure, and successive shots were made up the structure as to be hitting undamaged parts as the tests progressed.

The following series of photographs show the damage sustained by each of the insulators.



CURVE 10 LSV-1-A

CALIBRATION CURVE FOR

10 UNIT GENERATOR

15 x 40 ms WAVE

900
800
700
600
500
400
300
200
100
0

KV
CREST

NEGATIVE
POSITIVE

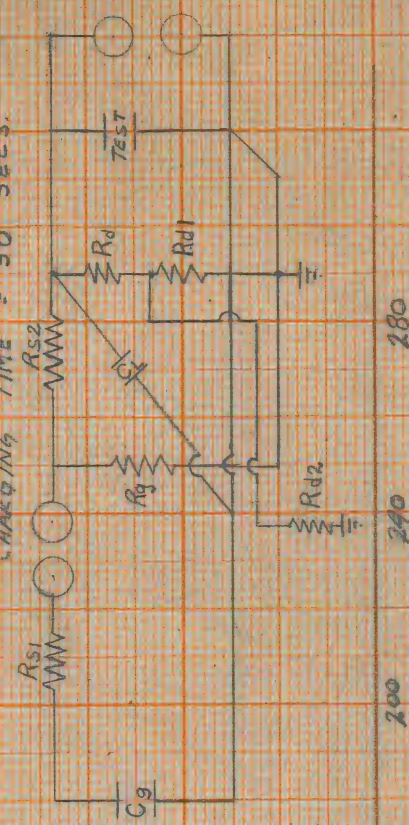
LOWER SIDE VOLTS (R.M.S)



$R_{d2} = 75 \Omega$
 $C_g = 0.33/20 \mu f$
 $C_L = 600 \mu f$
 $R_{s1} = 100 \Omega$
 $R_{s2} = 530 \Omega$
 $R_{d1} = 19,900 \Omega$
 $R_g = 4,110 \Omega$
 $C_s = 480 \mu f$ approx
 $R_{d1} = 75 \Omega$
 USE 8 FT. OF BRAID FROM TOP OF R_g
 RACK TO PULLEY.
 CHARGING TIME - 30 SECS.

RESISTORS
18-30'S
40-500'S
33-125'S

CHARGING TIME - 30 SECS.

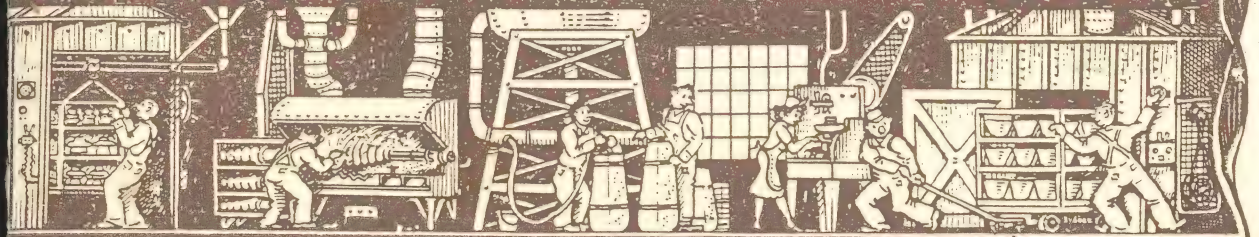


2-27-52
3-7-88
C.S.

PORCELAIN BODY • ANOTHER INSPECTION • PUGGING, PLUNGING AND THEN



MAIN DRYERS • TURNING • CASTING • ← • FINISHING • THE FIRST DRYER



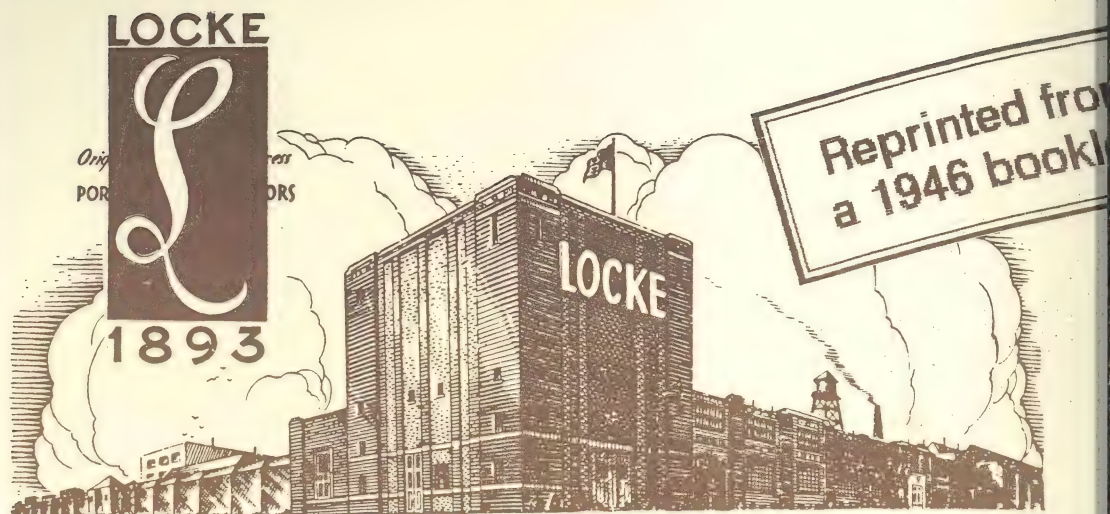
• ASSEMBLING • FINAL INSPECTION • TESTING IN LAB. • PACKING AND SHIPPING • →



*The Birth of a
LOCKE INSULATOR*



Locke Insulators
OPEN HOUSE-PLANT TOUR
August 6, 1988
Baltimore, Maryland, U.S.A.



Let's Look at Locke...

You are a welcome visitor to the plant of the Locke Insulator Corporation--the world's largest manufacturer of wet-process porcelain insulators.

Our company was founded in 1893 in Victor, New York, by Fred M. Locke. Mr. Locke was a telegraph operator on the New York Central Railroad. He conceived and developed the first wet-process porcelain insulator because of the difficulties that he personally experienced with the insulators then in use on telegraph lines.

From a small beginning in 1893 has grown a whole industry that is fundamental in making possible the safe and economical transmission and distribution of electric power. With the advent of the high-voltage transmission line around the turn of the century came a big problem--insulators that would stand such high electrical stresses and yet were strong and reliable. Mr. Locke's insulators proved to be the answer. In fact, it is the only material manufactured today for such use.

Our company's only plant was in Victor until 1920 when the Baltimore plant was started. From 1920 until 1935 both plants were operated. In 1935, the plant at Victor was abandoned and all manufacturing was taken over by Baltimore.

[Continued on inside-back cover]

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booklet.



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Locke.
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taken

-back cover.]

Welcome to

THE LOCKE INSULATOR COMPANY

OPEN HOUSE & PLANT TOUR

"It is a great pleasure to welcome Locke retirees, employees, and family members to visit our facility. Here you will be able to see why my Locke co-workers and I are proud of the over 2,000 products manufactured here in Baltimore. These electrical insulators and other porcelain products are used throughout the North American continent and in many countries of the world.

"All of us are engaged in a difficult struggle to help Locke become the Success Story of Maryland. If, in each job, we apply dedicated determination, willing cooperation, and skilled experience, I feel certain that we will make it happen. Such confidence can be greatly strengthened by the support and understanding of the members of our respective families. Thank you for coming to visit with us."

--Gus Isobe, President

Locke Insulators, Baltimore, Maryland, USA



FOR YOUR INFORMATION: Do you know that...

...Locke Insulators provides, as the following paragraphs detail, a flow of millions of dollars into the economy of greater Baltimore and the State of Maryland, helping to create jobs for hundreds of other Marylanders.

...to run the kilns and other equipment, last year Locke spent nearly one million dollars (\$968,840) for natural gas.

...the over 2,000 Locke products range from a list price of \$3.00 to over \$3,000 each.

...Locke's electrical bill for 1987 was over a half million dollars (\$575,302).

...we used 75,954,164 gallons of water last year costing over \$26,000.

...Locke's 1987 and projected 1988 tax bills from the City of Baltimore and State of Maryland will total over \$344,000.

...Locke ships its products to all 50 of the United States, plus Puerto Rico, and, through the cooperation of NGK, to over 11 countries.

...the total 1987 and projected 1988 payroll for Locke employees will be about \$23,745,000.

...the Locke facility is under nearly 20 acres of 123 separate major roofs; to re-roof the entire area would cost an estimated \$5 to 6 million. In roof maintenance alone, Locke spends \$300 to \$350 thousand each year.

...the cost of health care, insurance, and other benefits for Locke employees and their families during last year and projected for this year will amount to over \$8,243,000.

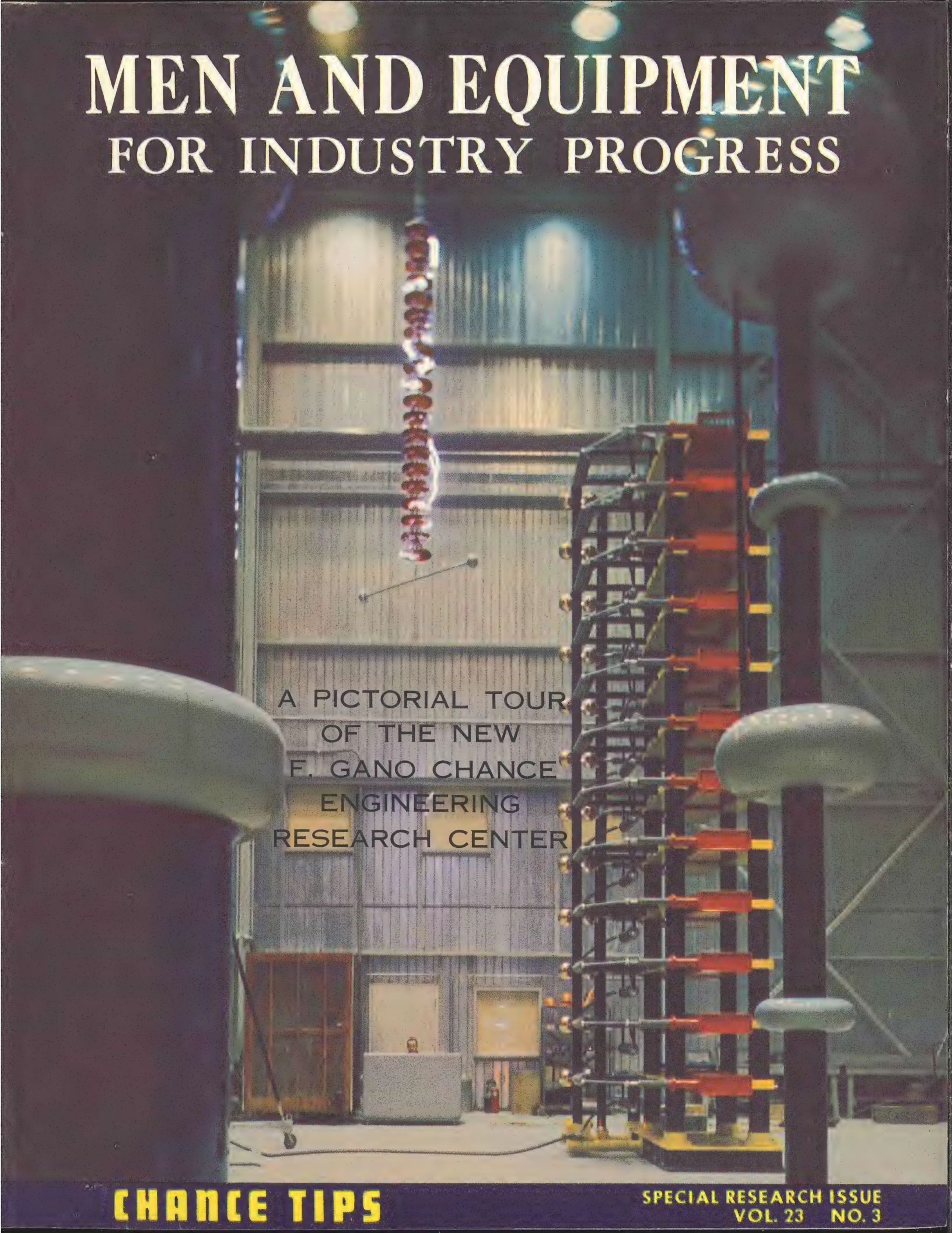
...two of Locke's tunnel kilns are about 400 feet long with firing temperatures as high as 2300 degrees Fahrenheit.

...the grand total figure for 1987 and projected 1988 salaries, wages, and benefits paid by Locke will amount to nearly \$32,000,000.

Locke Insulators, Baltimore, Maryland, USA



MEN AND EQUIPMENT FOR INDUSTRY PROGRESS

A photograph of a large industrial facility, likely a research center, with a tall, multi-story building and various pieces of equipment in the foreground. The building has a corrugated metal exterior and several windows. In the foreground, there are large, white, dome-shaped structures and a tall, black, spiral staircase-like structure with red and yellow accents. A long, thin, vertical object, possibly a probe or a sensor, is suspended in the air. The overall scene is dimly lit, with some light coming from the windows and the foreground equipment.

A PICTORIAL TOUR
OF THE NEW
F. GANO CHANCE
ENGINEERING
RESEARCH CENTER

CHANCE TIPS

**SPECIAL RESEARCH ISSUE
VOL. 23 NO. 3**

LOCKE INCORPORATED
Baltimore, Maryland

TECHNICAL REPORT NO. 546
May 23, 1949

SUBJECT

CHIO BRASS COMPANY SUSPENSION INSULATORS

This report contains:
4 Typewritten copies

Signed:

Jm Jesatko

Approved:

Chas. C. [unclear]

Te

MAGNETIC HEATING OF TRANSMISSION LINE CLAIMS

BY: MESSRS. V. L. CRAEB AND J. M. SHEADEL 49-212

Revised To E. L. McCoy

Schenectady,

August 4, 1949

Mr. W. J. Molachlan
BUILDING 2

Herewith is a copy of the above A.I.E.E. Paper which is to be presented at the Pacific General Meeting at San Francisco, Calif., August 23-26, 1949. I assume that you will be interested in this subject and may wish to arrange for preparation of discussion.

All discussions must be approved through the regular channels before being submitted in triplicate to A.I.E.E. Headquarter. It will be advisable to prepare an additional copy to be handed to the representative of ELECTRICAL WORLD who will be in attendance at the meeting.

By copy of this letter to the individuals listed below I am asking that they also endeavor to arrange for preparation of discussion.

F. P. CALLAHAN

FPC:LL

cc: ~~SB Crary, Bldg. 2~~
~~DL Beeman, Bldg. 2~~
~~CH Foust, Bldg. 37~~
~~ED Hoy, Pittsfield~~
~~MS Hill, Locke, Inc.~~
~~GB Shanklin, Bridgeport~~

July 1949
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MAGNETIC HEATING OF TRANSMISSION LINE CLAMPS

V. L. Crabb
Member AIEE

J. M. Sheadel
Associate AIEE

Both of:
The Ohio Brass Company
Barberton, Ohio

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33 West 39th Street, New York 18, N. Y.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23-26, 1949. Manuscript submitted May 23, 1949; made available for printing June 30, 1949.

PRICE: 30¢ To Members
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AIEE
Technical Paper
53-81

December 1952
Litho in USA



Discussion for publication
must be postmarked on or before
February 4, 1953.

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REAL POWER AND IMAGINARY POWER IN ALTERNATING CURRENT CIRCUITS

C. F. Estwick
Member AIEE
43 Cambridge Place
Brooklyn, N. Y.

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Manuscript submitted April 30, 1952; made available for printing December 3, 1952.

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60¢ To Nonmembers first class mailing desired)

Misc

MEASUREMENT OF EARTH RESISTANCES*

A.B. OSLON

Zlatoust

(Received 28 August 1955)

A three-electrode circuit is used to measure the resistances of an earthing system, these being: the earth electrode (earthing circuit), the current electrode and the potential electrode. All quantities referring to the earth electrode are denoted by the K , those referring to the current electrode by subscript T and those referring to the potential electrode by P .

Current is passed through the earth and current electrodes. The potential of the circuit is measured via the potential electrode. The earth resistance equals the measured potential divided by the current passing.

In Fig.1 the voltmeter and ammeter are instruments specially designed for measuring the resistances of earthing systems.

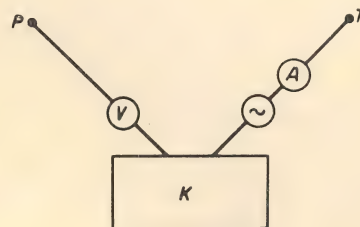


Fig. 1.

It is usually assumed that the current and earth electrodes must be sufficiently far apart not to distort the field and that a sufficiently large zero potential zone remains between them. The potential electrode must be placed in the zero potential zone [1,2].

Let us assume that we already know the earth resistance of the circuit R_K .

Is it then possible, having placed the current electrode at an arbitrary point, to so locate the potential electrode that the measured resistance is equal to R_K ? If this is possible, how can we determine the 'locus of precise measurements'?

To answer this question we will use the analogy between an electrostatic field and the field due to a current in a conducting medium.

* *Elektrichestvo* No.2, 56-58 (1957).

[Reprint Order No. EL. 10]

(5) The inter-turn voltages expected in travelling-wave tests can be calculated approximately from the machine winding data. As a rule, the test voltages will be sufficiently high in machines with few (two to four) turns per section.

REFERENCES

1. V.A. Karasev and Z.G. Kaganov; Wave propagation in the windings of electrical machines. *Elektrichestvo* No.4 (1949).
2. G.N. Petrov and A.I. Abramov; Inter-turn voltages in the windings of electrical machines during wave processes. *Elektrichestvo* No.7 (1954).
3. A.A. Timofeenko; Set-up for testing the inter-turn insulation of electric motors. *Elektricheskie Stantsii* No.6 (1950).
4. N.V. Smirnov; *Checking and Testing Windings in Electric Machines and Apparatus*. Gosenergoizdat, 1955.
5. N.V. Smirnov; Testing the turn insulation of electric motor windings under service conditions. *Elektrichestvo*, No. 5 (1955).
6. Deckans; Investigation of surges in H.V. motors. A.S.E. - Bull. No.35 (1953).
7. G.G. Shvets and S. Gretsikii; Experimental investigation of surges in the windings of electric machines. *Electrical Insulation* No.2 (1938).
8. R.C. Robinson; Distribution of impulse voltages in bar-wound high-speed turbogenerators. *Proc.Instn.Elec. Engrs.* No.77 (1953).
9. A.P. Aleksandrov et al. *The Physics of Dielectrics*. G.T.T.I. (1932).

A METHOD OF DERIVING EQUATIONS FOR THE ELECTROMECHANICAL TRANSIENT IN ELECTRIC CIRCUITS*

S.V. STRAKHOV

(Received 5 October 1956)

There are basically two methods of investigating the transient electromechanical processes in electric circuits, viz:

1. Physical modelling.
2. Mathematical modelling, this comprising two sections, viz:
 - (a) the section using physical analogs;
 - (b) the section using digital computers (integrators) with continuous and discrete action.

The method of physical modelling, comprehensively treated in papers of V.A. Venikov [1-3], M.P. Kostenko [4-6] and of other authors, consists in the replacement of large rotating electric machines and hydraulic turbines by similar units of small ratings with due consideration to the laws of similitude. Transmission lines, transformers, saturable reactors and static loads are replaced by assemblies of capacitances and inductances, networks with repeated members being used for transmission lines. In other words, in this case the physical character of the model and of the original are the same.

Among the advantages of the method of physical modelling, where rotating machines are concerned, we should mention the possibility of considering eddy currents, saturation, hysteresis, the actual distribution of stator and rotor windings in space, and of other factors. A drawback of this method is the difficulty of varying the parameters of individual machines, usually necessitating the availability of a number of inter-changeable rotors for them. It is, therefore, more convenient to use the method of mathematical modelling in cases where the parameters of the machines must be variable; because this method can deal in a much more simple way with such variations. However, physical modelling will still be preferable in all cases in which the system of differential equations describing the process is very complicated.

* *Elektrichestvo* No. 7, 5-10, 1957 [Reprint Order No. EL 32].

THE INDUCTION LAW FOR AN ELECTROSTATIC MACHINE*

A.A. BAL'CHITIS

(Received 19 December 1956)

Introduction

The fundamental equations of the classical theory of electrodynamics, the first and second equations of Maxwell point to two possible methods of conversion of mechanical into electrical energy. For example, by the first equation of Maxwell†

$$\text{curl } \vec{H} = \gamma \vec{E} + \frac{\partial \vec{D}}{\partial t} \quad (1)$$

such a conversion is possible when an electric field changes with time, i.e. by mechanical action on the electric field it is possible to obtain the magnetic field connected with it in space.

According to the second equation

$$\text{curl } \vec{E} = - \frac{\partial \vec{B}}{\partial t} \quad (2)$$

it is possible to obtain an electric field by changing the magnetic field associated with it.

The second equation of Maxwell was the generalized form of Faraday's experimental law of electromagnetic induction, viz.

$$E = B l v, \quad (3)$$

which was discovered in 1831 and forms the basis of the design of a large variety of electric machines, covered by the general term "electromagnetic machines".

Machines working on the principle of a mechanical change of an electric field (Maxwell's first equation) are not nearly so widely used; they are known as *electrostatic* machines. These machines are used for obtaining high and very high voltages for research purposes.

For a long time electrostatic machines did not find practical uses. The suc-

* *Elektrichestvo* No.7, 11 – 14, 1957 [Reprint Order No.EL33].

† All equations are given in terms of the absolute practical rationalized system of units.

Conference Paper



RESEARCH BY THE CENTRAL ELECTRICITY AUTHORITY

J. S. Forrest
Nonmember AIEE
Central Electricity Research Laboratories
Leatherhead, Surrey, England

Submitted in abstract or outline form only to the AIEE Committee on Research for the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted November 29, 1955; made available for printing December 9, 1955.

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Paper No. **CP**

56-267

TELEVISION IN THE WORLD TODAY

by

Charles J. Hirsch
Hazeltine Corporation
Little Neck, L.I., N.Y.

A conference paper for presentation at Winter General
Meeting of American Institute of Electrical Engineers,
New York City, Thursday, February 2, 1956, at 9:30 A.M.

WIND PRESSURE ON OVERHEAD TRANSMISSION LINE CONDUCTORS*

V.V. BURGSDORF

(Received 9 January 1957)

The correct assessment of wind pressure on conductors is of great importance in the design of transmission lines. This applies particularly to double-circuit lines and lines equipped with release clamps and safety (swivelling or collapsible) cross-arms, since in these cases there is an upper limit imposed for the maximum permissible wind loading. In designing large installations, it is necessary to know accurately the aerodynamic characteristics of conductors and the distribution of wind pressure.

As is well known, strong winds are always of turbulent nature and consist of fast-and slow-moving air masses. In other words, the wind velocity is never uniform along the front of a gust. The total load on a long object is therefore determined not by the maximum, but by some mean value, of the wind velocity. For spans longer than 200 m this lack of uniformity may be of considerable importance.

The first experimental investigations to ascertain the extent of the non-uniformity in the distribution of the wind velocities affecting the total load on conductors date back over 25 years [1] and [2]. These tests showed that for wind speeds up to 20 m/sec. this non-uniformity can be neglected for spans up to 100 m. long, but that it becomes sufficiently noticeable on spans about 200 m. long.

Later investigations carried out in Sweden in 1939 revealed a possibility of reducing the design value of wind load because of the finding that the wind pressure becomes less uniform with velocity [3]. Similar experiments were also carried out in other countries: France in 1951 [4] and [5], Australia in 1949 [6]; Belgium in 1952 [7]. Recently investigations were made in West Germany [8] and in the U.S.S.R. where eight experimental stations were erected with span lengths from 220 to 350 m.

The reduction co-efficient considering the non-uniform distribution of the pressure along the span was introduced in the Soviet Regulations for Trans-

* *Elektrichestvo* No.5, 47-52, 1957 [Reprint Order No. EL 23].

CORONA LOSSES ON LIVE TRANSMISSION LINES*

V.D. KRAVCHENKO, V.I. LEVITOV and V.I. POPKOV

(Received 7 February 1957)

The corona loss on an energized transmission line constitutes only a small fraction of the transmitted energy and is commensurable with or sometimes even smaller than the heat loss. Therefore, it is practically impossible to determine this loss by separating the current component which corresponds to the corona loss from the total line current as measured by conventional methods.

The corona loss is due to the cross currents, that is, the currents that flow between the conductors and between the conductors and earth. If it were possible to measure quantities which are proportional to these currents, or to their corresponding charges this would be the best solution of the problem of measuring the corona losses on energized lines.

Fig. 1 shows an arrangement consisting of a single phase-conductor, 1, and an aerial, 2, which is earthed through a measuring element Z connected to the middle of the aerial.

The e.m.f. induced electromagnetically in an aerial isolated from earth is so distributed that it is zero at the middle of the aerial [1]. Therefore, if this point is earthed through a measuring element Z , no current can flow in the element owing to the magnetic field of the line. The current which flows in the element is determined only by the electrostatic coupling between the line and the aerial.

The minimum height at which conductors are suspended on conventional lines is 7–8 m. At this height the space charge in the region G (Fig. 1) is distributed practically symmetrically with respect to the conductor axis, i.e. the space charge density depends only on the distance from the axis of the conductor of the element of charge considered. Consequently, the integrated electrostatic effect of the space charge on the aerial is the same as that of a linear charge of equal magnitude placed at the axis of the conductor.

For sufficiently small values of the impedance Z the relation between the charge on the aerial and the total charge of the conductor is given by:

$$\alpha_{12}q_1 + \alpha_{22}q_2 = 0 \quad (1)$$

* *Elektrichestvo* No. 7, 31 – 34, 1957 [Reprint Order No. EL 35].

THE NOMOGRAM FOR DETERMINING PROTECTIVE ZONES OF LIGHTNING CONDUCTORS*

L.M. LOPSHITS

(Received 24 April 1956)

This nomogram supersedes an earlier one (*Elektrichestvo*, No. 10, 1947) and is deemed necessary because of the distinction made in the latest instruction book on overvoltage protection of electrical installations for 3 - 220 kV (Gosenergoizdat, 1954) between the formulae for lightning conductors up to and above 30 m.

The nomogram is constructed for single and double lightning conductors up to 150 m using an empirical formula based on laboratory test results and on the assumption that orientation of the lightning stroke onto the lightning conductor takes place at the height of $H = 600$ m (for an open country).

The use of the nomogram is explained with three examples.

That part of the latest Code of Practice on protection against overvoltages [1] which deals with protection against direct lightning strokes is based on laboratory investigations carried out at the V.I. Lenin All Union Electro-technical Institute, and differs from the earlier edition of the Code [3] in that in it a distinction has been introduced between the formulae for rod lightning conductors up to 30 m high and above 30 m high. Thus, the earlier nomogram for determining protective zones, constructed for lightning conductors up to 60 m has become obsolete and now may be used only for lightning conductors up to 30 m.

Figs. 1 and 2 give curves constructed from the data included in [2] which describe protective zones of single and double lightning conductors respectively. The geometrical sense of the parameters of the protective zone a , h , h_a , h_x , b_x , and r_x is clear from Fig. 4; by H is denoted the height at which orientation of the lightning channel onto the lightning conductor takes place for open country.

For taller lightning conductors, $h > 30$ m, H was taken as 600 m, and for shorter lightning conductors, $h < 30$ m, the constant ratio of $H/h = 600/30 = 20$ was taken. It should be mentioned here that the Code of Practice does not set definite limits within which its recommendations are valid but merely states that the value of $H = 600$ m can be used for "very tall lightning conductors".

The curves given in Figs. 1 and 2 can be applied in these cases when the height of the lightning conductor does not exceed 150 m ($H/h = 4$), which corres-

* *Elektrichestvo* No. 7, 76 - 78, 1957 [Reprint Order No. EL 39].

ARCING SHORT-CIRCUITS ON 400 kV TRANSMISSION LINES AND METHODS OF DEALING WITH THEM*

A.S. MAIKOPAR and N.N. BELIAKOV

Central Scientific and Research Electrotechnical Laboratory,
Moscow Electric Station

(Received 19 September 1957)

On 400 kV transmission lines with a solidly earthed neutral, we have to expect mainly single-phase short-circuits to earth. As opposed to the lines with lower voltages, the restoring of the electric strength of the path of the arc after switching off the phase becomes more difficult on 400 kV lines because of appreciable influence of the current at the point of damage caused by capacitive and electromagnetic connections between the disconnected phase and the working phases. The supply current which will flow at the point of the fault, after automatically switching off the faulty section of the line, will sustain the electric arc for a certain time. The next reclosing can be done only after the extinction of the arc and restoration of the electric strength. This circumstance not only defines the placing of protective relays but also exerts an influence on the total lay-out of switchgear on the 400 kV lines. In particular, the problem of connecting shunting reactors directly to the line or through the circuit-breakers is strictly connected with the extinguishing of the sustained current arc. Several works are known dealing with research on the sustained current arcs [1-5]. Nevertheless, they do not give a clear idea of the range of sustained currents, for which it is possible to use single-phase automatic reclosing. As a result of these works, it is assumed that the extinguishing of the sustained current arc is possible for the currents of the order of 12-15 A.

Research into powerful open arcs, carried out by the C.S.R.E.L., has shown that an electric arc is capable of self-extinction even for currents of a few hundred amperes, if the conditions exist for a substantial increase of its length [6]. On this basis the investigations of the sustained current conditions were undertaken. Experiments on a 6 kV model have shown that the extinction of the sustained current arc for gradients of 5-15 kV/m occurs for currents up to 75-100 A, and experiments on a 220 kV grid 750 km long have shown the possibility of

* *Electrichestvo* No.1, 19-25, 1958 [Reprint Order No. EL 43].

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UNBALANCED LOADING OF THREE-PHASE TRANSFORMER BANKS

S. W. Anderson
Associate Member AIEE
Middle West Service Company
Chicago, Ill.

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H. A. FREY

A paper recommended by the AIEE Committee on Transmission and Distribution for the AIEE Great Lakes District Meeting, Des Moines, Iowa, April 15-17, 1957. Manuscript submitted January 14, 1957; made available for printing March 14, 1957.

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Paper No. DP

57-608

INSULATOR DEPARTMENT
GENERAL ELECTRIC COMPANY
Baltimore, Maryland

Technical Report No. LK-647
May 28, 1958

SUBJECT

Knox 6 Inch, 10,000 lb. Suspension Insulator

This report contains:

3 Typewritten Pages

Signed

Joseph Kaminski Jr

Approved

Fred C. Vase

GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT
Baltimore, Maryland

Technical Report No. IK-646-DR

May 28, 1958

SUBJECT

Knox 10 Inch 15,000 Lb. Insulator

J. Kaminski, Jr.

This report contains:

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Joseph Kaminski, Jr.

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Fred C Vase

Miss.

Conference Paper



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H. A. FREY

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POWER SYSTEM PLANNING ECONOMICS

A. J. Wood
Member AIEE
General Electric Company
Schenectady, N. Y.

A paper recommended by the AIEE System Engineering and Transmission and Distribution Committees for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Manuscript submitted January 31, 1958; made available for printing April 15, 1958.

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58-870

District Conference Paper



MAGNETIC LOOP CONTACTS FOR OUTDOOR GROUP-OPERATED SWITCHES

Eugene Gorin
Member AIEE
Memco Engineering & Mfg. Co., Inc.
Commack, L. I., N. Y.

A paper recommended by the AIEE Switchgear Committee for presentation at the AIEE Middle Eastern District Meeting, Baltimore, Md., May 19-21, 1959. Manuscript submitted March 12, 1959; made available for printing March 20, 1959.

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~~Mr. Hone~~
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Transactions Paper

(Reviewed and Accepted for Publication)

Miss



ZERO-SEQUENCE CURRENT DENSITY IN THE EARTH

Marion E. Forsman
Member AIEE
University of Florida
Gainesville, Fla.

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CRITICAL-PATH PLANNING AND SCHEDULING

A SUMMARY

by
J. E. Kelley, Jr.
and
Morgan R. Walker

Mauchly Associates, Inc.
Ambler, Pa.

May 1960

Misc.

Conference Paper



VOLTAGE NOMENCLATURE - SECONDARY AND UTILIZATION SYSTEMS

A. S. Anderson
Fellow AIEE
Ebasco Services Inc.
New York, N. Y.

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INSULATOR DEPARTMENT

Technical Report No. LK-183-CR

July 22, 1960

SUBJECT

THEORETICAL MODEL FOR VOLTAGE STRESS AND
PUNCTURE STRENGTH OF PORCELAIN DIELECTRIC PLATES

Ronald H. Lester

INFORMATION CONTAINED IN
THIS REPORT IS RESTRICTED
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This report contains:

8 typewritten pages

Baltimore, Maryland

Signed

Ronald H. Lester

Approved

P. B. Horton

Conference Paper

M. Weller

Thisc.



THE USE OF THE ELECTROLYTIC TANK FOR DETERMINING EXTERNAL INDUCTANCES OF ENCLOSED CONDUCTORS

L. L. Mankoff
Associate Member AIEE

R. H. Brealey, Jr.
Nonmember AIEE

Both of:
General Electric Co.
Philadelphia, Pa.

Submitted in abstract or outline form only to the AIEE Special Instruments and Auxiliary Apparatus Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 5, 1960. Manuscript submitted November 25, 1959; made available for printing December 14, 1959.

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Misc



MEASUREMENT OF FLICKER RESULTING FROM LARGE ARC FURNACE OPERATIONS

D. E. Simmons
Associate Member AIEE
Houston Lighting and Power Co.,
Houston, Tex.

Submitted in abstract or outline form only to the AIEE Transmission and Distribution Committee for presentation at the AIEE Southwest District Meeting, Houston, Tex., April 4-6, 1960. Manuscript submitted January 28, 1960; made available for printing February 10, 1960.

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GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT

Technical Report LK-694-DR

October 10, 1961

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NINE INCH SUSPENSION INSULATOR E1763

J. Kaminski, Jr.

This report contains:

6 typewritten pages

Baltimore, Maryland

Signed

Joseph Kaminski Jr.

Approved

Fred C. Vase

HIGH LINE TOOLS
FOR HIGH VOLTAGE LINES
AND HEAVY CONDUCTORS
PAST, PRESENT AND FUTURE

by

CLETUS R. BREWER
Chief Hot Line Tool Demonstrator
James R. Kearney Corporation
St. Louis, Missouri

Presented At:

Pacific Coast Electrical Association
Engineering and Operating Meeting
Overhead Transmission and Distribution Group

March 23, 1962

San Francisco, California

Transactions Paper

(Reviewed and Accepted for Publication)



RAINFALL RATE AND RESISTIVITY AT EAST PITTSBURGH, PA.

D. L. Whitehead
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

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62-1025

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Conference Paper



HIGH SPEED THREE POLE RECLOSING

Report of the Arc Delonization Times Working Group

of the AIEE General Systems Subcommittee

For presentation at the AIEE Summer General Meeting, Denver, Colorado,
June 17-22, 1962.

Arc Delonization Times Working Group: H.M. Ellis, Chairman; O.A. Demuth,
L.O. Barthold, A.E. Kilgour, D.F. Shankle, W. Watson, E.T.B. Gross,
R.E. Stade.

Conference Paper



ELECTROMAGNETIC AND ELECTROSTATIC TRANSMISSION LINE PARAMETERS BY DIGITAL COMPUTER

M. H. Hesse
Member AIEE
Electric Utility Analytical Engineering
General Electric Company
Schenectady, N.Y.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 7-12, 1962. Manuscript submitted June 7, 1962; made available for printing August 31, 1962.

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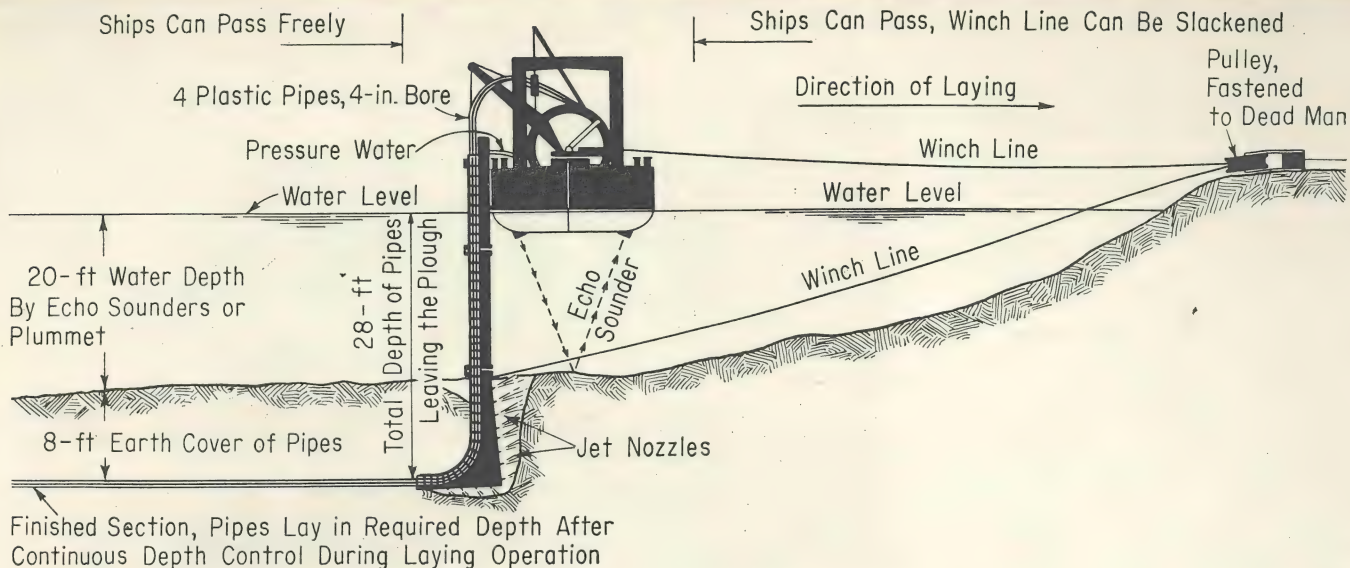
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62-1387



Conduits 'Hydro-Jet' Embedded for 750-Ft River Crossing

High density polyethylene conduit for 69-kv cable is currently being jet-embedded 8-ft below the bottom surface of Beach Thorofare waterway at Atlantic City Electric Co. A novel "hydro-jet" method of embedding the conduit is being employed for the job by the job-contractor, Harmstorf Corp, Larchmont, NY.

The project involves a distance of 750-ft at the point of waterway crossing. Four, 4-in. I.D. high density polyethylene conduits (0.45-in. wall thickness) have been jet-laid to date. Sixteen of them will eventually be installed in four separate cuts.

In contrast to conventional methods used in laying underwater conductor conduit or cable, the hydro-jet method does not require removal of soil with a dredge and its subsequent replacement, is not subject to "filling-in" (as in a dredged-trench) before the conduit or cable is laid: and, the method does not rely on the skill and physical stamina of divers. Furthermore, and of significance is the basic advantage of being able to efficiently and economically embed conduit under the river bottom.

The use of "buried" plastic conduits to house the cable permits the use of more flexible, less expensive unarmored cable. Also, spare conduits can be buried at the time of installation, so that additional cables

can be pulled through the spare conduits at a later date when service is expanded. Idle investment in spare conduits is low. Removal of cable for repair or replacement is simple.

Cable embedding begins with the "hydro-jetter" equipment positioned just outside the "near-shore" sheet piling; with winch-control lines rigged from both the near and far shore; and, with the four-conduit lines threaded from its source coil around the outboard side of the tug and down through the injector housing and conduit guide section.

The essential part of equipment required for hydro-jetting is the injector. It includes a high-pressure water section and a conduit guide section. At the leading narrow edge of the injector, in the direction of travel, and at its bottom, water jets are provided.

As the injection jets are pressurized to about 170 psi, a narrow cut of controllable depth is made into the bottom of the body of water and the conduit is simultaneously laid along the bottom of the cut—the winch lines from the far shore move the "hydro-jetter" along its laying route.

This bottom "trench" is produced primarily by the action of high-power water jets. The soil loosened by the jets, temporarily in suspension in the surrounding water, settles rapidly and immediately starts to embed the conduit laid along the



HYDRO-JETTER UNIT: 1-water-pressure hose; 2-injector; 3-plastic conduit to be embedded in river bottom; 4-winch line; 5-free-running conduit coils



Fundamental Aspects of Some Switching Overvoltages on Power Systems

J. ZABORSZKY
FELLOW AIEE

J. W. RITTENHOUSE
FELLOW AIEE

Summary: System overvoltages caused by switching are of interest in insulation co-ordination problems. This paper treats such overvoltages in a graphical fashion, so that a visual concept of overvoltage versus time is provided in both single- and 3-phase cases involving resistive loads, inductive loads, and capacitive loads. As special cases, attention is given to a neutral inversion problem and to a case of coupled circuits.

THE INCREASING complexity of power systems has created difficulty in analyzing specific cases of trouble which seem to stem from system overvoltages. It is believed that some of this difficulty can be minimized if one has a thorough grasp of the causes of overvoltages.

It is the purpose of this paper to demonstrate and review a few of the fundamental conditions that can cause overvoltages. In particular, overvoltages arising from switching operations will be discussed.

It is believed that the graphical approach that is followed provides an easy means of conducting a review in providing a good physical concept of the basic causes of many kinds of overvoltage phenomena.

Restrikes in a Single-Phase Resistive Circuit

A single-phase radially fed pure resistive load is shown in Fig. 1. The line itself is assumed to be purely resistive, and while this is admittedly not a practical combination, it is included here as an introduction to practical but more complicated situations which will be dealt with later.

Current is interrupted at time t_1 ; prior to that there is a voltage drop, with a peak value of ΔE , on the line. This, for the resistive circuit shown, is exactly in phase with the current, I , which in turn is exactly in phase with the source volt-

age E_a . Following current interruption at t_1 , the voltage E_a remains zero, while the source end of the switch follows the source voltage $E_a = E_a$.

The difference between the E_a and E_a curves, $E_a - E_a$, is the recovery voltage which is being built up across the gap of the switch.

If at some time after t_1 the recovery voltage exceeds the dielectric strength between the switch contacts, a restrike will occur. The potentially most dangerous time for this is t_2 when the peak recovery voltage is reached. Nothing unpleasant happens, however, in this purely resistive circuit. The current is re-established, and it instantaneously assumes the value it would have had at the instant of restrike if there had been no interruption.

The voltages of the terminals a and A instantaneously shift to satisfy the condition $E_a = E_a$ which would have existed with the load connected and if no interruption had occurred.

Restrikes in a 3-Phase Resistive Circuit

Conditions for the 3-phase purely resistive circuits are shown in Fig. 2. The line resistances have been omitted in this illustration to keep it as uncluttered as possible.

Current (not shown) in phase A is interrupted at time t_a . From here on $E_a = E_n$, and since n now is simply the midpoint of a voltage divider between points b and c , also $E_a = (E_b + E_c)/2$.

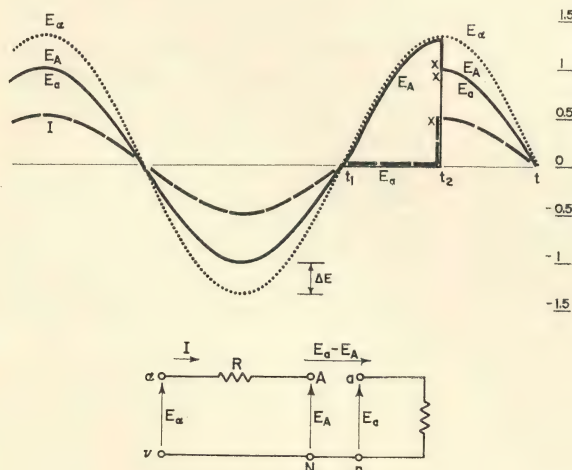


Fig. 1. Circuit, voltages, and current considered in the single-phase resistive restrike and energizing cases (left)

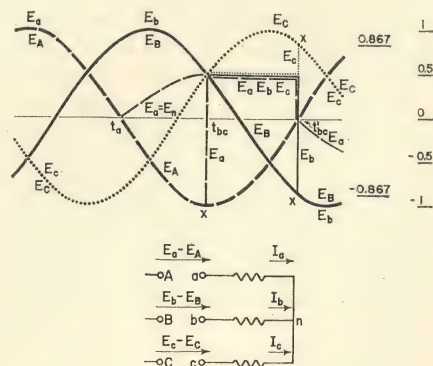


Fig. 2. Circuit and voltages considered in the 3-phase resistive restrike and energizing cases (right)

Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due July 5, 1963.



ARC DEIONIZATION TIMES ON HIGH SPEED THREE POLE RECLOSING

IEEE Working Group on Arc Deionization Times
of the
General Systems Subcommittee
of the
IEEE Transmission and Distribution Committee

A paper recommended by the IEEE Transmission and Distribution Committee and approved by the IEEE Technical Operations Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted April 20, 1962; made available for printing April 18, 1963.

Members of the IEEE Working Group on Arc Deionization Times of the General Systems Subcommittee: H. M. Ellis, Chairman; O. A. Demuth, L. O. Barthold, A. E. Kilgour, D. F. Shankle, E. T. B. Gross, R. E. Stade.

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Paper No.

63-938

TRANSVERSE LOADING of PIN TYPE INSULATORS

GENERAL ELECTRIC

ELECTRIC UTILITY ENGINEERING
OPERATION

MAIL ADDRESS:

1 River Road
Schenectady, N.Y.
June 9, 1965

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SUBJECT

ELECTRIFICACION DEL CARONI, C.A.
400-KV Tower Insulation Design
Study

*Messrs. Kaminski
Kryzhanov*

*Please return
to M.S. for
file.*

~~Miss Mary Stack~~
2525 Insulator Drive
BALTIMORE

Dear Miss Stack:

A copy of this report has been mailed to R. E. Bauer in accordance with his request. This was a customer study and the results are proprietary to General Electric Company.

R. L. Thompson

R. L. Thompson
Application Engineer
A-C Transmission Engineering
Building 2 - Room 610 - Dial Comm 8*235-3657

RLT:pms
Encl.

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JUN 15 1965

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ELECTRIFICACION DEL CARONI, C.A.

400-KV TOWER INSULATION

DESIGN STUDY

May 4, 1965

L. O. Barthold

R. L. Thompson

General Electric Company
Schenectady, New York



IEEE SUMMER POWER MEETING

JUNE 22-27, 1969
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General Engineering Consultants to the San Francisco Bay Area Rapid Transit District

Number	Title	Author	Company	Date
Reprint GE Review	EFFECTO OF SHORT LENGTHS OF CABLE ON TRAVELLING WAVES	McEachron, KB Hemstreet, JG Seelye, HP	General Electric Schenectady, NY	Nov. 1930
Paper	A HYPOTHESIS CONCERNING LIGHTNING PHENOMENA AND TRANSMISSION LINE FLASHOVER	Johnson, IB Schultz, AJ	General Electric AIEE Members	
Paper	ANALYTICAL STUDIES ON LIGHTNING PHENOMENA INVOLVING TOWERS, INSULATOR STRINGS, AND TRANSMISSION LINES	Johnson, IB Schultz, AJ	General Electric AIEE Members	
AIEE 50-163	A METHOD OF ESTIMATING LIGHTNING PERFORMANCE OF TRANSMISSION LINES	AIEE Working Group	AIEE	May 1950
AIEE 55-475	TRAVELING WAVE PROTECTION PROBLEMS - II	Boehne, EW	MIT Cambridge, MA	June 20, 1955
Minutes Memorandum	AMERICAN GAS & ELECTRIC FLASHOVER PROBLEM FIELD STUDIES--SURGE CHARACTERISTICS OF 300 KV TOWERS	Johnson, IB	General Electric	Aug. 31, 1956
Electrical World	WHY EHV LINES SHOW EXCESS OUTAGES	Millers, CJ Jr.	Ohio Brass Co. Barberton, OH	Sept. 5, 1955
AIEE 56-733	A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES	Wagner, CF	Westinghouse E. Pittsburgh, PA	March 28, 1956
Paper	PRINCIPLES FOR THE CALCULATION OF THE LIGHTNING PERFORMANCE OF A TRANSMISSION LINE FOR A DIRECT LIGHTNING STROKE TO THE LINE	Lundholm, Ragnar	Sweden	1956
Letter to IB Johnson	Re. Prof. Lundholm's paper	Skeats, WF	General Electric Philadelphia, PA	Nov. 26, 1956
Comments to Skeats Letter	re: Prof. Lunholm's paper	Lundholm, R per Finn, RB Jr.	Am. Gas & Electric New York	Dec. 12, 1956
Booklet	INDUCED OVERVOLTAGE-SURGES ON TRANSMISSION LINES AND THEIR BEARING ON THE LIGHTNING PERFORMANCE AT MEDIUM VOLTAGE NETWORKS	Lundholm, R.	Gothenburg, Sweden	1957

INDEX FOR: LIGHTNING - THEORY

Number	Title	Author	Company	Date
Report 57TP150	THEORY AND MODEL TESTS OF LIGHTNING VOLTAGES ON TRANSMISSION LINES	Anderson, JG	General Electric Pittsfield, MA	Jan. 2, 1957
Paper	LIGHTNING FLASH COUNTER	Cawkel1, AE	Middlesex, England	April 1957
DP 57-537	CALCULATION OF TRANSMISSION LINE LIGHTNING VOLTAGES BY FIELD CONCEPTS	Lundholm, R.	Assoc AIEE Member Gothenburg, Sweden	May 2, 1957
AIEE DP 57-548	AN APPROXIMATE TRANSIENT SOLUTION OF THE TAPERED TRANSMISSION LINE	Bathold, LO	General Electric Schenectady, NY	Feb. 27, 1957
AIEE DP-549	FIELD STUDIES OF THE SURGE RESPONSE OF A 345 KV TRANSMISSION TOWER AND GROUND WIRE	Breuer, GD Price, WS Schlommann, RH Schultz, AJ	AIEE Members	May 1957
AIEE DP 57-561	FACTORS AFFECTING THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES	Hagenguth, JH Anderson, JG	General Electric Pittsfield, MA	May 1957
AIEE DP 57-568	A HYPOTHESIS CONCERNING LIGHTNING PHENOMENA AND TRANSMISSION LINE FLASHOVER	Johnson, IB Schultz, AJ	General Electric Pittsfield, MA	May 2, 1957
Discussion of Paper:	CALCULATION OF TRANSMISSION LINE LIGHTNING VOLTAGES BY FIELD CONCEPTS	Lundholm, R Finn & Price	American Gas & Electric - NY	Oct. 3, 1957
AIEE 57-1079	FACTORS AFFECTING THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES	Hagenguth, JH Anderson, JG	General Electric Pittsfield, MA	May 31, 1957
Handwritten Notes	THEORY OF CLOUD CHARGE	??		1958
AIEE 58-24	THE LIGHTNING STROKE	Wagner, CF Hileman, AR	Westinghouse E Pittsburgh, PA	Oct. 14, 1957
AIEE 58-176	ARC DROP DURING TRANSITION FROM SPARK DISCHARGE TO ARC	Wagner, CF Lane, CM Lear, CM	Westinghouse E Pittsburgh, PA	Oct. 10, 1957
AIEE CP 58-189	ANOMALOUS FLASHOVERS ON TRANSMISSION LINES -- Part II	Miller, CJ Jr	Ohio Brass Co. Barberton, OH	Nov. 6, 1957

Number	Title	Author	Company	Date
AIEE 58-829	THE PRESTRIKE THEORY AND OTHER EFFECTS IN THE LIGHTNING STROKE	Griscom, SB	Westinghouse E. Pittsburgh, PA	March 10, 1958
Paper	THE TEINOGRAPH - A NEW HIGH-VOLTAGE SURGE RECORDER	Anderson, JG Giacomoni, RU	General Electric Pittsfield, MA	May 19, 1959
AIEE CP-59-275	RESPONSE OF A 345 KV TRANSMISSION TOWER TO A SIMULATED LIGHTNING STROKE	Armstrong, HR Barthold, LO Schultz, AJ	Detroit Edison Co General Electric Schenectady, NY	1959
AIEE 59-341	DETERMINATION OF LIGHTNING RESPONSE OF TRANSMISSION LINES BY MEANS OF GEOMETRICAL MODELS	Fisher, FA Anderson, JG Hagenguth, JH	AIEE Members	Jan 21, 1959
AIEE 59-644	A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES - II	Wagner, CF Hileman, AR	Westinghouse E. Pittsburgh, PA	Feb. 19, 1959
AIEE 60-657	DETERMINATION OF THE WAVE FRONT OF LIGHTNING STROKE CURRENTS FROM FIELD MEASUREMENTS	Wagner, CF	Westinghouse E. Pittsburgh, PA	Feb. 1, 1960
AIEE 60-658	A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES PART III. A SIMPLIFIED METHODS - STROKE TO TOWER	Wagner, CF Hileman, AR	Westinghouse E. Pittsburgh, PA	Jan. 6, 1960
AIEE 61-88	MONTE CARLO COMPUTER CALCULATION OF TRANSMISSION LINE LIGHTNING PERFORMANCE	Anderson, JG	General Electric Pittsfield, MA	Oct. 26, 1960
AIEE 62-1094 CP	RELATION BETWEEN STROKE CURRENT AND VELOCITY OF THE RETURN STROKE	Wagner, CF	Westinghouse E. Pittsburgh, PA	March 21, 1962
AIEE CP 62-1181	EFFECT OF PREDISCHARGE CURRENTS UPON LINE PERFORMANCE	Wagner, C. F. Hileman, AR	Westinghouse E. Pittsburgh, PA	April 11, 1962

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Effects of Short Lengths of Cable on Traveling Waves

By

K. B. McEachron, J. G. Hemstreet and H. P. Seelye

REPRINT

From November, 1930, Issue

Pages 624-646 Incl

Theory

A HYPOTHESIS CONCERNING
LIGHTNING PHENOMENA AND TRANSMISSION LINE FLASHOVER

I. B. Johnson

A. J. Schultz

INTRODUCTION

Unpredicted lightning outage rates on high voltage transmission lines have occurred over the years. More recently this fact has been emphasized by operating experience with new twin circuit high voltage transmission lines using one ground wire. Present methods of predicting lightning performance fall short of the experience records. The inadequacies of the current methods of prediction result in a lack of confidence of a certain degree in the evaluation of various designs of transmission lines and tower structures.

One method of calculating line performance is presented in an A.I.E.E. Committee Report.¹ Broadly the method of calculation from a circuit viewpoint is based on three areas of consideration:

1. Insulation strength of the insulator string.
2. Characteristics of lightning surges to transmission lines - magnitude, rate-of-rise and duration of surge current.
3. Surge response of the transmission line to lightning strokes - footing resistance, tower inductance, coupling factor, effect of ground wires, etc.

A critical review of the foregoing should reveal whether or not all of the factors have been realistically evaluated. If so, the A.I.E.E. method, perhaps, need only be modified to extend its validity and usefulness.

A current study is in progress to investigate the areas of insulation strength, surge response of the transmission line, and the severity of the lightning surges likely to be experienced on transmission lines. The results of the studies on insulation strength and surge response of transmission lines and towers are reported in companion papers.²⁻⁶ The results of these studies have not produced sufficient modifying effects in the calculations to account for the unexplainable outage rates.

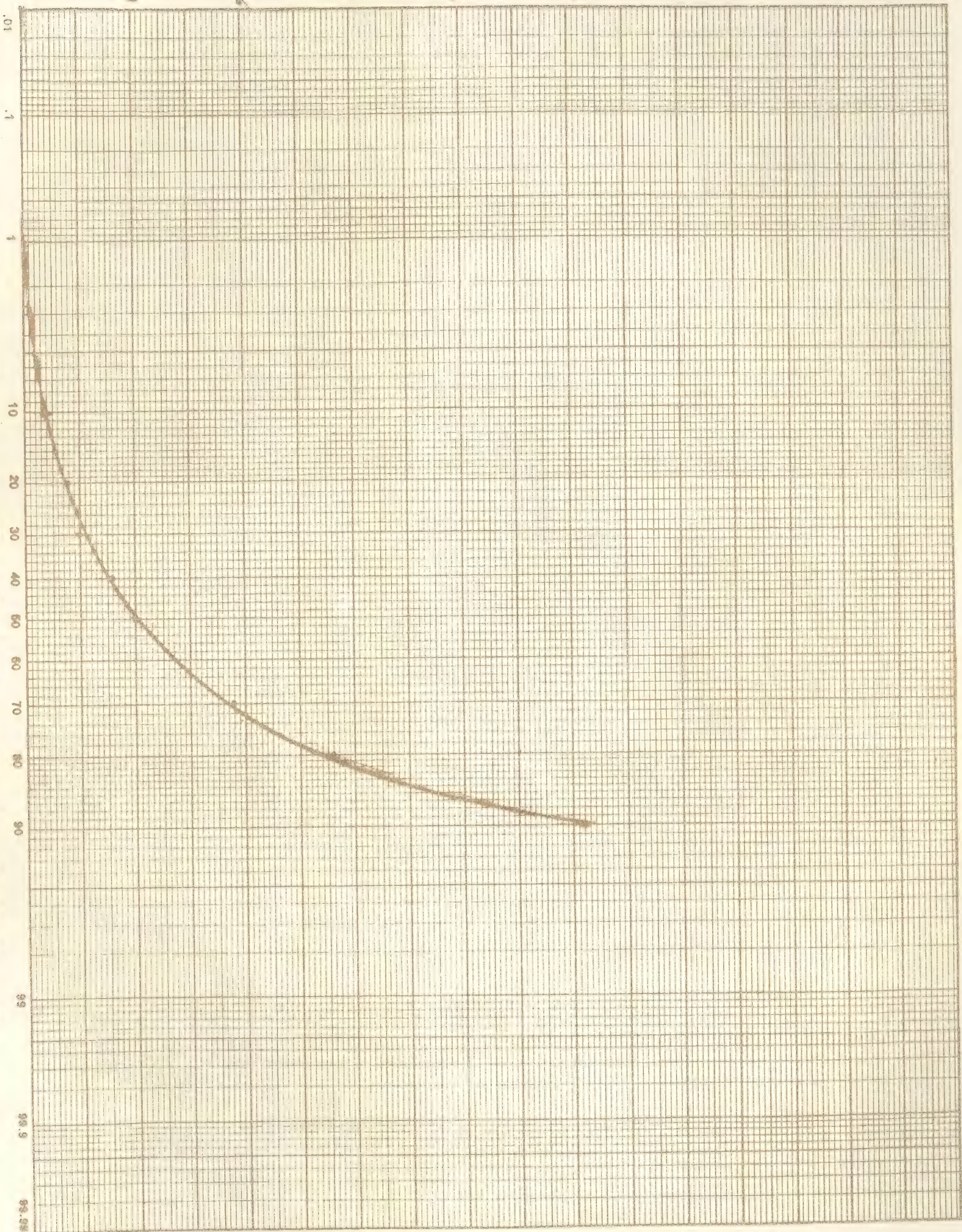
On the questions concerning the characteristics of lightning, there is some speculation pertaining to the magnitude and wave shapes of lightning surges occurring on transmission lines. Specifically, there are questions on the direct applicability of the data obtained on relatively tall structures, such as buildings and radio towers, to transmission lines and on the differences among the data obtained on various tall structures. It is the purpose of this paper to review these data from tall structures and to present a possible correlation of these data to the end that they may be more suitably applied to transmission line structures, resulting in a more accurate prediction of the lightning performance of high voltage transmission lines.

DATA ON MAGNITUDES OF STROKE CURRENTS

The methods of predicting line outages from lightning mentioned in the Introduction necessarily depend on a statistical knowledge of the severity of lightning strokes. This is generally expressed as a percentage distribution curve of the crest magnitudes of the currents measured in lightning strokes. A number of these percentage-distribution curves as obtained by different observers in different locations is shown in Figure 1. Curve A of Figure 1 was obtained from 30 magnetic link measurements of strokes to lightning rods mounted on top of towers and from 80 stroke measurements on overhead ground wires.⁷

TIME - μ S
R W A S

PER CENT OF STROKE CURRENT HAVING TIMES TO
WAVE FRONT GREST EQUAL TO OR LESS THAN ORDINATE
FIG 10



ANALYTICAL STUDIES ON LIGHTNING PHENOMENA INVOLVING
TOWERS, INSULATOR STRINGS, AND TRANSMISSION LINES

Henry

I. B. Johnson
Member AIEE

A. J. Schultz
Member AIEE

INTRODUCTION:

Certain high voltage transmission lines have experienced line flashovers from lightning at a rate in excess of that anticipated for these lines by conventional methods of calculation.¹ Particularly has this been true for double-circuit lines using one ground wire.^{2,3} Since these lines have very low footing resistances, it has been necessary to examine other factors which may be of significance and which heretofore have not been realistically appraised. One of these factors is the surge response of the tower and the nature of the lightning current required in the tower impedance to produce sufficient voltage to cause flashover.^{4,5,6,7}

To assist in analyzing the foregoing factors, a series of tests were made using models of a transmission tower and its associated conductors. The design of the model tower was based on calculations and their verification by field studies on the surge characteristics of transmission towers.^{3,7} This paper describes the design and construction of the model, the nature of the data obtained and the results that followed from these studies.

MODEL TOWER

The model tower is a miniature representation of an actual tower having a height of 170 feet. The miniature tower was arbitrarily assigned a height of 6 feet. This establishes a physical ratio of 170:6 or 28:1 between the actual system and the model. All physical dimensions of the tower and its associated conductors and ground wires must be represented in the model, therefore, by dimensions that are one-twenty-eighth of the same dimensions in the actual system.

The fundamental electrical constants which determine the surge response of any conductor are inductance and capacitance. Since:

$$\text{Inductance per unit length, } L \approx \ln \frac{2h}{r}$$

$$\text{Capacitance per unit length, } C \approx \frac{1}{\ln \frac{2h}{r}}$$

it can be seen that the inductance and capacitance for one foot of the model system will be equal to that of one foot of the actual system if the height and radius are reduced by the same ratio. Since the inductance and capacitance per unit length of the model system are identical with the inductance and capacitance per unit length of the actual system, the velocity of surge propagation is the same for the model as for the actual system. But since the distances involved in the model system are only one-twenty-eighth as long as the corresponding distances in the actual system, the times of travel on the model are one-twenty-eighth of those on the actual system. The round trip travel time of a surge on the actual tower, at the speed of light, is on the order of a third of a microsecond. The corresponding time on the model system would be, therefore, on the order of 10 milli-microseconds. With such a short time scale, the production of a surge with a sufficiently high rate of rise and the measurement of the phenomenon occurring on the model system becomes extremely difficult. This difficulty can be overcome by making a time base change.

May 1950
Litho in USA



A METHOD OF ESTIMATING LIGHTNING PERFORMANCE OF TRANSMISSION LINES

Theory

AIEE Working Group on Methods of
Estimating the Lightning Performance
of High Voltage Transmission Lines
of the
AIEE Lightning and Insulator Subcommittee

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American Institute of Electrical Engineers
33 West 39th Street, New York 18, N.Y.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12-16, 1950. Manuscript submitted May 15, 1950; made available for printing May 15, 1950.

Personnel of the AIEE Working Group on Methods of Estimating the Lightning Performance of High Voltage Transmission Lines: E.R.Whitehead, Chairman; L.V.Bewley, G.D.McCann, Jr., E.L.Harder, S.K.Waldorf, W.W.Lewis.

PRICE: 30¢ To Members
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AMERICAN GAS AND ELECTRIC FLASHOVER PROBLEM

*Lightning
Theory*

Minutes of Meeting - August 18, 1955 - Schenectady, New York

Present: G. D. Breuer, General Electric Company, Schenectady
C. Concordia, General Electric Company, Schenectady
C. M. Foust, General Electric Company, Schenectady
J. H. Hagenguth, General Electric Company, Pittsfield
I. B. Johnson, General Electric Company, Schenectady
W. S. Price, American Gas and Electric Service Corporation
R. Schlomann, American Gas and Electric Service Corporation
A. J. Schultz, General Electric Company, Schenectady
C. A. Woodrow, General Electric Company, Schenectady

1. Field and Analyzer Studies

Demonstrations were made of models developed so far as possible aids in the solution of the problem being considered. Field flux plotting results of a transmission tower and of a vertical wire were discussed also insofar as the surge impedance characteristics of the tower might prove to be a predominantly important factor.

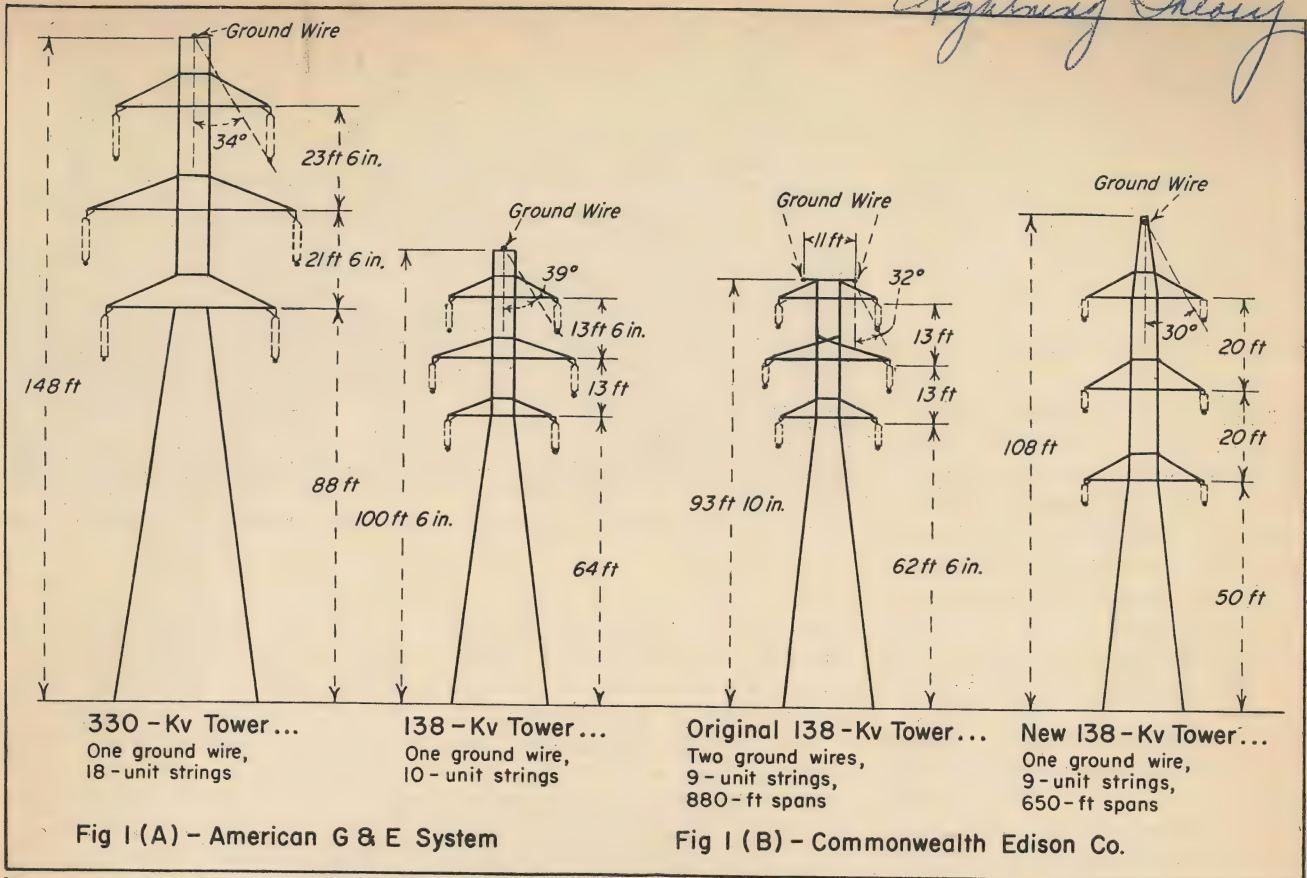
A description was given of the field studies made on and at tower 268 of the Muskingum-East Lima 330 kv transmission line near Columbus, Ohio. Oscillographic records were made of the surge response characteristics of tower 268 with and without the ground wire connected, and of the effect of adjacent towers. Similarly results were obtained for an artificial tower and for a vertical wire both erected 200 ft. away from tower 268. In addition some capacitance measurements were made of the artificial tower and of the vertical wire. A memorandum giving the essence of the results of the field study is attached. To those present at the meeting it is to be mentioned that the memorandum modifies the data given at the time of the meeting.

2. Voltage-Time Flashover Recorder

Mr. Foust described refinements in the design of the recorder. Following discussions on the voltages that would actuate the recorder in relation to the voltages that would be acting on the insulator string to cause flashover, it was agreed that it would be desirable to calibrate the recorder both with a structural assembly and with surge currents simulating actual conditions as close as possible. It was agreed that the recorder be constructed with four R-C elements to record and cover anticipated surge voltage fronts ranging from 0.1 microsecond to 5 microseconds.

Mr. Foust agreed to:

- (a) Complete design of the Double Polarity Recorder.
- (b) Manufacture a production sample for tests.
- (c) Get cost estimates on manufacture of 400 recorders for 80 stations.
- (d) Make laboratory calibrations of four element recorder without voltage divider.



Evaluation of New Tower Designs May Reveal . . .

Why EHV Lines Show Excess Outages

TRANSMISSION Design

Lightning causes flashovers considerably in excess of the rate predicted from design data. Investigation reveals:

- Burns on both upper and lower surfaces of suspension insulators removed from lines after flashover.
- Steep-front pulses in laboratory create similar markings.
- Test waves flash insulator strings shunted by tower leg.

DR CHARLES J. MILLER, JR., Research Engineer, The Ohio Brass Co., Barberton, Ohio

Two power companies have experienced outages caused by lightning on extra-high-voltage tower lines far in excess of the rate predicted by usual methods. Studies seeking a satisfactory explanation are now underway.

Many of the outages resulted from flashovers of the top or the middle-phase insulator strings on towers with very low footing resistance. Examination of these insulators reveals glaze burns produced by lightning which indicate that the flashover paths hug both the upper and lower surfaces of each unit in the string. This characteristic suggests that the lightning voltage pulses which produce these glaze burns have very steep fronts.

Furthermore, glaze burns from the resulting power are generally found on both upper and lower surfaces of nearly every unit in the string. In a number of cases

investigated, marks on the tower tops indicate where they were hit by lightning strokes.

Laboratory investigations show that when a steep front voltage pulse from a 3-million-v impulse generator is applied to a 22.5-ft section of 6-in. angle-iron tower leg, enough potential is produced to flash over a 3-unit string of suspension insulators connected in parallel with it. Glaze burns from these tests are very similar to those produced by natural lightning.

Photographic studies of flashovers produced in the laboratory with very steep front voltage pulses on various length insulator strings indicate strings could flash over in a fraction of a microsecond when subjected to suitably steep voltage pulses.

By use of traveling wave theory, it can be shown that when a lightning stroke hits the top of a tower, voltage at that point rises rapidly until reflected waves of opposite polarity return from the tower base and alleviate the

LABORATORIES DEPARTMENT - PHILADELPHIA
November 26, 1956

Mr. I. B. Johnson
Analytical Engineering
Bldg. 2-627
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RB Finn, A.G. and E
W Price, A.G. and E
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CM Foust, Schdy. Works
J Hagenguth, Pittsfield
→ BE Kingsbury, Baltimore
AJ Schultz, Schdy. Works
NR Schultz, Schdy. Works
CH Titus, 10-7
WR Wilson, 6-3
FC Vose, Baltimore
HA Frey, Baltimore

I have reviewed with some care the paper "Principles for the Calculation of the Lightning Performance of a Transmission Line for a Direct Lightning Stroke to the Line" by Ragnar Lundholm, copies of which you sent to several engineers on May 31 of this year, and would like to summarize and comment on it as follows.

The paper describes a method for calculation of the voltage appearing across an insulator string on a conventional steel transmission line tower as a function of the lightning stroke current magnitude and steepness of front. It also includes calculations for several cases in which the lightning stroke current was 50,000 amperes, the front time varying from 0 to 1 microsecond. These calculations are referred to a typical American Gas and Electric 330kv transmission tower.

The method of calculations assumes that the stroke starts at the tower top and comprises the following steps:

1. Determination of the division of stroke current between tower and ground wire.
2. Establishment of a loop path including the insulator string for determination of induced voltage.
3. Determination of the voltage across each element of the new path induced by stroke current, tower current, ground wire current, and their ground reflections.
In this determination, it was recognized that immediately after the inception of current, current would flow in only a small length of each conducting path immediately adjacent to the point of inception of the stroke, this length increasing as the wave travelled away from point of inception along the various paths.

PRINCIPLES FOR THE CALCULATION OF THE LIGHTNING PERFORMANCE OF A TRANSMISSION LINE FOR A DIRECT LIGHTNING STROKE TO THE LINE

BY: RAGNAR LUNDHOLM

Introduction

In the older theories for the computation of the lightning performance of a given type of line construction (the theory of Torok and Ellis-1933, of Jordan-1934, and of the author-1944) one is concerned chiefly with the voltage at the tower top or with the potential difference between the tower top and the phase conductors. In the calculations the tower is regarded either as a concentrated inductance or as a surge impedance. Some years ago the author began to suspect that these theories, including his own, are in some respects insufficient and he published in a CIGRE Report, #305, 1952, a very brief outline of a new theory. This new method has since been developed further and will be described below after the reasons for rejecting the older methods have been presented.

The physical definition of the electric potential difference V between two points A and B is:



Fig. 0-1

$$V_A - V_B = - \int_A^B E_s ds$$

Where E_s is the electric field component along the path of integration. In a pure electrostatic field V is independent of the path of integration and

4. Summation of all the voltages determined under (3) to give the total voltage generated around the loop. Since the loop was selected in such a way that no voltage could exist along any element of it except the insulator string, all of this voltage would appear across the insulator string.

There is one point with regard to the final step which is not made clear in the report and that is the question whether the summation is made all at the same time or whether some allowance is made for the time required for voltage generated in a relatively remote part of the loop to appear across the insulator string. Consider, for example, the voltage produced across the bottom ten feet of the tower as it is traversed by the surge of current flowing down the tower. If the voltages around the loop are summed just as the surge reaches the ground, this voltage will be included in the sum; yet it is difficult to see how this voltage could affect the voltage across the insulator string before a time enough later to allow its influence to reach there when traveling at the speed of light - approximately one tower transit time later. On this basis, summation on a simultaneous basis appears to be wrong but it is not clear from anything I have yet been able to find in the report that any other procedure has been followed. In fact, the statement on page 64 to the effect that "image currents will affect the voltage across the string before the string becomes enveloped in the sphere of influence from the image tower top" appears to indicate that simultaneous summation has been used. No very careful study has been made of the effect of any correction which might be required on this account, but it would appear that the voltage in the second tenth of a micro-second would be decreased and that in the third tenth possibly increased, resulting in more nearly a straight line or concave wave shape instead of the convex curve arrived at by the author.

There are three other items which may influence the result in some degree. These are:

1. The surge impedance of the stroke path is assumed to be so high that the stroke current is negligibly modified by any voltages appearing at the tower top.
2. The ground at the base of the tower is assumed to be infinitely conducting.
3. The author states that no attempt has been made to include the voltages generated by displacement currents.

From F. Hirschfeld
9/24/58

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1957

*Lightning
Theory*

INDUCED OVERVOLTAGE-SURGES ON
TRANSMISSION LINES AND THEIR BEARING
ON THE LIGHTNING PERFORMANCE AT
MEDIUM VOLTAGE NETWORKS

BY

R. LUNDHOLM



GUMPERTS FÖRLAG
GÖTEBORG

Lightning Flash

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

LIGHTNING FLASH COUNTER.

The frequency of occurrence of lightning flashes to earth constitutes one of the main features of the lightning discharge on which more factual information is required by electrical supply engineers, physicists and meteorologists. An instrument capable of providing the necessary information must not only be technically sound but must also be simple and inexpensive so as to facilitate its world-wide distribution.

Following a suggestion by Dr E.T. Pierce of the Cavendish Laboratory, Cambridge, England, a lightning flash counter has been designed capable of recording lightning flashes to earth within a radius of about 40 kilometres (25 miles). The device, as illustrated, is operated by the electrostatic field change produced by the return stroke of a lightning flash to earth from a negatively charged cloud. It consists essentially of a cold-cathode valve connected to an input circuit designed to avoid operation as the result of slow field changes and of cloud discharges. An electromagnetic counter registers the operation of the device.

The instrument is fitted with two dry batteries of standard pattern and is thus independent of external electricity supply. A test button permits checking the operation. The counter is to be connected to an outside aerial, the dimensions of which will be specified in an instruction sheet to be issued with the instrument.

The counter is designed for use in the tropics. It is housed in a sheet steel case measuring 10 x 6 x 7 inches (25 x 15 x 17.5 cm). The total weight is $14\frac{1}{4}$ lb ($6\frac{1}{2}$ kg). The cost of the device is £23 with a possible slight reduction for bulk orders. Orders for the instrument should be addressed to -

Messrs A.E. Cawkell,
Electronic Engineers,
6-7 Victory Arcade,
Southall,
Middlesex, England.

April, 1957.

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TECHNICAL INFORMATION SERIES

TECHNICAL INFORMATION SERIES		
Title Page		
AUTHOR <i>J.G. Anderson</i> J.G. Anderson	SUBJECT CLASSIFICATION <i>Theory</i> 1. Lightning. 2. Transmission Lines. 3. Transient Phenomena.	NO. 57TP150 DATE 1-2-57
TITLE	Theory and Model Tests of Lightning Voltages on Transmission Lines.	

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>J.G. Anderson</i> J.G. Anderson	SUBJECT CLASSIFICATION 1. Lightning. 2. Transmission Lines. 3. Transient Phenomena.	NO. 57TP150
		DATE 1-2-57
TITLE Theory and Model Tests of Lightning Voltages on Transmission Lines.		
ABSTRACT A study of the structure of the lightning stroke and its equivalent electric circuit is given. The magnitudes of the stroke capacitances to earth and to transmission lines are measured experimentally, and from these values stroke charges are computed. The nature of the surge current components produced by a direct stroke to a ground wire of a 330 KV double circuit system is then deduced.		
G.E. CLASS II	REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS	NO. PAGES 60
GOV. CLASS NONE		
CONCLUSION 1. If an upward corona streamer 10 feet or more in length exists from a ground wire, the conventional concepts of mid-span lightning stroke voltages and currents are not seriously altered by the effects of released charges on the wires near the stricken point. 2. Measured capacitances to earth of a model lightning pilot streamer channel account roughly for observed currents and tail wave shapes of lightning currents, but certain axial voltage gradients and expansion of streamer diameters are required. 3. Magnetically induced currents for mid-span strokes can be neglected. 4. Various model system charge density measurements on lines, towers, and earth are included, as well as a theoretical area effect in transmission line protection.		

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR General Information.

TESTS MADE BY D. C. Shampang, J. G. Anderson

Tests Completed: Nov. 1, 1956

Power Transformer Engineering-

COUNTERSIGNED J. H. Hagenguth

SECTION High Voltage Research

BUILDING and ROOM No. 9-102

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Measurement error can readily be set up. However, all cables have some attenuation and their surge impedance is never the same for all frequencies.^{1,2,3} In low-voltage impulse work (where very short cables can be used) such factors may be negligible under certain conditions, but for measuring high-voltage surges a fairly long cable (50 feet or longer) is usually required and possible errors caused by the cable should be considered, especially for measuring steeply rising surges. The purpose of this paper is to discuss such errors and devise methods for measuring and minimizing them.

Attenuation Errors

Cable losses are caused by the resistance of the center conductor and outside sheath together with conductance and dielectric hysteresis in the insulating material between conductors. Losses are usually expressed as an attenuation in decibels per 100 feet at a fixed frequency and in general the logarithm of attenuation in decibels increases in direct proportion to the logarithm of the frequency. For any given surge it is theoretically possible to determine the change in peak value and waveform caused by cable attenuation by using the known values of attenuation at various frequencies and the Fourier integral procedure. However such a procedure is time consuming and would

Errors Introduced Cables

to be done for each different wave-
of applied surge. Also, it is not
pletely reliable unless the variation
ase shift with frequency is also taken
account.

an experimental approach is much
r to apply and probably more
reliable. One method is to arrange the
surge generating circuit so that the pulse
to be measured, or one similar to it in
shape and rate of rise, can be accurately
repeated from shot to shot. (The peak
value can be repeated by using a linearly
rising voltage chopped with a sphere gap.)
Oscillograph records are then taken with
(1) a measuring cable of minimum length
 L , (2) a cable twice this length $2L$, and
(3) a cable three times this length $3L$. If
the oscillograms obtained under these
three conditions are appreciably different
in waveshape or peak value, a cable hav-
ing lower attenuation should be used or a
correction for attenuation computed. Polyethylene coaxial cables are used to
obtain low attenuation and attenuation
can be reduced by using a cable of mini-
mum length and one whose center conduc-
tor is large.

For surges which, in general, rise
linearly and are chopped by the spark-
over of a gap, a correction for the error
in peak-voltage measurement due to cable
attenuation can be determined. This is
done by obtaining values of peak volt-
age with the three different cable lengths,
 L , $2L$, and $3L$ as indicated. The de-
crease in peak voltage ΔV when the cable
length is changed from L to $2L$ should
be the same as that obtained when the
cable length is changed from $2L$ to $3L$,
within the accuracy of the measurements.
The average of the two values of ΔV is
added to the peak voltage obtained with

Conductors

a cable of length L to correct for attenua-
tion.

This method of correcting for cable
attenuation was used during an investiga-
tion of the change in sparkover value of
standard 12.5-cm (centimeter)-diameter
spheres set 6 cm apart as the rate of rise
of the applied voltage was increased. Values of ΔV were obtained for rates of
voltage rise from 10 to 10,000 kv per μ sec
(microsecond). They were computed as
a percentage of total voltage and plotted
against rise time (time to sparkover) as
obtained by dividing peak voltage by
rate of rise. Results are shown in Fig. 1
for RG-58/U and RG-8/U coaxial cables.

Errors Due to Cable Termination

For most impulse and surge work the
CRO cable is terminated by a non-
inductive resistor which is considered to
be equal to its surge impedance in ohms
and thus to produce no errors due to re-
flections. This assumption is not strictly
justified, because the surge impedance of
all cables varies with frequency and re-
flections due to different types of surges
cannot all be prevented by a terminating
resistor of fixed value. The change in im-
pedance with frequency is introduced by
(1) the cable resistance and conductance
which put a $j\omega$ term in the impedance and
can only be neglected over certain fre-
quency ranges and (2) the change in cable
inductance caused by nonuniform distri-
bution of current in the sheath and center
conductor as frequency is increased. This last factor is actually due to skin
effect which also causes a change in
resistance with frequency and further
complicates factor 1.

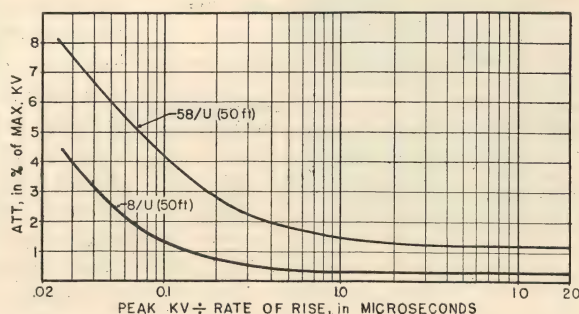
Thurston³ gives a plot in arbitrary
units showing the variation of character-
istic impedance with frequency for
nominal 50-ohm polyethylene cables. Below 100 kc the impedance is given as
constant and equal to 55 ohms. From
100 kc to 10 megacycles there is a gradual
change from 55 to 50 ohms and it remains
at 50 ohms for higher frequencies. Thus
if a 50-ohm terminating resistor is used
with such a cable (as would normally be

Paper 58-110, recommended by the AIEE Special
Instruments and Auxiliary Apparatus Committee
and approved by the AIEE Technical Operations
Department for presentation at the AIEE Winter
General Meeting, New York, N. Y., February 2-7,
1958. Manuscript submitted October 9, 1957;
made available for printing November 8, 1957.

J. H. PARK is with the U. S. Department of Com-
merce, National Bureau of Standards, Washington,
D. C.

The author acknowledges the assistance of H. N.
Cones and J. L. Mills of the National Bureau of
Standards who performed the experimental work
reported in this paper.

Fig. 1. Attenuation of
linearly rising chopped surges
by RG-58/U and RG-8/U
coaxial cables



January 19, 1959

Mr. J. A. Rawls, Chairman
Towers, Poles, and Conductors
Subcommittee, AIEE
Virginia Electric and Power Co.
Richmond 9, Virginia

Dear Mr. Rawls:

Attached herewith is a summary of the replies to the questionnaire on broken wire assumptions, which was issued in 1958 under the auspices of the Transmission and Distribution Committee of the AIEE.

A working group of the Towers, Poles, and Conductors Subcommittee developed the questionnaire, distributed it to 63 utilities or agencies operating lines of 60 kv or higher, and analyzed the replies. As is usual in instances where questionnaires are utilized to obtain information, the comments which the various transmission engineers supplied along with the answers to the questionnaires are particularly interesting and informative. However, comments do not lend themselves to inclusion in summaries, and they are being tabulated in a far bulkier supplemental report in order that they may not be lost to the engineer interested in details. It is suggested that some means be found to place this bulkier information in the hands of transmission engineers concerned with the details of transmission design when the comments have all been tabulated.

The attached report summarizes the answers received to the questionnaire in fairly concise form, and is probably suitable for transmitting to our parent Transmission and Distribution Committee. In the event your Subcommittee finds it acceptable in its present form, enough copies have been provided to enable you to furnish this summary to all the members of the committee.

Very truly yours,

E. L. Kanouse

E. L. KANOUSE

ELK:GB

Attachment

Transactions Paper

(Reviewed and Accepted for Publication)



BUNDLED CONDUCTOR VOLTAGE GRADIENT CALCULATIONS

J. Reichman
Associate Member AIEE
The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

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H. A. FREY

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1959. Manuscript submitted October 27, 1958; made available for printing December 2, 1958.

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Paper No.

59-82

Discussion in Duplicate Due February 20, 1959.

Transactions Paper

(Reviewed and Accepted for Publication)



RELATIONSHIP BETWEEN CORONA AND RADIO NOISE ON TRANSMISSION LINES

PART II. CONDUCTOR AND INSULATOR CORONA

T. W. Liao
Member AIEE

J. J. LaForest
Associate Member AIEE

Both of:
General Electric Company
Pittsfield, Mass.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1959. Manuscript submitted November 3, 1958; made available for printing December 3, 1958.

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Transactions Paper

(Reviewed and Accepted for Publication)



~~Welles~~
~~Walters~~
~~Karamirski~~
~~Jesaitis~~
Kingsbury

RADIO INFLUENCE VOLTAGES CAUSED BY SURFACE IMPERFECTIONS ON SINGLE AND BUNDLE CONDUCTORS

T. W. Liao
Member AIEE
General Electric Company
Philadelphia, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Middle Eastern District Meeting, Baltimore, Md., May 19-21, 1959. Manuscript submitted February 13, 1959; made available for printing April 6, 1959.

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Paper No.

59-643

Discussion in Duplicate Due June 4, 1959.

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Conference Paper



SHORT-TIME ANNEALING CHARACTERISTIC OF ELECTRICAL CONDUCTORS

PART I. METHODOLOGY

L. F. Roehmann

Member AIEE

Kaiser Aluminum & Chemical Corp.

Spokane, Wash.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Manuscript submitted March 23, 1959; made available for printing April 29, 1959.

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Paper No. **CP**

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Transactions Paper

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A
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I

LABORATORY AND FIELD EVALUATION OF CONNECTORS AND OTHER ACCESSORIES FOR ALUMINUM CONDUCTORS IN SEVERE MARINE ENVIRONMENTS

William J. Sanders

Member AIEE

Kaiser Aluminum & Chemical Corp.
Spokane, Wash.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Manuscript submitted March 23, 1959; made available for printing April 28, 1959.

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Paper No.

59-899

Discussion in Duplicate Due July 10, 1959.

Conductors

Transactions Paper

(Reviewed and Accepted for Publication)



ICE BUILD-UP ON CONDUCTORS OF DIFFERENT DIAMETER

E. K. Lanctot
Associate Member AIEE
Aluminum Co. of America
Massena, N. Y.

H. E. House
Member AIEE
Aluminum Co. of America
Massena, N. Y.

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E. S. Zobel
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New York, N. Y.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-16, 1959. Manuscript submitted June 8, 1959; made available for printing July 20, 1959.

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Transactions Paper

(Reviewed and Accepted for Publication)



ICE BUILD-UP ON CONDUCTORS OF DIFFERENT DIAMETER

E. K. Lanctot
Associate Member AIEE
Aluminum Co. of America
Massena, N. Y.

H. E. House
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Aluminum Co. of America
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Paper No.

59-1122

Discussion in Duplicate Due October 30, 1959.

RESEARCH STUDY
ON
GALLOPING OF ELECTRIC POWER
TRANSMISSION LINES

Progress Report

No. 1

December 1, 1959

AEROELASTIC AND STRUCTURES RESEARCH LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

RESEARCH STUDY
ON
GALLOPING OF ELECTRIC POWER
TRANSMISSION LINES

PROGRESS REPORT

NO. 2

FEBRUARY 1, 1960

AEROELASTIC AND STRUCTURES RESEARCH LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

Conference Paper



EMISSION OF WEATHERED CONDUCTORS AFTER SERVICE IN RURAL AND INDUSTRIAL ENVIRONMENTS

W. S. Rigdon
Nonmember AIEE
Purdue University
Lafayette, Indiana

H. E. House
Member AIEE
Aluminum Company of America
Massena, N. Y.

R. J. Grosh
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Purdue University
Lafayette, Indiana

W. B. Cottingham
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DISCUSSION OF CONFERENCE PAPER NO. 60-1273

"EFFECT OF BUNDLED CONDUCTOR FIELD

INFLUENCE ON E. H. V. TRANSMISSION

LINE DESIGN"

BY

R. W. HARMON
THE OHIO BRASS COMPANY
BARBERTON, OHIO

DISCUSSION BY:

R. L. MC COY
AND
J. KAMINSKI
INSULATOR DEPARTMENT GENERAL ELECTRIC COMPANY
BALTIMORE, MARYLAND

OCTOBER 12, 1960

Conference Paper



TEMPERATURE, CURRENT, AND RESISTANCE CHARACTERISTICS OF BARE ALUMINUM DISTRIBUTION CONDUCTORS

Earl Hazan
Member AIEE
Kaiser Aluminum & Chemical Co.
Spokane, Wash.

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H. A. FREY

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Conductor

District Conference Paper



FIRST REPORT ON FIELD INVESTIGATION OF THE EFFECTS OF CONDUCTOR AGING AND CLEANING ON ELECTRICAL CONNECTIONS

O. A. Boyer
Member AIEE
Central Power and Light Co.
Corpus Christi, Texas

J. Hus
Associate Member AIEE
Burndy Corp.
Norwalk, Conn.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE South East-South Central District Meeting, New Orleans, La., April 5-7, 1961. Manuscript submitted February 2, 1961; made available for printing February 10, 1961.

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H. A. FREY

Conductors

Conference Paper



THERMAL LIMITS OF OVERHEAD CONDUCTORS AT VARIOUS METEOROLOGICAL CONDITIONS

J. A. McElyea
Associate Member AIEE
Illinois Power Company
Decatur, Ill.

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MAY 26

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Paper No. CP

61-823

Conference Paper



THE ELECTRICAL PROPERTIES OF SINGLE-LAYER ALUMINUM CONDUCTORS,
STEEL-REINFORCED (ACSR), HAVING SINGLE STEEL CORE WIRES
WITH HEAVY ALUMINUM COATING

C. H. Jensen (Retired)
Associate Member AIEE
Copperweld Steel Co.
Glassport, Pa.

R. E. DeMuth
Associate Member AIEE
Battelle Memorial Institute
Columbus, Ohio

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Associate Member AIEE
Battelle Memorial Institute
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Conductors

Conference Paper



SAG AND TENSION CALCULATIONS BY THE NOMOGRAPHIC METHOD

Robert H. Sarikas
Member AIEE
Illinois Power Company
Decatur, Ill.

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Paper No. CP

62-107

Chart Finds Transmission Gradient Factor

KARL W. SCHMIDT, Winnipeg, Manitoba

Conductor surface gradient, which is dependent on at least seven independent parameters, can be found with this nomogram. It can be valuable for gaining first information for such considerations in EHV work as electrostatic unbalance, corona loss and radio interference.

The scales and curves of this chart have been derived from the generally known equation below for F_1 , which is assumed to give the desired information with sufficient accuracy. This equation, and so the nomogram, is based on the assumption of balanced charges and symmetrical bundle spacings not smaller than five conductor diameters.

The following apply:

d = conductor diameter
 H = line height
 D = phase spacing
 s = subconductor spacing
 n = number of subconductors
 E = line-to-line operating voltage, kv
 F_1 = gradient factor, v(rms) per cm per kv(rms)
 F_2^* = strand factor, dimensionless
 G = maximum surface gradient, kv (rms) per cm
 $G = \frac{EF_1}{1,732}$

$$F_2 = \frac{G \text{ for stranded conductor}}{G \text{ for smooth conductor of same diameter}}$$

$$F_1 = 2,000F_2 \left(\frac{1}{d} + \frac{n-1}{s} \sin \frac{\pi}{n} \right) (n \log_e AB)^{-1}$$

where $A = 2^{n+1/n} (\alpha d s^{n-1})^{-1/n}$

$$\alpha = \begin{cases} 1. & \text{when } n = 1, 2 \text{ or } 3 \\ 1.405 & \text{when } n = 4 \\ 2.601 & \text{when } n = 5 \\ 6.192 & \text{when } n = 6 \end{cases}$$

$B = HD(4H^2 + D^2)^{-1/2}$ for center phase

$B = HD[(4H^2 + D^2)(H^2 + D^2)]^{-1/4}$ for each outer phase

The procedure for finding the maximum gradient is as follows:

• Single conductor. Enter the chart at the right with phase spacing, D , go across to height, H , then down to edge L_3 . Draw a straight line from here to P_1 .

Draw a perpendicular to this line from the grid point, strand factor, F_2 , vs conductor diameter, d , (upper right grid) to scaleless line L_4 .

Read the result where a straight line connecting

this point with P_2 intersects the gradient factor scale. This gradient factor multiplied by line voltage and divided by 1,732 yields the maximum conductor surface gradient (first equation). The small sketch at the bottom of the opposite page shows the method.

• Bundled conductor. Proceed as above, but instead of P_1 and P_2 , use the projections on L_1 and L_2 drawn from the grid points determined by the ratio $\frac{s}{d}$ and the number of subconductors, n . Again, a sketch shows the method.

Sometimes the literature assumes that corona loss is a function of either the average gradient factor or the arithmetic mean between average and maximum factors. If, then, instead of taking the projection on L_2 one enters the lower left grid with s (2 through 6) on line L_2 , the result is not the maximum but the average value of the gradient factor.

Examples given in the table are based on curves by Adams² and Reichmann³ computed by digital computer. These results check within 1½% of those obtained by the nomogram.

Phase	Adams Center	Reichmann			Hand-Calculated Center
		Center	Outer	Outer	
d	1.5	1.0	1.1	0.6	1.246
D	20	35	25	35	30
H	60	40	40	35	60
n	1	2	3	4	4
s		10	12	12	24.92
F_2	1.0	1.0	1.0	1.0	1.4
E	330	340	460	352	500
G	17.71	16.65	16.65	16.65	20.32
By Nomogram:					
F_1	90	83	61.4	80	69.5
G	17.15	16.29	16.31	16.26	20.06

* Not to be mistaken for *stranding* factor as recently defined by L. N. Stone. According to G. E. Adams³, the strand factor equals 1.4 "if the stranding does not change the capacitance appreciably." This assumption may not apply to bundled conductors. If not, F_2 could be determined by W. S. Peterson's formulas¹.

The nomogram makes it possible to define and determine equivalent conductor diameters, not only in considering equality of corresponding gradients, but also with respect to any other quantity.

Design of 500-Kv California Intertie Disclosed

Details of the proposed 103-mile 500-kv line linking systems of the Pacific Power & Light Co and Pacific Gas & Electric Co have now been disclosed.

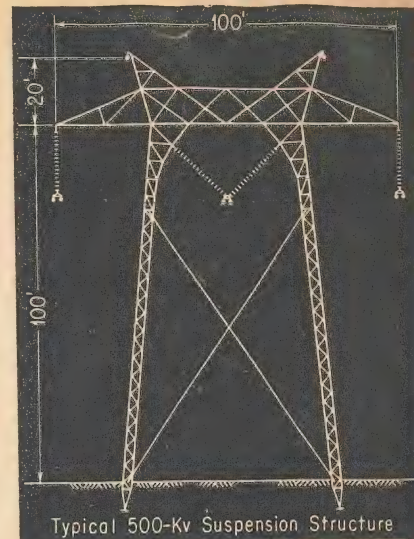
Some 600 latticed-steel guyed H-frame structures 100 ft wide and 120 ft high will be used in the \$11-million line which will extend from Klamath Falls, Ore., to Round Mountain near Redding, Calif. (EW, Jan. 29, p 55). The average span is 900 ft. Each phase will consist of two ACSR Chuckar conductors of 1,780-MCM aluminum, 1.6 in. dia, spaced 18 in. horizontally. Outside phases use suspension strings of 35 insulators. Center phase conductors are restrained by two V-strings of 35 units, as shown.

The line will be designed and constructed for a maximum voltage of 550 kv. This is a 10% tolerance above the nominal 500 kv rather than the 5% currently used in the US. In addition the line design

takes into consideration the fact that much of the route is over mountainous and rolling country at 5,000-ft elevation with the maximum at 5,800 ft.

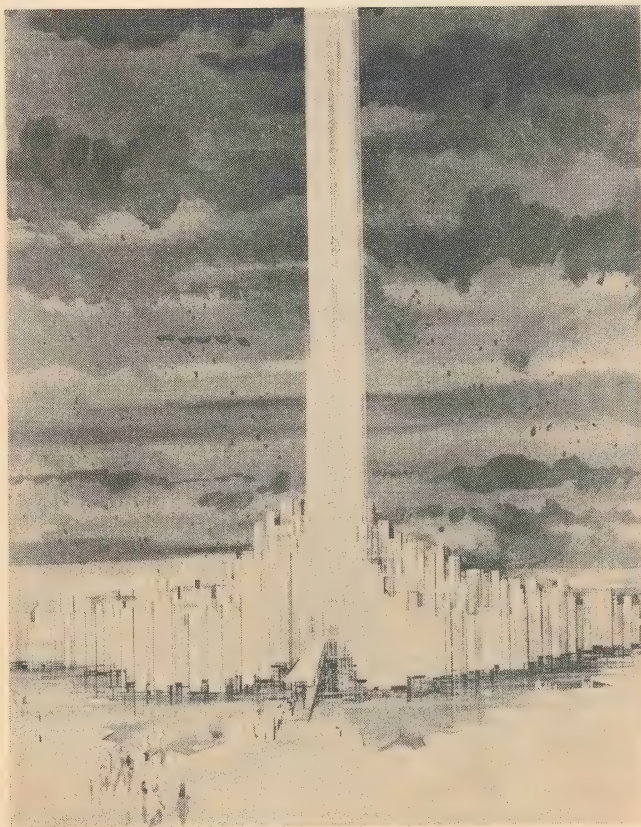
The PG&E-designed structures, shown, will have longitudinal guys from the two 3-ft square legs to the ground. However, the structure is essentially stable without them, PG&E's W. R. Johnson told *Electrical World*. Steels to be used are ASTM A-7 medium strength and high elastic with ultimate strength not less than 65,000 psi and yield strength not less than 45,000 psi. Steel grillage footing will be used.

Design has been coordinated with PP&L for uniformity. Each company will build half the line. When completed in 1963 it will be the first line built for commercial use at this voltage in the US. It will operate initially at 230 kv with 230/500-kv substation facilities added later, when justified.



No design details have been furnished on the similar 500-kv intertie to Southern California Edison from PG&E's Round Mountain Substation (EW, April 2, p 26).

Industry to Present Exhibit at NY World's Fair



PAVILION FOR NEW YORK FAIR (above) was designed by Robinson-Stern, who designed the industry's Seattle exhibit

The nation's investor-owned electric utilities' exhibit at the 1964-65 New York World's Fair will be housed in a newly designed "pavilion of light prisms," according to Ernest R. Acker, chairman of the board of Central Hudson Gas & Electric Corp and president of the corporation set up to administer the utilities' participation in the fair.

"Vertically staggered triangular metal prisms will rise to a height of 80 ft, forming an asymmetrical structure resembling a crystal palace of ever-changing light and color or a sort of Gothic 'Cathedral of Light,'" Acker said.

Three Pylons Crown Exhibit

Crowning the pavilion will be three vertical pylons rising an additional 60 ft. The pylons will frame a vertical shaft of brilliant light and power rising from a central core on the ground level of the structure. This can be reviewed from a moving ramp carrying visitors across a reflecting pool to the pavilion entrance.

The interior walls of the vertical prisms are designed to serve directly as a background for the exhibit, becoming curtains of varicolored light. Visitors will be carried through the exhibit chambers on an elevated revolving ring and will exit by a spiral ramp, leading them past the core of the tower of light.

"With the prisms appearing to change color by day and the extending effect of the tower of light high above the fair at night, the new pavilion will present a dramatic picture," Acker commented.

Conductors

Conference Paper



FAULT AND LOAD CURRENT TESTING OF A BUNDLE CONDUCTOR SPACER

R. L. Retallack
Associate Member AIEE
American Elec. Pwr. Serv. Corp.
New York, N. Y.

T. R. Fry
Member AIEE
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Centralia, Mo.

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Associate Member AIEE
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Centralia, Mo.

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62-284

Conference Paper



RADIO NOISE AGING CHARACTERISTICS OF SMALL ALUMINUM CONDUCTORS

J. J. LaForest
Member AIEE

E. A. Whepley
Associate Member AIEE

Both of:
General Electric Company
Pittsfield, Mass.

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Transactions Paper

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EQUIGRADIENT LINES IN THE VICINITY OF BUNDLE CONDUCTORS

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Member AIEE
Aluminum Company of Canada, Ltd.
Montreal, P. Q., Canada

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H. A. FREY

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EQUIGRADIENT LINES IN THE VICINITY OF BUNDLE CONDUCTORS

A. S. Timascheff

Member AIEE

Aluminum Company of Canada, Ltd.

Montreal, P. Q., Canada

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 7-12, 1962. Manuscript submitted June 6, 1962; made available for printing August 9, 1962.

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Discussion in Duplicate Due February 15, 1963.

IEEE

ELECTRODYNAMIC STUDIES OF BUNDLED CONDUCTOR SPACERS

J. R. Ruhlman
Member IEEE

R. A. Eucker
Application Pending

R. L. Swart
Application Pending

All of:

Preformed Line Products Company
Cleveland, Ohio

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the Winter General Meeting, New York, N. Y., January 27-February 1, 1963. Manuscript submitted October 29, 1962; made available for printing December 17, 1962.

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Paper No.

63-88

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Conference Paper



DESIGN CHARACTERISTICS OF THE 5005 ALL-ALUMINUM ALLOY CONDUCTOR
FOR THE
VEPCO 500 KV PROJECT

H. W. Adams
Senior Member IEEE
Reynolds Metals Co.
Richmond, Virginia

John Shaw
Senior Member IEEE
Virginia Electric & Power Co.
Richmond, Virginia

District Paper for presentation at IEEE Southeastern District
Meeting in Richmond, Virginia, April 24, 25, and 26, 1963.

District Conference Paper



APPLICATION OF COMPUTER TO THERMAL RATING OF OVERHEAD CONDUCTORS

T. Hunter
Senior Member IEEE

K. E. Voigt

Both of:
Duquesne Light Co.
Pittsburgh, Pa.

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Paper No. DP

63-783

Conference Paper



ON THE DESIGN OF BUNDLE CONDUCTOR SPACERS

A. T. Edwards Both of:
J. M. Boyd The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

Submitted in abstract or outline form only to the IEEE Transmission and Distribution Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted April 15, 1963; made available for printing April 19, 1963.

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Paper No. **CP**

63-1075

GENERAL ELECTRIC CO.

PROJECT EHV

American Electric Power Service Corp.

Conductor Characteristics for

1000/1100-Kv A-C Transmission

Report No. 2

L. O. Barthold
August 20, 1963



Conference Paper

EVALUATION OF SPACERS FOR BUNDLED CONDUCTOR TRANSMISSION LINES

R. A. Krahn
Member IEEE

M. B. Bessler

Both of:
U. S. Department of the Interior
Bureau of Reclamation
Denver, Colorado.

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Paper No.

69 CP 8 - PWR

McKingsbury

H. A. Frey



A PROPOSED FRICTION DAMPER FOR GALLOPING CONDUCTOR WAVES

A. H. Kidder
Fellow IEEE
Philadelphia Electric Company
Philadelphia, Pa.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, New Orleans, La., July 10-15, 1966. Manuscript submitted October 6, 1965; made available for printing March 22, 1966.

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Paper No.

31 PP 66-307

BPA TRANSMISSION LINE STRUCTURES

Wood and Steel Designs

A. A. Osipovich
Member A.I.E.E.

U. S. BONNEVILLE POWER ADMINISTRATION

January 1953

MODERN 220-KV STEEL TOWER TRANSMISSION LINE CONSTRUCTION

Eduard Fritz
Associate Member AIEE

A. N. Shealy
Member AIEE

Both of:
Pennsylvania Water & Power Co.
Baltimore, Maryland.

Prepared for Presentation

at the

Conference on Steel and Wood Towers

AIEE Winter General Meeting, New York, N. Y.

January 20, 1953

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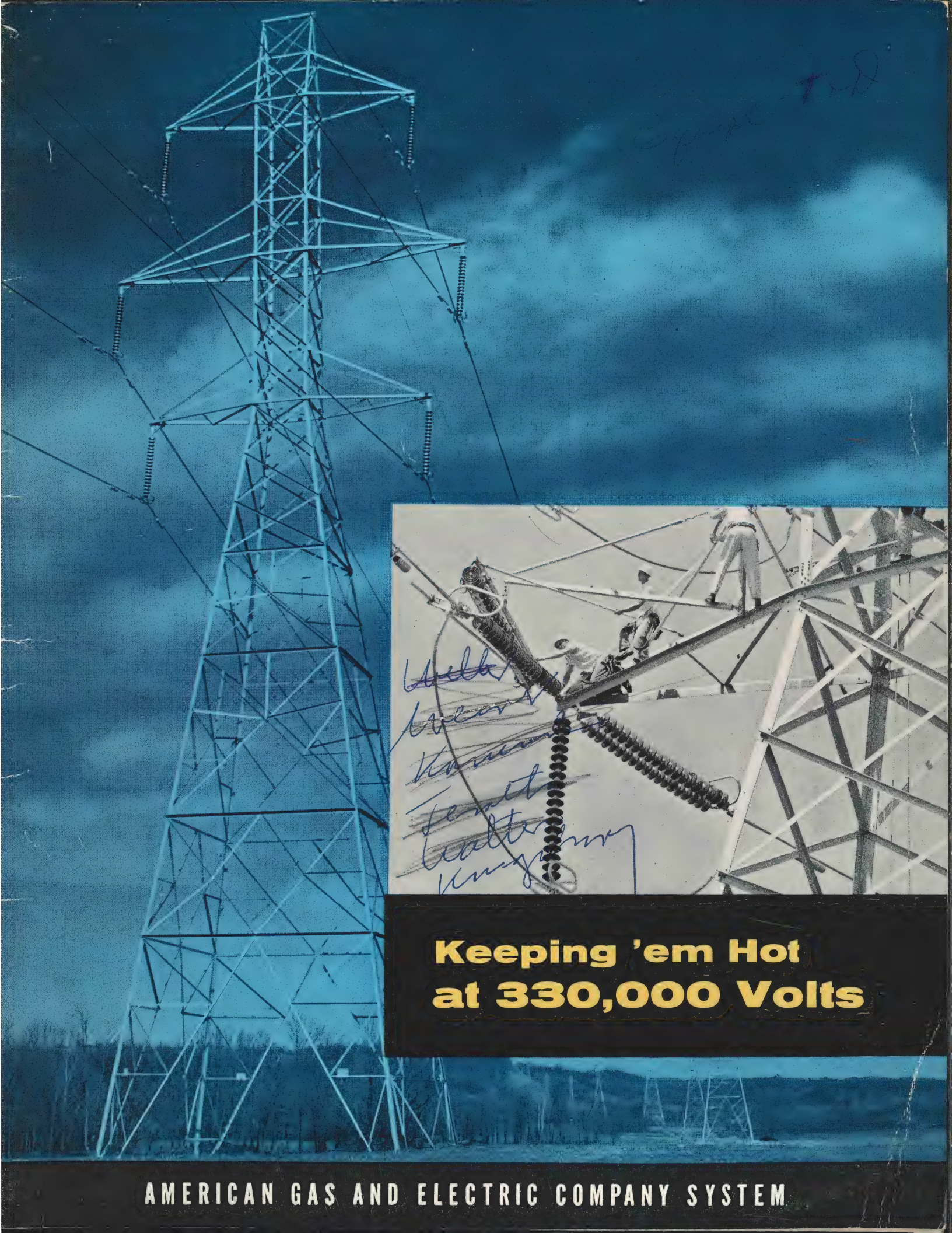


Exhibit T-8



*Wells
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Wells
Fennell
Walter
Kingsbury*

**Keeping 'em Hot
at 330,000 Volts**

AMERICAN GAS AND ELECTRIC COMPANY SYSTEM

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ENG. DEPT.

Conference Paper



Muller

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~~Tea~~

~~Waters~~

Equip, J & D

HIGH SPEED MAGNETIC AIR BREAKER FOR DISTRIBUTION CIRCUITS

Kingbury

H. P. Sleeper
Fellow AIEE
Public Service Electric & Gas Co.
Newark, N. J.

J. D. Findley
Associate Member AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

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District Conference Paper



ADVANCES IN FEEDER PROTECTION THROUGH ELECTRONICS

R. F. Jones
Associate Member AIEE
Line Material Industries
McGraw Edison Company
Birmingham, Ala.

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H. A. FREY.

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MAINTENANCE OF GALVANIZED STEEL TOWERS AND SUBSTATION STRUCTURES

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Subox, Inc.
Hackensack, N. J.

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H. A. FREY.

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62-519

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DIELECTRIC TESTING OF INSULATED AERIAL BASKETS

R. W. Carter

R. L. Murray
Member AIEE

Both of:

Alabama Power Company
Birmingham, Ala.

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DOCUMENT NO. 65SD 364

TECHNICAL INFORMATION SERIES

TITLE

**GENERALIZED FRAME ANALYSIS
COMPUTER PROGRAM**

AUTHOR

J. Gallagher

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PN-612 (12-48)

RE-ENTRY SYSTEMS DEPARTMENT

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M. JADVANI

Time to go on a statistical diet for Structural reliability

Are your products overweight—yet unreliable as far as strength goes? If so, then you should design with statistical data in mind

C. DICKS, Structural Specialist, S. WILSON, Project Engineer, General Electric Co, Daytona Beach, Fla

MORE savings in weight and cost are possible by applying reliability techniques to structural design rather than to areas such as electronics. The problem, however, is that the structural designer, whether he is working on automobiles, missiles, aircraft, or home appliances, knows very little about statistical analysis—and the reliability expert knows very little about strength analysis.

The classic approach in structural design is to determine working design stresses by multiplying the actual stresses by a safety factor. Then the working design stresses are compared with the allowable strengths to obtain the margins of safety.

But when many structural components are involved and weight or material costs are important factors companies tend to take the final design, which includes the compounded safety

factors, and arbitrarily reduce the final safety factor to obtain a more realistic design. They then build the assembly and subject it to dynamic testing, and when certain parts fail, as they sometimes do, they "beef up" portions of the design—a very costly and undesirable procedure.

The new approach, just beginning to take hold, is to determine the "probability of success" (the probability of failure is equal to one minus the probability of success, so adding the two factors together gives a value of unity). This probability-of-success-factor can then obsolete the safety factor in many complex designs.

The technique involves applying common statistical methods, such as the Monte Carlo method, to obtain a more realistic tie-in between loads, tolerances, and stresses. Because of the need for repetitive calculations, it is

best to conduct the method on a computer, but a desk calculator may do in some cases.

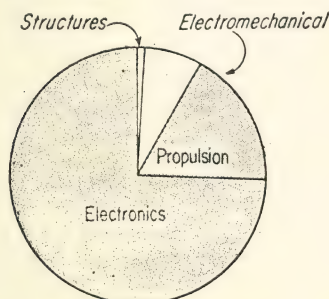
A simple problem is given here, with a step-by-step procedure based on the actual design of a structure—an automobile door handle.

Where do most failures occur?

Experience tells us that electronic systems are more likely to cause a failure—especially in missiles, Fig 1—than are structures. So it is natural that electronics should receive the greatest attention and program cost, Fig 2.

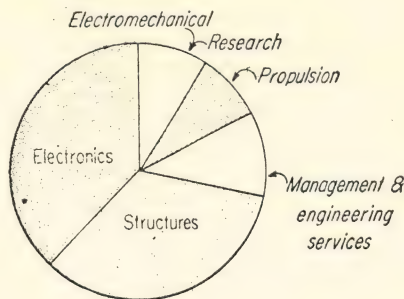
Thanks to this highly subsidized research, the electronics engineer can tell approximately what the failure rate will be for a particular electronic system. Not so the structural designer. Without such "standard failure rates," he usually just compares the design

1.. FAILURES



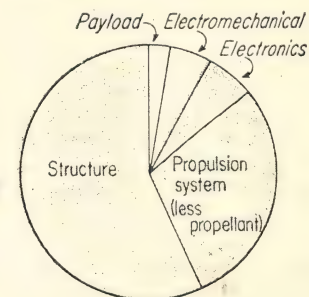
Typical missile failure sources. Most failures occur in the electronics area. Structural failures are almost nonexistent—but in many cases structures are overweight. Missile program costs are

2.. COSTS



high for structures because of the bulk of expensive materials and processes, so the slight increase in design cost by going to a structural reliability program is easily absorbed by the resulting sav-

3.. WEIGHT



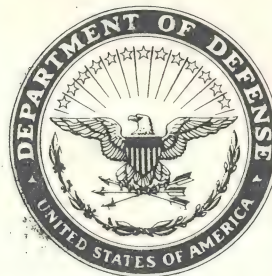
ings that is obtained in materials and in electronic design costs. **Largest weight contributor** in a missile system (when the propellant of the propulsion system is excluded) is structures.

MIL-STD-202C
12 September 1963

SUPERSEDING
MIL-STD-202B
14 March 1960

MILITARY STANDARD

TEST METHODS FOR ELECTRONIC AND ELECTRICAL COMPONENT PARTS



Number	Title	Author	Company	Date
Reprint	POLAR TO RECTANGULAR CONVERSION CHART	Olmstead, Don G.	Vickers, Inc.	
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AIEE 50-246	TRANSPPOSITIONS AND THE CALCULATION OF INDUCTANCE FROM GEOMETRIC MEAN DISTANCES	Boast, WB	Iowa State College Ames, Iowa	August 1950
AIEE 51-226	DETERMINATION OF INSTANTANEOUS CURRENTS AND VOLTAGES BY MEANS OF ALPHA, BETA, AND ZERO COMPONENTS	Duesterhoeft, WC Schulz, Max W Jr Clarke, Edith	Univ. of Texas GE -Pittsfield Univ. of Texas	May 1951
Reprint Electric Light & Power	General Electric POWER-REACTIVE DIAGRAMS STILL USEFUL	Butler, RM	General Electric Schenectady, NY	July-Aug 1952
AIEE 53-182	A DIRECT METHOD FOR SAG-TENSION CALCULATIONS	Harley, TP	Bur of Reclamation Denver, Colorado	April 1953
AIEE 53-401	ELECTROSTATIC UNBALANCE TO GROUND OF TWIN CONDUCTOR LINES	Gross, Eric TB McNutt, WJ	Illinois Inst. of Technology, Chicago	August 1953
AIEE 54-213	EVALUATION OF THE INTEGRATION METHOD FOR ANALYSIS OF NON-STANDARD SURGE VOLTAGES	Jones, Andrew R	Westinghouse Pittsburgh, PA	April 1954
AIEE 55-477	ELECTROMAGNETIC UNBALANCE OF UNTRANSPPOSED TRANSMISSION LINES, II. SINGLE LINES WITH HORIZONTAL CONDUCTOR ARRANGEMENT	Gross, ETB Nelson, SW	Illinois Inst. of Technology Chicago, IL	May 1955
AIEE 55-479	A RATIONAL METHOD FOR THE STEP-BY-STEP CALCULATIONS IN POWER SYSTEM TRANSIENT STABILITY STUDIES	Norinder, EO	Swedish State Power Bd - Stockholm, Sw	May 1955
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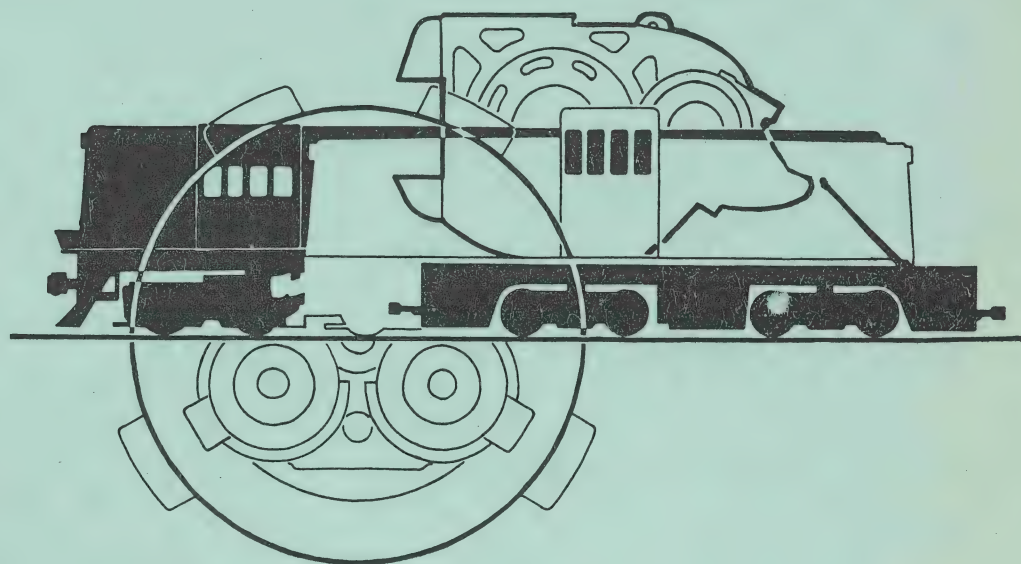
POWER COLLECTION AT HIGH SPEEDS BY
NON-STEERING GROUND ORIENTED VEHICLES
- REPORT ON VISIT TO ENGLAND -

R. T. Gray

G.E. Class - 1

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**A Technical Discussion on
Pantographs, Catenaries and Locomotives**

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RAILWAY OVERHEAD CONTACT SYSTEMS, CATENARY-
PANTOGRAPH DYNAMICS FOR POWER COLLECTION AT HIGH SPEEDS

by

S. Levy, J. A. Bain, and E. J. Leclerc
Mechanical Technology Laboratory

Report No. 67-C-259

June 1967

TECHNICAL INFORMATION SERIES

AUTHOR Levy, S Bain, JA Leclerc, EJ	SUBJECT railway catenary- pantograph dynamics	NO. 67-C-259 DATE June 1967
TITLE Railway Overhead Contact Systems, Catenary-Pantograph Dynamics for Power Collection at High Speeds		G.E. CLASS 2 GOVT. CLASS None
ADDITIONAL COPIES AVAILABLE AT Distribution Unit, Bldg. 5, Room 345 Research and Development Center P.O. Box 8, Schenectady, New York 12301		NO. PAGES 64
SUMMARY A program has been prepared for the GE-625 computer in FORTRAN IV language to compute the dynamic behavior of a catenary and pantograph for railroad cars moving at constant velocity. The catenary is considered to consist of two wires joined by elastic hangers* at arbitrary locations. The upper catenary wire is in turn supported by elastic towers at arbitrary locations. Account is taken of tension and mass in each wire, wire sag, damping of the wires, springing between shoe and wire, springing and damping between shoe and pantograph frame, damping of the pantograph frame to the railway car, lifting of the wire away from the shoe, and stops in the pantograph to limit motion between shoe and pantograph frame. Up to eight arbitrarily spaced pantographs can be included, with as many as sixty hangers and ten towers. *droppers		
KEY WORDS railroad pantograph, railroad catenary, dynamics, power collection, GE-625 computer, nonlinear mechanics, current-collecting		

INFORMATION PREPARED FOR:

Mechanical Technology Laboratory

August 1950
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TRANSPPOSITIONS AND THE CALCULATION OF INDUCTANCE FROM GEOMETRIC
MEAN DISTANCES

W. B. Boast
Member AIEE
Iowa State College
Ames, Iowa

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May 1951
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Math.

DETERMINATION OF INSTANTANEOUS CURRENTS AND VOLTAGES BY
MEANS OF ALPHA, BETA, AND ZERO COMPONENTS

W. C. Duesterhoeft
Associate AIEE

University of Texas
Austin, Texas

Max W. Schulz, Jr.
Nonmember AIEE

General Electric Company
Pittsfield, Mass.

Edith Clarke
Fellow AIEE

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Austin, Texas

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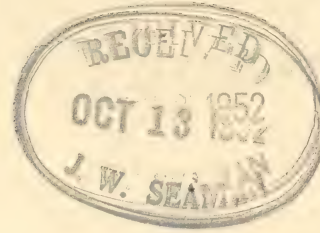
A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ont., Canada, June 25-29, 1951. Manuscript submitted February 26, 1951; made available for printing May 3, 1951.

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Mr. Frey

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POWER-REACTIVE DIAGRAM STILL USEFUL

R. M. Butler

*Electric Utility Engineering Divisions
General Electric Company
Schenectady, N. Y.*

Reprinted from *Electric Light and Power*,
Vol. 30, July and August, 1952

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Bureau of Reclamation
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ELECTROSTATIC UNBALANCE TO GROUND OF TWIN CONDUCTOR LINES

Eric T. B. Gross
Fellow AIEE

W. J. McNutt
Associate Member

Both of:
Illinois Institute of Technology,
Chicago, Ill.

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Transactions Paper

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EVALUATION OF THE INTEGRATION METHOD FOR ANALYSIS OF NON-STANDARD SURGE VOLTAGES

Andrew R. Jones
Associate Member AIEE
Westinghouse Electric Corp.
Industrial Atomic Power Section
Pittsburgh, Pa.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21-25, 1954. Manuscript submitted March 24, 1954; made available for printing April 12, 1954.

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ELECTROMAGNETIC UNBALANCE OF UNTRANSPOSED TRANSMISSION LINES, II. SINGLE LINES WITH HORIZONTAL CONDUCTOR ARRANGEMENT

E. T. B. Gross
Fellow AIEE

S. W. Nelson
Nonmember AIEE

Both of:
Illinois Institute of Technology
Chicago, Ill.

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A RATIONAL METHOD FOR THE STEP-BY-STEP CALCULATIONS IN POWER SYSTEM TRANSIENT STABILITY STUDIES

E. O. Norinder
Nonmember AIEE
Swedish State Power Board
Stockholm, Sweden

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by

Gabriel Kron

Report No. 57GL330

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TRAVELING WAVE PROTECTION PROBLEMS — II

E. W. Boehne

Fellow AIEE

Massachusetts Institute of Technology
Cambridge, Mass.

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W. B. Nelson and J. M. Miller*
Information Sciences Laboratory

Report No. 67-C-160

August 1967

*Member of Telecommunications and Information Processing Operations,
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by

W.B. Nelson, Information Sciences Laboratory

Report No. 69-C-018

December 1968

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ELECTRICAL DESIGN OF EHV SUBSTATIONS

L. O. Barthold
General Electric Company
Schenectady, N.Y.

and

J. B. Tice
General Electric Company
San Francisco, California

Presented at the Pacific Coast Electric Association
San Francisco, California, March 19-20, 1964

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**AN ANALYSIS OF VARIANCE TEST FOR NORMALITY
(COMPLETE SAMPLES)**

BY

**DR. S. SHAPIRO - GENERAL ELECTRIC CO.
DR. M. WILK - BELL TELEPHONE LABORATORIES, INC.**

REPORT NO. 64GL140

SEPTEMBER 3, 1964

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Evaluation of Arcing and Tracking Resistance
of
Insulation Surfaces at High Voltages
by
Direct and Indirect Test Methods

October 20, 1958

K. N. Mathes

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Evaluation of Arcing and Tracking Resistance
of
Insulation Surfaces at High Voltages
by
Direct and Indirect Test Methods

October 20, 1958

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Richard A. Stimson

RICHARD A. STIMSON
Chief, Electro-Mechanical
Division

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Robert E. Cooper

ROBERT E. COOPER
Chief, Qualifications
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1 Encl

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Conference Paper



A POLYMER INSULATOR FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
Senior Member IEEE
General Electric Co.
Baltimore, Md.

F. S. Nichols
General Electric Co.
Pittsfield, Mass.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 26, 1963; made available for printing April 18, 1963.

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Paper No. **CP**

63-1039

Conference Paper



SOME CHARACTERISTICS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
Senior Member IEEE
General Electric Company
Baltimore, Md.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 11, 1963; made available for printing December 20, 1963.

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Paper No. **CP**

64-36

Conference Paper



FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
General Electric Co.
Baltimore, Md.

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Paper No.

31 CP 65-663

FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose

SUMMARY

The first report on GEPOIR[®] insulators for high voltage transmission lines was presented at the 1963 Summer Annual IEEE meeting in Toronto (CP-63-1039) and a second report on these insulators was presented at the IEEE Winter Power meeting in New York in 1964 (CP-64-36). These two papers reported on the original concept of a polymer insulator and the limited field trials of the insulator, as well as on the laboratory tests and characteristics of a revised design of the original polymer insulator. Since the publication of these two papers, the revised design has undergone extensive field service tests on the transmission lines of many utilities in the United States, under widely varied atmospheric conditions. This paper has been written as an interim report on the results of these field service tests and to present a detailed description of the insulators and the laboratory tests that have been made on insulators returned from field service, with varying periods of time in the field.

INTRODUCTION

In order to keep track of all parameters in this large scale field trial, the following steps were taken:

1. Each insulator manufactured was marked with a serial number. The date of its manufacture and conditions relating to the manufacturing process were recorded.
2. Each utility participating in the field trials was asked to return a questionnaire on the details of the installation of the insulators. This provided information on the date of installation, the voltage applied and any pertinent details concerning exposure, such as degree of contamination and kind of contaminants involved in the exposure.
3. Records were kept of the serial numbers of the insulators and the exposure as indicated by the returned questionnaires.

It was suggested to the sixty-eight utilities cooperating in the field trials that at least some of the exposure be made in severe locations so that a true cross-section of operating conditions would be obtained. Actually, of the approximately 1,700 insulators in service, a disproportionately high percentage was placed in areas involving severe contamination of various kinds.

The first insulators of this design were placed in service on field trial in October, 1963, and additional quantities have been put into service at intervals since then. Some of the 1,700 insulators presently in service have been operating for seventeen months and some of the more recent units have been in service for only a few months. The weighted average service time is probably about six months.

Of those insulators which have been placed in areas subject to abnormally severe contaminants, the contaminating materials covered a wide range including salt, gypsum, coal dust, fertilizer dust, fly ash, limestone, phosphates, acid fumes, cement, potash dust and heavy industrial contamination. In these field trials none of the insulators of this design were washed, even though in some cases porcelain insulators, when used in these same exposures, were subjected to regular washing operations.

In several cases the insulators were placed in areas which have been notorious for vandalism and where porcelain insulators were regularly broken by rifle fire.

PRELIMINARY COPY

*Received from
Gene Hunter
Jun 1965*

PLASTIC SUSPENSION INSULATORS

J. C. Parker
Memphis Light, Gas, and Water Division

*

On a 115-kv overhead line feeding a chemical plant, we find corona on conventional 5 3/4" x 10" porcelain suspension insulators from time to time. This corona occurs only when these insulators are contaminated with matter originating in the plant and when their surfaces are also wet due to severe condensation, fog or mist. This corona has not resulted in a flashover or any damage, but it is a nuisance because when the plant operators see it they become alarmed and insist that we eliminate it before it results in a flashover that would interrupt their production.

The addition of two insulators to the nominal seven insulator strings we use on 115-kv lines did not appreciably improve this condition.

The contamination has the appearance of a deposit of fine white dust a few mils thick. It can easily be wiped off of the insulators, but a new deposit soon reappears.

Cleaning the insulators and applying Insulgrease eliminated this trouble for about a year. However, it was found to be difficult to remove from the insulators at the end of its useful life. The substitution of Insulcone for Insulgrease produced the same results and could easily be wiped off of the insulators at the end of its useful life. We realize that with different contaminants the performance of these two products will probably be different. Other brands of silicones of the same types will no doubt produce the same results.

Upon the insistence of a manufacturer that this annual maintenance could be eliminated by using his polymer insulators, we purchased six for a trial installation. These one-piece, 12-petticoat insulators were each supposed to be the equivalent of a string of seven standard ten-inch porcelain-suspension insulators. The delivered cost was approximately three times the cost of the equivalent standard insulators. These insulators were installed at random in the contaminated area. Their trouble-free life was approximately half that of porcelain insulators coated with Insulcone.

The polymer insulators have been removed and the manufacturer notified. His comments will be interesting.

Upon examining the polymer insulators after removal, about the same amount of contamination was found on them as on porcelain insulators. Tracking was found only at one point on one insulator. This tracking was confined to an area approximately 3/32" x 1/2" and was apparently over the end of the metallic fitting embedded in the end of the insulator. The depth of the tracking could not be determined without dissecting the insulator which was not considered advisable until the insulator is examined by the manufacturer. All of the insulators had rough spots of various sizes and shapes at random locations on their surfaces. There was no indication that these insulators would

Epoxy-Fiberglass Insulating Columns For Power Circuit Breakers

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ABSTRACT

Insulating columns having a structural tube of filament wound glass-epoxy, together with a filled cast epoxy outside covering combining weathering protection and creepage path, have been shown to be an excellent substitute for porcelain ceramic columns. These columns have been made in sizes applicable for 138 KV and 500 KV ATB Air Blast Circuit Breakers made by the Power Circuit Breaker Department.

Introduction

One of the major components in the air blast circuit breaker is a column of porcelain which supports the interrupting head above ground both electrically and physically. These columns must have capability to withstand high steady state and high impulse electrical stresses. Furthermore, by means of exterior convolutions sufficient creepage path is provided so that atmospheric contaminants will not permit electrical conduction between the high potential interrupting head and the ground.

Furthermore, these columns serve as structural members holding up the heavy steel casings containing the interrupting mechanisms. There are also extra loads due to pull of the transmission lines, wind and vibrational loading. Additionally there is a large axial load which is produced by the internal tie-rod construction which holds the interrupting head to the base of the circuit breaker. This is necessitated by the design using porcelain in which the porcelain column must be kept under compression for suitable mechanical performance; in addition, a high load must be applied to elastomer gaskets used in the sealing of high dielectric gases in the insulating column.

The use of a fiberglass wound structure to act as both the electrical and mechanical support for the interrupting head has been considered for some time. New advances in resin and glass winding technology have increased confidence that such a structure could be made to perform the required function satisfactorily, and, additionally, give the very long life that is required for use in utility apparatus. Evidence of satisfactory life has been obtained from the experience of the Insulator Department (Baltimore) which has had in service for over five years fiberglass reinforced, epoxy clad, transmission line tension supports. Other manufacturers have made many filament wound structures and have gained valuable experience in understanding how such reinforced composite structures can satisfactorily carry heavy loads.

DYNAMIC INSULATOR DUTY - CHAPTER 11

CONTROL OF CONDUCTOR VIBRATION DETERMINES DYNAMIC LIFE-EXPECTANCY OF INSULATORS

Having explored extensively dynamic effects on insulators in previous chapters, it would seem desirable to summarize the question with some specific comments. These may sometimes appear in a degree of conflict. We feel sure, however, the reader will gather from the discussion at least an appreciation of the complexity of the subject.

Obviously there is a magnitude of vibratory deflection below which pin flexure is relatively harmless, and above which it is hazardous. Figures 1 and 2 depict typical examples of these conditions. Pin providing data for Figure 1 has a large diameter for most of its length, and necks-down to a shank of .72-inch diameter for a length of only .55-inch. (See Figure 3) This is an extreme case of reduced flexure in both length and diameter of the flexing member. Data in Figure 2 is typical of a pin with a diameter of .625-inch and an exposed length of 1.75-inch over which this diameter exists, giving it considerable flexure length. (See Figure 4) The difference in fatigue tolerance between the two pins is considerable.

Every pin design shows a typical range of tolerance, and the O-B laboratory has investigated most of the common pins now on the market. The data shows many differences resulting from pin conformation, but the general comparison between the shorter, less-flexible shank and the longer, more-flexible type is the most significant, and is presented in the two curves.

It will be noted in Figures 1 and 2 that mechanical load on the insulators is not an important factor, as indicated by the rather narrow dispersion of the line. Maximum service load is the common application assumption of 50 per cent of rated strength. Minimum load is the equivalent of a lightly loaded sus-

pension point. For convenience, call this under 1,000 pounds. Bear in mind that in tangent points, load on the pin has little relation to conductor tension.

Fracture at the fillet line on the head of the pin of a ball-and-socket connection is a dynamic fatigue phenomenon, having only a second-order relation to static tensile load. While static load opens this fracture line more rapidly when it is established, it is not a primary factor in initiating the condition.

This being the case, why is conductor tension such an important consideration not only in strain but in tangent positions? It must be understood that pin damage is a function of aeolian vibration in the conductor. This vibration results from a "tuned" condition, and is affected by internal damping of the cable. Conductors strung below 15 per cent of their ultimate strength are basically self-damping, but very few such low tensions exist on modern EHV lines with long spans and generous ground clearances. Aeolian response of conductors is a subject far into the province of the cable manufacturer, and we will not presume to trespass on this territory. However, it is clearly delineated and we urgently recommend a thorough investigation as a part of preliminary line design.

We now reach a controversial point, namely, armor rods and vibration dampers. Like the umpire in a baseball game, we will call balls and strikes "as we see 'em" and may elicit some boos from the bleachers.

For the purpose of protecting the insulator string from damaging vibration, any damping device on the conductor must absorb energy in sufficient degree to fall within the limits outlined in Figures 1 and 2. We ignore the effect of such de-

vices on the conductor . . . they may or may not be adequate to furnish protection for this member. We confine ourselves to the question of how much vibration generated in the open span will reach an insulator string.

According to conductor manufacturers, there are two general categories of armor rods, from an energy-absorption standpoint: (A) Either formed or straight, of continuous diameter. (B) Tapered, which change pitch when wrapped and set up inter-strand friction. The first type supplies no protection to the insulator string. The second provides a moderate degree of energy absorption.

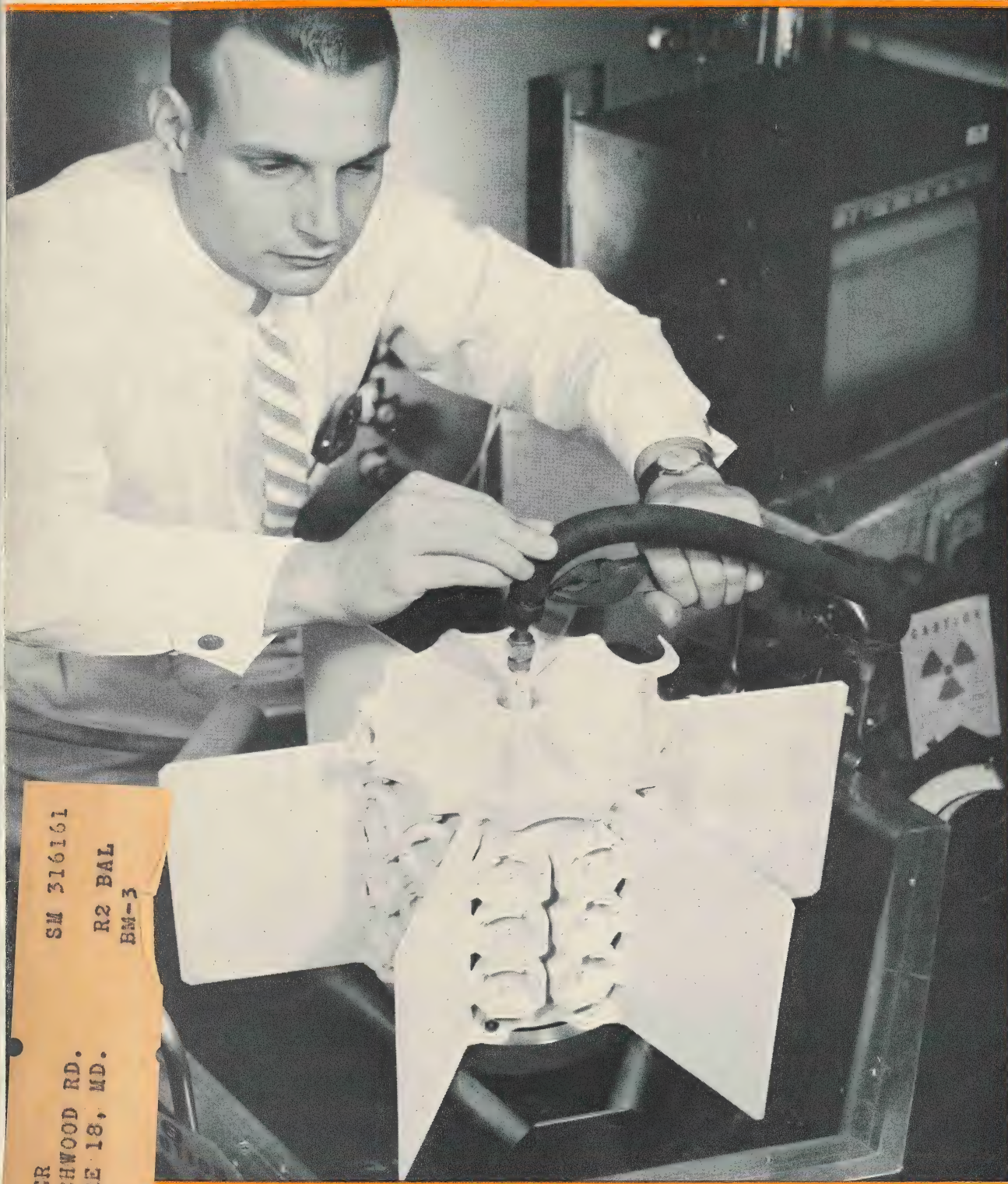
Vibration dampers of accepted design are highly effective. We know of only one service failure of an insulator string protected by dampers. Dampers, in this case, were not installed for a short time after the line was built, and during this period a pin fracture was undoubtedly initiated. This fracture was then able to grow with the low level of vibration permitted by the dampers. Study of the fracture showed many progressive stages of its development.

Much of this discussion is predicated on a knowledge of amplitude and loop length in a vibrating string of insulators. Observation of these phenomena is extremely difficult. As was mentioned in the previous chapter, this observation is best done with a transit telescope which brings the viewer within a few feet of the insulator and provides a hair line as a reference point. This observation must be done from the side of the line because of orientation of the vibratory movement.

Even under ideal conditions, a string of insulators in vibration appears as no more than a blur at the antinode points, and accurate measurement of this fuzzy image

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NOVEMBER 1963



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1639 LOCHWOOD RD.
BALTIMORE 18, MD.

Pumped storage hydroelectric plants—page 654

A high-power d-c/d-c static inverter—page 661

Buried urban telephone distribution—page 677

Original Text for
IEEE Conference Paper CP 63-1039

A POLYMER INSULATOR FOR
HIGH VOLTAGE TRANSMISSION LINES

By

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F. S. Nichols
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Presented at IEEE Summer General
Meeting June, 1963, in Toronto, Canada

A POLYMER INSULATOR FOR
HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose

F. S. Nichols

SUMMARY

Porcelain has been the principal insulating element in suspension insulators for many years. This paper describes how a modified epoxy type polymer with a fiberglass core is used in the design of a developmental suspension insulator for application on future transmission lines. Included in the paper is a resume of certain special tests run to prove the insulator, and a review of its current service record. The potential advantages of this type of insulator are summarized.

INTRODUCTION

Wet process electrical porcelain has been used in all types of suspension insulators for many years. Its long life, high dielectric strength, imperviousness to most chemicals, resistance to electrical tracking, and low materials cost have retained for porcelain a unique position as the insulating element in suspension insulators. There are probably over a hundred million porcelain suspension insulators in service today in the United States. Some of these have been providing reliable service over the span of many decades. For these reasons, efforts to replace the porcelain with other materials has so far been significantly unsuccessful.

Voltages and mechanical loads on insulators are increasing as the trends toward higher voltages, use of large conductors, multiple conductors and longer spans continue. These factors bring increasing need for higher reliability in materials and components for use in transmission lines. The need for an even better suspension insulator to meet these requirements becomes readily apparent. These needs can be defined in terms of practical design consideration.

1. A lighter but stronger insulator would facilitate construction and hot line maintenance.
2. An insulator with a much higher resistance to impact would reduce the susceptibility to breakage during handling and erection, and also would reduce outages caused by rifle fire and other accidental and malicious impacts during normal operation.
3. Puncture proof insulators, with the ability to sustain power arc follow currents without damage, would reduce outages due to lightning and switching surges, and would eliminate dropped lines caused by puncture induced explosion forces.

Early in 1954, a program was initiated by the General Electric Company to find an insulating material for use in outdoor insulators which would provide maximum reliability consistent with the utility industry's future requirements. Literally hundreds of formulations were investigated and tested. Finally, in 1957, a modified epoxy type polymer which appeared to meet our requirements for outdoor service was developed.

To fully explore the possibilities was a time-consuming process. It involved a great variety of investigations and tests to truly understand the characteristics of this material and to develop means of designing practical insulators with it as a base. When working with any new material for application to the exacting requirements of high voltage insulators, one must put aside preconceived ideas. Many of the design and test criteria presently applied to porcelain insulators are either meaningless or inadequate when applied to materials having entirely different characteristics. Other

Conference Paper



SOME CHARACTERISTICS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

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FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR
HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose

SUMMARY

The first report on GEPOL[®] insulators for high voltage transmission lines was presented at the 1963 Summer Annual IEEE meeting in Toronto (CP-63-1039) and a second report on these insulators was presented at the IEEE Winter Power meeting in New York in 1964 (CP-64-36). These two papers reported on the original concept of a polymer insulator and the limited field trials of the insulator, as well as on the laboratory tests and characteristics of a revised design of the original polymer insulator. Since the publication of these two papers, the revised design has undergone extensive field service tests on the transmission lines of many utilities in the United States, under widely varied atmospheric conditions. This paper has been written as an interim report on the results of these field service tests and to present a detailed description of the insulators and the laboratory tests that have been made on insulators returned from field service, with varying periods of time in the field.

INTRODUCTION

In order to keep track of all parameters in this large scale field trial, the following steps were taken:

1. Each insulator manufactured was marked with a serial number. The date of its manufacture and conditions relating to the manufacturing process were recorded.
2. Each utility participating in the field trials was asked to return a questionnaire on the details of the installation of the insulators. This provided information on the date of installation, the voltage applied and any pertinent details concerning exposure, such as degree of contamination and kind of contaminants involved in the exposure.
3. Records were kept of the serial numbers of the insulators and the exposure as indicated by the returned questionnaires.

It was suggested to the sixty-eight utilities cooperating in the field trials that at least some of the exposure be made in severe locations so that a true cross-section of operating conditions would be obtained. Actually, of the approximately 1,700 insulators in service, a disproportionately high percentage was placed in areas involving severe contamination of various kinds.

The first insulators of this design were placed in service on field trial in October, 1963, and additional quantities have been put into service at intervals since then. Some of the 1,700 insulators presently in service have been operating for seventeen months and some of the more recent units have been in service for only a few months. The weighted average service time is probably about six months.

Of those insulators which have been placed in areas subject to abnormally severe contaminants, the contaminating materials covered a wide range including salt, gypsum, coal dust, fertilizer dust, fly ash, limestone, phosphates, acid fumes, cement, potash dust and heavy industrial contamination. In these field trials none of the insulators of this design were washed, even though in some cases porcelain insulators, when used in these same exposures, were subjected to regular washing operations.

In several cases the insulators were placed in areas which have been notorious for vandalism and where porcelain insulators were regularly broken by rifle fire.



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June 2, 1965

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Miss M.A. Stack
Advertising & Sales Promotion
General Electric Company
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E.K. Gannett
Managing Editor

EKG/sls

Conference Paper



THE DEVELOPMENT OF POWER FACTOR MEASUREMENT OF INSULATION IN THE FIELD

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58-49

Mr. King

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GENERAL ELECTRIC
Research Laboratory

*Equipment
Testing*

CAPACITANCE BRIDGE BALANCER

by

D. A. Felton and P. G. Frischmann

Report No. 56-RL-1616

September 1956

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SCHENECTADY, NEW YORK

LOCKE INSULATORS, INC

GAGE HISTORY NO:

GAGE I.D. NUMBER :
 LOCATION :
 CALIBRATION INT. :

DESCRIPTION :
 DRAWING # :
 NEXT CAL. :

GAGE SUPPLIER :
 DATE ACQUIRED :

CAL. STANDARD :
 GAGE ACCURACY :

CALIBRATION PROCEDURE:

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CALIBRATION HISTORY

CURRENT STATUS:

TYPE	DATE	COMMENTS
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LAST CALIBRATION DATA

DATE:

BY:

CHARACTERISTIC	ACTUAL	CHARACTERISTIC	ACTUAL
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COMMENTS:

SERIAL # OF MASTER:

WHERE USED:

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Transactions Paper

(Reviewed and Accepted for Publication)



SWITCHING SURGES AND ARRESTER AND GAP PERFORMANCE

DURING 220 KV LINE-DROPPING TESTS

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DEVELOPMENT OF POWER VACUUM INTERRUPTERS

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CONSIDERATIONS IN ESTABLISHING A STANDARD OF MECHANICAL LOADS ON OIL CIRCUIT-BREAKER BUSHINGS

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POWER DEVELOPMENT IN THE U. S. S. R.

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SOME FUNDAMENTAL ASPECTS OF RECOVERY VOLTAGES

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HIGH AND EXTRA HIGH VOLTAGE SUBSTATION DESIGN AND ECONOMIC COMPARISONS

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Conference Paper



RADIO NOISE AGING CHARACTERISTICS OF SMALL ALUMINUM CONDUCTORS

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Transactions Paper

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FUNDAMENTAL ASPECTS OF SOME SWITCHING OVERVOLTAGES ON POWER SYSTEMS

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FAULT AND LOAD CURRENT TESTING OF A BUNDLE CONDUCTOR SPACER

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THE DESIGN AND TESTING OF AIR SWITCHES ABOVE 345KV

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RESULTS FROM THE FIRST YEAR OPERATION OF PROJECT EHV

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Conference Paper



PROJECT EHV - THE VALUE OF RESEARCH

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AIEE Winter General Meeting
January 29, 1962

Conference Paper



PROJECT EHV - THE VALUE OF RESEARCH

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Schenectady, New York

AIEE Winter General Meeting
January 29, 1962

Paper No. **CP**

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EHV

District Conference Paper



PROBLEMS AND USE OF EXTRA HIGH VOLTAGE

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H. A. FREY

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RESULTS FROM THE FIRST YEAR OPERATION OF PROJECT EHV

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Discussion in Duplicate Due July 6, 1962.

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OBSERVATIONS ON A FATIGUE PHENOMENON

by

G. M. Rentzepis
Mechanical Technology Laboratory

Report No. 66-C-376

October 1966

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**"A SYSTEM OF CATEGORIES FOR FAILURE MECHANISMS-
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BY

R. H. NORRIS

REPORT NO. 65GL21

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CYCLIC SOFTENING EFFECTS IN METALS

by

L.F. Coffin, Jr., Metallurgy and Ceramics Laboratory

Report No. 66-C-211

July 1966

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H. A. FREY

GENERAL ELECTRIC
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CYCLIC STRAIN AND FATIGUE BEHAVIOR OF METALS
IN THE CREEP RANGE

by

L. F. Coffin, Jr.

Report No. 64-RL-3830 M

December 1964

CLASS 1

SCHENECTADY, NEW YORK

Technical Report
7W.LK-633

TECHNICAL INFORMATION SERIES

AUTHOR <i>EW</i> EJ Mets NW Roberts <i>NR</i>	SUBJECT CLASSIFICATION Fatigue of Metals	NO. 57TP469 DATE 7-10-57
TITLE Fatigue Characteristics of Aluminized and Galvanized Plain Forged Steel		
ABSTRACT		

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AUTHOR	SUBJECT CLASSIFICATION	NO.
H. Fehlmann <i>H Fehlmann</i>	1. L.A. - Line Station and H.V. 2. L.A. - Testing 3. Insulators	59PT157
		DATE
		12/9/59
TITLE		
CONTAMINATION TEST ON LIGHTNING ARRESTER HOUSINGS		
ABSTRACT		

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR H. Fehlmann <i>H. Fehlmann</i>	SUBJECT CLASSIFICATION 1. L.A. - Line Station and H.V. 2. L.A. - Testing 3. Insulators	NO. 59PT157 DATE 12/9/59
TITLE CONTAMINATION TEST ON LIGHTNING ARRESTER HOUSINGS		
ABSTRACT Sixty-cycle flashover tests were made on L.A. housings with three variations of both housing diameter and number of petticoats. In addition to fog tests with 0%, 3%, and 10% salt solutions, standard dry and wet tests were made. Also tested were a 79 kv Ohio Brass L.A. housing and 7785 pin type insulators.		
G.E. CLASS IV GOV. CLASS None	REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS Pittsfield, Mass.	NO. PAGES 54
CONCLUSION 1. Under contaminated conditions the withstand voltage increased and the leakage current decreased with the number of petticoats. 2. The Ohio Brass housing and the 7785 insulator supports had significantly higher withstand values under salt spray contamination than the G.E. housings. This appears to be the result of both increased creepage length and different design. More detailed conclusions are given at the end of the report.		

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For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR Lightning Arrester/W.J. Rudge

TESTS MADE BY JS Bozyczko, JE Eulian, HR Fehlmann Tests Completed: 9-24-59

COUNTERSIGNED F.J. Turner *F.J. Turner* SECTION High Voltage Laboratory

BUILDING and ROOM No. #9 - Rm. 102 LOCATION Pittsfield, Mass.
/hrq

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
<i>J.P. Benedict</i>	1. L.A.-Line Station and H.V.	60PT145
JP Benedict	2. L.A.-Testing	DATE
	3. Insulators	7/6/60
TITLE CONTAMINATION TEST ON SIX TYPES OF DEVELOPMENTAL LIGHTNING ARRESTER HOUSINGS. PHASE II		

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR <i>J.P. Benedict</i> JP Benedict	SUBJECT CLASSIFICATION 1. L.A.-Line Station and H.V. 2. L.A.-Testing 3. Insulators	NO. 60PT145 DATE 7/6/60
TITLE CONTAMINATION TEST ON SIX TYPES OF DEVELOPMENTAL LIGHTNING ARRESTER HOUSINGS. PHASE II		
ABSTRACT Sixty-cycle flashover tests were made on develop- mental L.A. housings having various hood configurations. In addition to fog tests with 0% and 3.8% salt solutions, standard dry and wet tests were made. Also tested were a 79 kv Ohio Brass L.A. housing, a 9LA3K066 housing and 7785 cap and pin type insulators.		
G.E. CLASS IV M GOV. CLASS None	FILE COPY AVAILABLE IN THE WILLIAM STANLEY LIBRARY, PITTSFIELD Pittsfield Works	NO. PAGES 18
CONCLUSION 1. On the basis of these tests, two designs appear to be best suited for application in contaminated areas. They are: a. Lightning arrester housings having 14 hoods with the underside corrugated. b. Lightning arrester housings having 15 hoods with a 15 degree undercut. 2. The ability of these lightning arrester housings to withstand 10 cycles of 3.8 percent salt solution fog at 50 kv appeared to be a function of design profile rather than the total creepage length or the ratio of protected creepage length to the total creepage length.		

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INFORMATION PREPARED FOR Lightning Arrester / W.J. Rudge

TESTS MADE BY HR Fehlmann, JE Eulian, and JP Benedict Tests Completed: 6/13/60

COUNTERSIGNED AF Rohlfis *A. F. Rohlfis* SECTION High Voltage Laboratory

BUILDING and ROOM No. 9-102 LOCATION Pittsfield, Massachusetts

-mjb

Mechanics - Fracture

GENERAL ELECTRIC
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PHYSICAL NATURE OF PLASTIC FLOW AND FRACTURE

by

J.J. Gilman

Report No. 60-RL-2410 M April 1960

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CLASS 1

FRACTURE MECHANISMS IN ELECTRICAL INSULATOR PORCELAINS

by

G.E. Kluwe, Jr. and R. C. Anderson, Metallurgy and Ceramics Laboratory

Report No. 68-C-385

October 1968

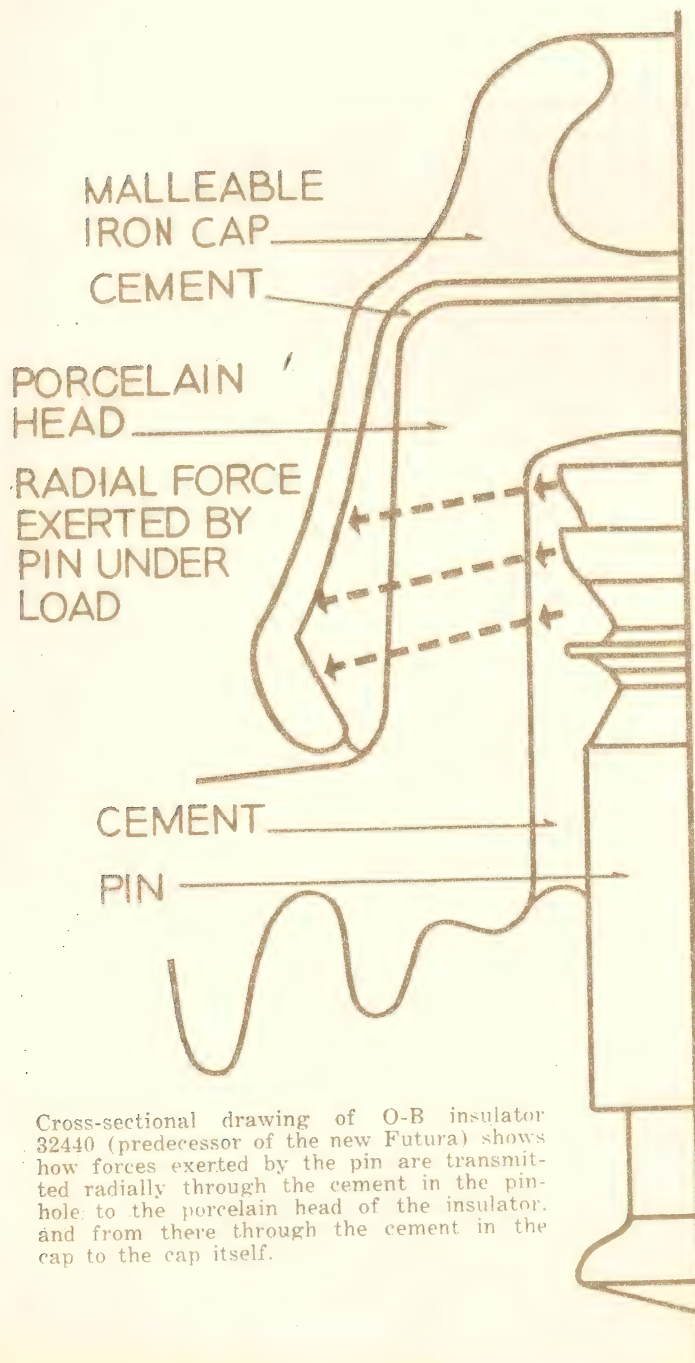
**how the development
of improved research
tools aided the
development of an
improved insulator design**

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SEP 29 1961
G. M. BOYD

EDITOR'S NOTE: Since the introduction of the Futura insulator last July, our efforts in this publication have been directed primarily toward a more complete explanation of the substantial benefits users should expect from this insulator as a result of the incorporation of the Corrosion Intercepting

FUTURA

A NEW DESIGN



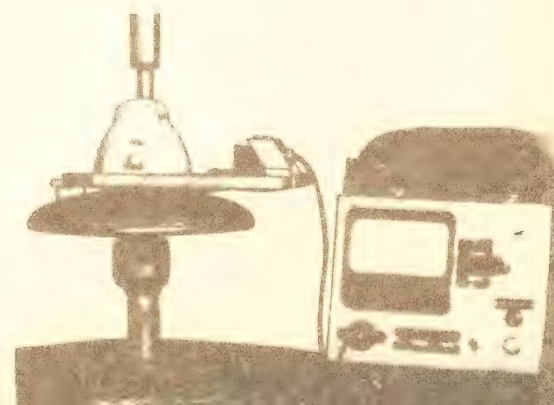
Cross-sectional drawing of O-B insulator 32440 (predecessor of the new Futura) shows how forces exerted by the pin are transmitted radially through the cement in the pin-hole to the porcelain head of the insulator, and from there through the cement in the cap to the cap itself.

Among the early problems confronting O-B engineers in their search for an improved insulator design was the problem of determining -- more precisely and more accurately than ever before -- what actually happens to an insulator when it is subjected to various types of mechanical and electrical loads and stresses.

Conventional tools and tests, techniques and instrumentation, were frequently too crude to probe many of the areas they wanted to explore more thoroughly.

They had to develop, for example, a new technique of impulse testing, new instrumentation to record fast waves (of the order of .01 micro-seconds), improved ways to measure the deflection of porcelain under mechanical load, and other new laboratory aids.

Some of the new tools they developed will be revealed for the first time in future technical papers; others will be discussed in this publication.



Mr. Bogel

Mechanics

Conference Paper

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ALUMINUM COLD FLOW COMPENSATION IN BOLTED ELECTRICAL CONNECTIONS

G. L. Flynn
Nonmember AIEE

T. L. Rundlett
Member AIEE

Both of:
Anderson Electric Corp.
Birmingham, Ala.

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AUG 8 1961
H. A. EREY

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Pacific General Meeting, Salt Lake City, Utah, August 23-25, 1961. Manuscript submitted May 25, 1961; made available for printing June 23, 1961.

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Mechanics

BASIC CONCEPTS IN THE DESIGN
OF ELECTRICAL BUS FOR SHORT CIRCUIT CONDITIONS

A. C. HATON

INTRODUCTION

The adequacy of the mechanical structure of an electrical bus to withstand short circuit forces has been an engineering consideration for many years. During this time the problem must have occupied the attention of many capable engineers, and as a result one would expect to find a basic knowledge of the subject widespread. However this does not seem to be true. Possibly this is because there may have been insufficient economic pressure to cause a deviation from an over simplified method which resulted, fortunately, in an over strong structure. Another possible reason is that the subject demands both electrical and mechanical analysis. Unfortunately, the electrical engineer tends to drop his careful thinking once the electrical considerations are analyzed, and the mechanical engineer may have trouble in making an adequate analysis because of insufficient knowledge of the electrical origin of the problem. Whatever the reason, confusion seems to exist, and the purpose of this paper is to make an earnest attempt to contribute information which will lead to an appreciation of the basic elements of the problem.

LIMITATION OF TREATMENT

There are many questions which might be asked about the design of a new bus structure for an intended service, or the analysis of the adequacy of an old one for a new service condition. The answers to such questions must result from an analysis, and hence must be deferred until at least some acceptably approximate analysis has been made.

It is necessary drastically to limit the subject matter in order to permit a grasp of the elementary aspects of the problem. For this purpose, a single phase circuit employing parallel conductors on rigid supports has been chosen.

THE CIRCUIT, CURRENT, AND FORCE

An ideal single phase circuit is shown in Fig. 1. The R and X are the total resistance and reactance involved in the current flow, and E is an ideal voltage source having no impedance. It is assumed that the switch is closed at the time necessary to produce the greatest initial offset of the current wave. With i representing the instantaneous value of current, and i_{sp} the peak value of asymmetrical or steady state current, the offset wave may be expressed as:

$$i = \frac{E}{Z} \omega t - \cos \omega t \quad (1)$$

MEMORANDUM

TO: All Supervisors
FROM: Paul Ankrim
SUBJECT: Roof Leaks Survey Report
DATE: May 3, 1989 (Wednesday)

=====

Attached are three different reports (six sheets of paper) relating to the factory leaks that were reported by Locke supervisors.

Each leak has a unique number and locator number. The number in most cases takes the Department Number and adds to it sequential two-digit numbers beginning with 01. Hence, for example, leak Number 02001 is the first leak reported by the Shipping Department.

Only the Ceramics Lab and High Voltage Lab have a different numbering system in this survey. (The specially prepared map for the Ceramics Lab is not attached to this report.)

The attached map records 68 of the 79 leaks' approximate positions. Those of the Ceramic Lab and High Voltage Lab are not plotted.

Please see the attached data recording form for understanding the various headings such as "Prior#1," "other-des," etc.

The reports are:

1. "Leaks Summary, All Fields--this provides an overview of all responses.
2. Three reports providing detailed information about leaks in each of the three classifications. The number of each classification is as follows:
 - a. Dangerous: 24 (30.4 %), of which eight are in department 165 and four are in department 169.
 - b. Hazardous: 21 (26.6 %), of which four are in department 161.
 - c. Damaging: 34 (43.0%), of which half are equally shared by departments 020 and the ceramic lab.

Thank you very much for your cooperation in completing this survey. Perhaps you will discover leaks or condensation that are not recorded, especially from pipes, drain leaders, heaters, air conditioning tubes, etc. Please provide that information at your convenience.

Documenting the leaks was the easiest step; making the repairs is the real challenge, but you have my assurance that these will be made as efficiently and timely as possible.

Number	Title	Author	Company	Date
1796-63-8	BASIC TEXT OF PRESENTATION ON NEW POLYMER INSULATOR HIGH VOLTAGE TRANSMISSION LINES AT PRESS MEETING ON MAY 8, 19633	Peltosalo, A.E.	Insulator Dept Baltimore, MD General Electric	5/8/1963
Memo	Test to determine relative resistance of several insulating structures to gunfire	Sweeney, JO	Insulator Dept. GE Baltimore, MD	3/26/1963
IEEE CP 63-1039	A POLYMER INSULATOR FOR HIGH VOLTAGE TRANSMISSION LINES	Vose, FC Nichols, FS	General Electric Balto & Pittsfield	3/26/1963
Paper	A NEW THOUGHTS ON HIGH VOLTAGE INSULATORS	Frey, HA	GE-Insulator Dept	
IEEE CP 64-36	SOME CHARACTERISTICS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES	Vose, Fred C.	GE-Insulator Dept Baltimore, MD	11/11/1963
Advertisement	NEW GENERAL ELECTRIC TERMI-MATIC		General Electric	
IEEE CP 31 CP 65-663	FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES	Wose, Fred C	GE-Insulator Dept Baltimore, MD	4/6/1965
Paper	USE OF FIBERGLASS IN CONSTRUCTION OF TRANSMISSION LINES	Jerome, FD		10/5/1966
Paper	EPOXY HIGH VOLTAGE INSULATORS FOR OUTDOOR USE	Wheeler, Edw S	GE-Insulator Dept	4/6/1967
Excerpt IEEE	CONCEPT & ANALYSIS OF EPOXY-CERAMIC INSULATOR SYSTEM FOR OVERHEAD LINES	Halley, Hugh G Popeck, Chas. A.	IEEE members	December 1967
Copy	HI-LITE INSULATORS ARE COMPARED TO PORCELAIN IN THEIR STRENGTH-TO-WEIGHT RATIO		Ohio Brass	
Discussion Paper	MECHANICAL RATINGS ON NON-CERAMIC INSULATORS Paper for WG on Nonceramic & Composite Ins.	Holte, Kirby C. Moleff, Ted	So. Calif Edison	
Paper	CHARACTERISTICS OF FIBERGLASS AND POLYMER INSULATION	Wheeler, Edw S	General Electric Baltimore, MD	
TR LK-864	COMPOSITION OF LOW VOLTAGE POLYMERIC INSULATORS MARKETED BY OUR COMPETITORS FOR INDOOR USE	Nichols, G.	General Electric Blatimore, MD	2/2/1968

Basic Text of Presentation on
New Polymer Insulator for High Voltage
Transmission Lines at Press Meeting on May 8, 1963
at Park Lane Hotel, New York City

Arthur E. Peltosalo, General Manager
Insulator Department
General Electric Company
Baltimore, Maryland

General Electric announces Phase 3 of its long range program to provide uniquely different insulation systems for high voltage electric power systems. Phase 3 is pilot production of fiber-glass polymer suspension insulators (Company trademark is GEPOL) in cooperation with electric utility systems who will make trial installations in 1963-64.

The initial phase of this research program was the development of the material and process for an experimental insulator model. The second phase involved limited field test installations, along with continued process development in perfecting the initial experimental models.

Conference Paper



A POLYMER INSULATOR FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
Senior Member IEEE
General Electric Co.
Baltimore, Md.

F. S. Nichols
General Electric Co.
Pittsfield, Mass.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 26, 1963; made available for printing April 18, 1963.

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Paper No. **CP**

63-1039

NEW THOUGHTS ON HIGH VOLTAGE INSULATORS

H. A. Frey, Mgr.-Engineering

Insulator Department General Electric Company

I very much appreciate this opportunity to present to the Electrical Equipment Committee some of the new thoughts on materials for high voltage insulators, and the problems associated with such material.

I know that your Committee's primary interest lies in electrical equipment and apparatus insulation rather than line insulation. However, in these two areas the fundamental insulating material problems are interchangeable so that I hope you will understand if many of my remarks are directed toward line insulators, since it is in this area that we have much of our total experience with some of the new materials for high voltage outdoor insulation.

Virtually all high voltage insulators, whether used in apparatus or as line insulation, must perform three basic functions:

1. They must provide mechanical support and so they must have mechanical strength consistent with their expected service load.
2. They must have adequate dielectric strength to support line voltage plus expected overvoltages due to surges.
3. They must be so designed as to make efficient electrical use of the surrounding medium, which in the case of outdoor insulators is air.

In the most general sense, the basic requirements for the materials of which high voltage outdoor insulators are made are shown in the following tabulation.

Conference Paper



SOME CHARACTERISTICS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
Senior Member IEEE
General Electric Company
Baltimore, Md.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 11, 1963; made available for printing December 20, 1963.

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Conference Paper



FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
General Electric Co.
Baltimore, Md.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, Detroit, Mich., June 27-July 2, 1965. Manuscript submitted April 6, 1965; made available for printing April 19, 1965.

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Paper No.

31 CP 65-663

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& Rose

The use of Fiberglas in the construction of transmission lines has increased in the last few years as new ways of using this material are being discovered.

I would like to tell you of several ways that we at Carolina Power & Light Company are putting it to use on our transmission lines.

Since it has such a high insulating value we are trying to use it to raise the impulse level of the structure by replacing certain parts of the structure with the Fiberglas.

For example, on one of our older 115 KV double circuit tower lines we wished to improve the lightning performance of the line by increasing the insulation, but were unable to add additional insulators because of the limited airgap clearance between the top conductor and the middle crossarm brace. This clearance limited the number of insulators that could be installed.

In order to increase the airgap we are in the process of replacing the middle crossarm brace with Fiberglas braces.

These braces are to be ordered with a turnbuckle in one end. The turnbuckle is for the purpose of allowing the brace to be delivered with the normal manufacturing tolerances as to length. Unless special procedures are used to obtain an exact length for the Fiberglas brace, the tolerances would be too large for the brace to be substituted for the metal brace on the arm. The turnbuckle provided a convenient means of adjusting the length to fit the tower. These braces cost about \$12.00, and allow us to increase the number of insulators from 7 to 9. The replacing of the brace is done at the same time we re-conductor the line.

On wood H-frame lines the same Fiberglas brace with built-in turnbuckle can also be used as outside knee braces to support the ends of the crossarm.

EPOXY HIGH VOLTAGE INSULATORS
FOR OUTDOOR USE

Edward S. Wheeler
Manager-Engineering
General Electric Company
Insulator Department
Baltimore, Maryland

For presentation at the Symposium

"HIGH VOLTAGE APPLICATIONS OF EPOXIDE RESINS"

The University of Manchester
Institute of Science and Technology
Manchester, England

April 6, 1967

with which it can make a bilateral schedule change; it is desired to balance out for total inadvertent in each area; if the algebraic sum of all inadvertent around the interconnection is or can be made zero, full balance between areas can be achieved; and, if it is not or can not be made zero, then there is a residual amount of inadvertent that is uncorrectable, and the equitable thing to do is to distribute it among all areas in proportion to their size.

The suggested technique is for all areas, at regular and previously stipulated times and for previously stipulated periods, to reset their net interchange schedules to eliminate their respective inadvertent accumulations during the stipulated period. This would be done universally and regularly, on a system-wise basis, at hourly or other time intervals, and for stated time periods which could even be the full hour. To the extent that areas can respond to these reset schedules, inadvertent accumulations would be corrected.

If the algebraic sum of all inadvertents were indeed zero, as several of the discussers suggest it would be, then the algebraic sum of schedule offsets would be zero, and frequency would not be influenced as inadvertent accounts were being automatically reduced to zero. If it turned out that the algebraic sum of inadvertents were not zero, then there is an uncorrectable residual inadvertent. The algebraic sum of schedule offsets would not be zero, and a small frequency deviation would develop, sufficient to spread the uncorrectable accumulation uniformly among all areas in proportion to their bias settings.

To simplify matters for system operators, and to avoid confusion with normal interchange schedule settings, separate setting dials could be used for the inadvertent correction setting. In each case it could be calibrated directly in terms of the inadvertent accumulation to be corrected, with appropriate allowance for the stipulated time

allocated to the correction. Suitable megawatt constraints and frequency limits within which the corrections would be effective could be applied.

It is recognized that the suggested technique would require regularly scheduled concerted setting action on the part of all areas. Perhaps operating areas would not regard this as a greater burden than system-wide concerted resetting of frequency schedules for time error correction, particularly since the inadvertent accumulation correction action would be taken at regular times on a universal system-wide programmed basis.

In closing, I again wish to thank the several discussers for their thoughtful and penetrating comments.

REFERENCES

- [1] B. Littman and T. S. Chen, "Simulation of Bull Run supercritical generation unit," *IEEE Trans. Power Apparatus and Systems*, vol. PAS-85, pp. 711-722, July 1966.
- [2] J. Adams, D. R. Clark, J. R. Louis, and J. P. Spanbauer, "Mathematical modeling of once-through boiler dynamics," *IEEE Trans. Power Apparatus and Systems*, vol. PAS-84, pp. 146-156, February 1965.
- [3] R. R. Walker and W. H. Baker, "Control response of once-through steam generators," presented at the 1966 IEEE Winter Power Meeting.
- [4] D. J. Ahner, C. E. Dyer, F. P. deMello, and V. C. Summer, "Analysis and design of controls for a once-through boiler through digital simulation," *Ninth Nat'l Power Instrumentation Symp., ISA Proc.* pp. 11-30, May 16-18, 1966.
- [5] A. A. Ward and R. L. Stubbins, "Control testing on rapid load changes of the supercritical boiler at Alamitos Steam Station Unit 5," presented at the 1966 ASME Winter Annual Meeting.

Concept and Analysis of Epoxy-Ceramic Insulation System for Overhead Lines

HUGH G. HALLY, SENIOR MEMBER, IEEE, AND CHARLES A. POPECK, SENIOR MEMBER, IEEE

Abstract—A new insulation system for overhead electric lines is presented, together with the system concept and analysis of testing and development data upon which specific designs and application of epoxy-ceramic assemblies (ECA) have been based. For the purposes of data presentation and application referral, the discussion is directed principally toward transmission voltages of 69 kV and above. However, the system presented applies to the lower voltages as well.

PRESENT PROBLEMS AND NEEDS

THE NEED for improved and more sophisticated insulation techniques for overhead systems is becoming increasingly apparent as the problems of "beautility," reliability, right of way, higher voltages, and underground are brought into focus in practical and economic relationships. The ECA insulation system is proposed as a major step toward fulfillment of such needs by providing shorter arm lengths and shorter suspension insulator string length.

Paper 31 TP 66-401, recommended and approved by the Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, New Orleans, La., July 10-15, 1966. Manuscript submitted April 11, 1966; made available for printing June 14, 1967.

The authors are with the A. B. Chance Company, Centralia, Mo.

In many situations, the most realistic alternative to heavy investment in new overhead or underground facilities and right of way is the upgrading of the existing overhead plant to higher capacity through conversion to higher voltages. Of prime consideration in such ventures is the preservation of existing right of way boundaries, the appearance of the converted structures, and the adequacy of the line insulation to give satisfactory performance.

Traditional overhead construction consisting of wood-porcelain or steel-porcelain combinations has a long history, but it has not been without its problems. Pole fires, crossarm burning, and uncertainties in impulse levels and insulation coordination have caused greater spacings and more insulation to be provided than might otherwise be required.^[1] With voltage levels gradually increasing over the years, overall economic and practical considerations indicate the necessity for departures from former practices.

The search for new insulating materials and techniques for overhead line construction has been going on for several decades. Until recent years, however, the lack of sufficient and accurate information regarding the performance characteristics of conventional construction has slowed the efforts toward a more sophisticated insulation system.^[2]

Overhead line construction and insulation techniques now seem to be entering a new era. Vastly increased testing facilities,

MECHANICAL RATINGS OF NON-CERAMIC INSULATORS
DISCUSSION PAPER
FOR

WG on Non-Ceramic and Composite Insulators for
Transmission Lines

Discussion Prepared
by

Kirby C. Holte
Ted Moleff

Southern California Edison

CHARACTERISTICS OF FIBERGLASS AND POLYMER INSULATION

Edward S. Wheeler
General Electric Company
Baltimore, Maryland

INTRODUCTION

Although today we tend to think that porcelain line insulation has always given satisfactory operation, there really are several things historically not quite right with that point of view. For the first thirty years or so of its use, porcelain insulation was unreliable all too frequently. Fortunately, utilities and manufacturers alike learned the problems of porcelain, and designed the product and use of it to accommodate these shortcomings. Nowhere has that been truer than in suspension insulators. From the manufacturer's viewpoint, the product is slow to manufacture, heavy, and can be fragile if handled roughly. Designs and processes must reflect the inherent nature of the materials used. The utility is concerned with its bulkiness and weight, and must allow considerable warehouse space for its storage. The suspension insulator's arch enemy has historically been the gun carrying vandal, but more recently the ecologist has turned our attention to the appearance of its bulky profile, and the clutter on the pole top that can easily be caused with several porcelain discs in series.

Seventeen years ago we began to study outdoor high voltage insulation, asking whether some alternative might be found in the newer insulation materials. What developed from more than a decade of research and development has come to be known as the GEPOL[®] insulator. (Figure 1)

The GEPOL insulator is, properly speaking, a track-resistant, fiberglass reinforced polymer insulator. It depends for its electrical and mechanical integrity on a fiberglass reinforced central rod, about which is cast the track-resistant material, a flexibilized epoxy formulation.

It would have been possible to make a plastic insulator along these general lines twenty years ago. It would not have worked, however. Scientists and design engineers have known for many years that almost all organic materials will track when exposed to contamination and moisture outdoors in electrical service. Tracking may be defined as the formation of carbonaceous conducting paths on the surface of

[®]Trademark of General Electric Co.

TECHNICAL REPORT LK-864

COMPOSITION OF LOW VOLTAGE POLYMERIC INSULATORS
MARKETED BY OUR COMPETITORS FOR INDOOR USE

Author:

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G. Nichols
Polymer Engineer R&D

Distribution: ES Wheeler
FC Vose
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AJ Pezdek
KW Cermak
CD Croskey
JM Jesatko
G Nichols

Approved:

E. S. Wheeler 2/8/68
E. S. Wheeler
Manager-Engineering

General Electric Company

Baltimore, Maryland

February 2, 1968

POLYMER HIGH VOLTAGE INSULATORS FOR
OUTDOOR USE

Edward S. Wheeler
Manager-Engineering

Presented at:

26th Annual Technical Conference
Society of Plastics Engineers, Inc.
New York, New York
May 10, 1968

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New York, New York
May 10, 1968

OUR FAMOUS FIRSTS IN THE FIELD OF ELECTRICAL INSULATION

1893	First Wet Process Porcelain Insulator
1896	First 60 KV Pin Type Insulator
1896	First Triple Petticoat Insulator
1897	First Helmet Type Insulator
1904	First Suspension Insulator
1904	First High Voltage Laboratory
1908	First Clevis Type Suspension Insulator
1908	First Radio Insulator
1908	First Nicholson Arcing Ring
1909	First Switch Insulator
1911	First Switch Insulator for High Voltage
1920	First Stack Type Switch Insulator
1929	First Major Improvement in Glaze
1931	First to Reglaze over the Sand Grip
1932	First Noiseless Pin Type Insulator
1934	First Hi-Top Insulator
1935	First Compression Glaze
1938	First Compression Sand for Cement Grip
1939-45	First Mat Glaze for Metallizing Porcelain for Hermetic Sealing
1939-45	First Vacuum Pressed Steatite
1947	Newest and Most Modern Ceramic Research Laboratory
1953	First Mechanized Manufacturing for Line Type Insulators
1955	First High Strength Ceramic Body for E.H.V. Applications
1956	First Ball and Socket Type 36,000 Lb. Suspension Insulator
1956	First 10" - 25,000 Lb. Suspension Insulator for 4-3/4" or 5" Spacing
1957	First 650 KV BIL Switch and Bus Insulator Stack
1957	First Combination Stacking Unit for Economical Strength Grading
1958	First Color Coding for Suspension Insulators
1958	First Spray for Silicone Grease - INSULJEL
1959	First Complete Line of Extra High Strength Stacking Switch Insulators
1959	First Rugged 6" Distribution Insulator
1959	First Polymer Suspension Insulator
1960	First Insulator String Designs for Large Scale 500 KV Line in U.S. - Penelec
1961	First Insulator String Designs for 770 KV Line - EHV Pittsfield
1963	First Polymer Insulator Laboratory and Pilot Shop
1964	First Polymer Insulators for EHV Station Equipment
1965	Installation of World's Tallest Kiln for EHV Porcelains
1966	First Shrouded Clevis Hardware Fitting for EHV Assemblies
1967	First Polymer Distribution Deadend Insulator
1967	First Catalog of Standard EHV Assemblies
1967	First (Joint G.E.-Bethea) D.C. - E.H.V. Hardware System
1968	First 80,000 Lb. Suspension Insulator in the U.S.

FOR USE OF G-E EMPLOYEES ONLY



TECHNICAL INFORMATION SERIES

Title Page

AUTHOR F.C.Vose K.N.Mathes L.J.Hogue	SUBJECT POLYMER HIGH VOLTAGE INSULATORS	NO. 68LK906
		DATE Nov. 1968
TITLE DEVELOPMENT OF ANTITRACKING GEPOL [®] HIGH VOLTAGE INSULATORS		G.E. CLASS 2
		GOVT. CLASS None
REPRODUCIBLE COPY FILED AT ENGINEERING SECTION INSULATOR DEPARTMENT BALTIMORE, MD.		NO. PAGES 10
SUMMARY A technical paper presented at the Insulating Materials and Dielectric Behavior Technical Conference, Research and Development Center Auditorium, The Knolls, Schenectady, New York on November 13, 1968. The evolution of the design and development of the General Electric Insulator Department's GEPOL high voltage insulators for transmission and distribution lines is covered from 1959 to the present. Many of the primary principles that should be applied in using polymeric materials for this application are covered. Results of field trials are presented. The various laboratory tests used to evaluate the antitracking characteristics of the organic materials used and the insulators developed are discussed.		
KEY WORDS INSULATORS, GEPOL		

INFORMATION PREPARED FOR --

TESTS MADE BY --

AUTHOR

Fred C Vose

COMPONENT

Insulator Department; R&D Center

APPROVED

Edward J. Mathes

NGK TECHNICAL REPORT

No. 11 - 1969

NGK RESIN INSULATORS



NGK INSULATORS, LTD.

(Nippon Gaiishi Kaisha, Ltd.)

MIZUNO, NAGOYA, JAPAN



NGK INSULATORS, LTD.

(Nippon Gaisi Kaisha, Ltd.)

MIZUHO, NAGOYA, JAPAN

RESIN INSULATOR

(Abstract of NGK Review No.27, Jan., 1969)

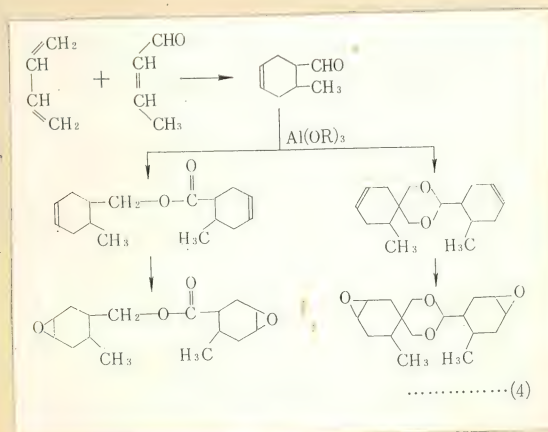
5. OUTDOOR RESIN INSULATORS

What has been said till now is all about indoor resin insulators which are made of bisphenol-type epoxy resin. This bisphenol-type epoxy resin contains in its structural formula benzene nucleus, because of which it lacks strength against tracking under outdoor polluted conditions.

It is reported that Outdoor Resin Insulators using a resin of this type have been put into trial service on transmission lines of some utilities in USA, but unfortunately within a year tracking occurred on the resin surface of some of these specimens.

Tracking is related to the "mobility" of electron and its characteristics vary according to the quantity of benzene nucleus and to the number of conjugate double bonds.

Our recent research revealed that for lack of benzene nucleus as shown in (4) formula, some formulation of cycloaliphatic type resin has excellent weatherability and anti-tracking characteristics, which make it feasible for outdoor use.





NGK INSULATORS, LTD.

MIZUHO, NAGOYA, JAPAN

April 26, 1974

To: LOCKE INSULATORS, INC.

MEMORANDUM

Sub.: Anti-tracking property of silicone insulators

It is reported in the brochure from the manufacturer that a RODURFLEX-insulator composed of a FRP core and silicone rubber sheds has good anti-contamination performance because of its water-repellency, slenderness and long surface creepage distance. We have no firsthand information nor test data in our laboratory to evaluate these claims by the manufacturer.

In relation with the anti-contamination performance, tracking resistivity is also very important particularly for outdoor insulators made of synthetic materials especially when they are used under severely contaminated environment. According to our test results, tracking resistivity of silicone rubber was inferior to that of cycloaliphatic epoxy resin and polytetrafluorethylene (P.T.F.E). Refer to Technical Note TN-74012 attached.

At the present moment, NGK is focussing our development efforts on cycloaliphatic epoxy resin insulators and P.T.F.E. insulators though silicone rubber remains one of our objects of research and development.

Highest leakage current impulse as criterion for the
insulation performance of polluted insulators

M. P. Verma ⁺

Pollution conditions are more or less inherent for outdoor insulation and lead to the development of conductivity on the surface of an insulator. This gives rise to thermal processes resulting into discharges which reduce the insulation strength. The insulation strength can be reduced to such an extent that a pollution flashover at the line-to-ground voltage becomes feasible. Fig. 1 shows a pollution flashover of an insulator.

To estimate the insulation strength of insulators under pollution in service, usually the limiting characteristic "Flashover voltage as a function of the degree of pollution" is determined in the laboratory (Fig. 2). The degree of pollution is expressed, according to the test procedure applied, in g/l for the case of salt fog test, in surface conductivity μS for the case of solid layer test procedure and in specific deposit mg/cm^2 for the Japanese procedure. These values represent, however, the static degree of pollution (without test voltage). The dynamic value of the degree of pollution occurring during a pollution test can not be directly determined. The relation between the static and the dynamic values of the degree of pollution depends on the procedure used. Hence, the characteristics differ from each other correspondingly. These differences have led to many thoughts and discussions on the suitability and the correspondence of the existing test procedures with respect to the various natural pollution conditions.

⁺ Dr.-Ing. M. P. Verma is Head of the Insulator Department of the Forschungsgemeinschaft für Hochspannungs- und Hochstromtechnik e. V., Mannheim-Rheinau.

Composite Longrod Insulators for Transmission Lines

Dr. M. P. Verma
Forschungsgemeinschaft für Hochspannungs-
und Hochstromtechnik e. V.
Mannheim, Germany

Paper for
IEEE WG, Winter Power Meeting, New York 1977

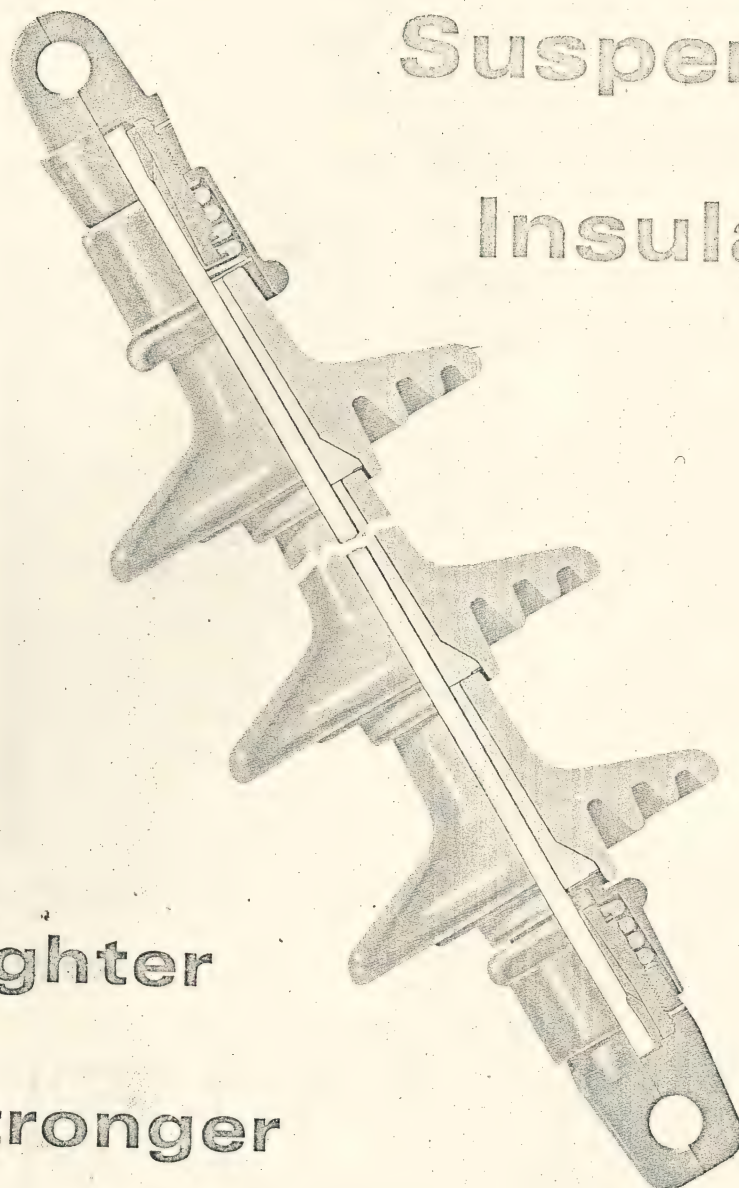
Introduction

A composite longrod insulator offers many advantages as compared with the conventional porcelain longrod and porcelain and glass cap-and-pin insulators /1/. The composite longrod insulator, however, also presents new problems leading finally to the question of life-time of insulators in service. A few types have been developed using different constructional details and synthetic materials covering a glass-fibre-resin rod, the latter being in common to all types /2/. Before the question of regular use of these insulators in transmission lines is decided, the laboratory tests must be defined and specified. From the point of view of such an insulator, the tests should cover the materials used and also the final insulator with specific reference to its construction. With respect to the stresses experienced by the insulators in service, some of these can be very different depending on the climatic and environmental conditions of the site or the country of use. The following view points must therefore be kept in mind while dealing with the question of test specifications.

Unitary

Suspension

Insulator



- **Lighter**
- **Stronger**

CATALOG 302-69

Utility preferred products by
JOSLYN
Mfg. and Supply Co.
PINCO DIVISION

Survey of new insulation methods

Companies reveal their operating experiences with new plastic and fiberglass line insulators

By Merlin F. Wadsworth, Senior Transmission Engineer, Tampa Electric Co., Tampa, Fla.

◆ As the pressures continue to increase on the utilities to beautify or go underground with transmission lines, new techniques of insulation have been appearing on the market in recent years. Hopefully, these methods will successfully meet the criteria of being eye appealing while still maintaining the reliability of the more proven methods. This paper is a summary of the success or failure of some of the new methods as reported in a survey.

The information for this survey was compiled from answers to a questionnaire which was sent to all of the 24 members of the Southeastern Electric Exchange, Transmission and Large Substation Section. Several questions were asked dealing with the use of new methods of insulation at the transmission voltage levels. Twenty-three of the companies responded, and of these, 17 had used plastic or fiberglass insulation for transmission lines.

Experimental and standard

The installations by these companies were both on an experimental basis and as a standard of construction. The two major types of insulation reported on were the epoxy-type polymer insulator and the epoxy-fiberglass rod in series with porcelain or toughened glass insulators. One company reported an installation using the epoxy-type polymer in series with porcelain. The 17 companies that used these new methods of insulation reported on 32 different installations; of these

32, 16 were considered to have successful operating records and 16 had unsuccessful operating records.

No attempt is made to discuss the relative merits of each type of insulation nor is any inference made from the answers received on the questionnaire. The information is factually reported in a summary of the results in the following paragraphs.

Epoxy-type polymer

Out of the 12 installations of the epoxy-type polymer insulator, 11 had unsuccessful operating records. The one company which reported no trouble to date had 3 units installed in the horizontal deadend position. These units have been in service for 5 years. These 12 installations consisted of a total of 496 units, 420 of which were installed by one company. The other installations were in small quantities on an experimental basis only. These companies, all 10 of which reported problems with these units, have removed from service all of the units on their systems. The company which had 420 units installed, has removed all suspension units and retained 222 units in service in strain strings on which they had no problems. This is consistent with the problems which arose on all installations.

The majority of the units causing problems were installed in the vertical suspension position. The major problem was surface tracking. The tracking caused carbonization of the units which gradually increased to the point of flashover or puncture of the skirts on the unit. Eight of the

11 installations were credited with causing one or more outages.

Many of the units were installed in contaminated areas and the life of those which failed was dependent on the amount of contamination. The fact that the horizontal units performed better than those in suspension, seems to support the theory that insulators in horizontal strings perform better in contaminated areas than do those in vertical strings. The life ranged from several months to 6 years for those units which failed; the mean life approximated 2 years. The operating voltages of the installations were 69 kV, 115 kV, and 138 kV.

Epoxy-fiberglass rod

The other major category of plastic and fiberglass insulation reported on by the companies answering the survey was the epoxy-fiberglass rod in series with porcelain or toughened glass insulators. The voltage range of these installations was from 23 kV to 230 kV.

There were 20 different installations of this type of insulation; four of these had unsuccessful operating records and 15 were reported to be operating satisfactorily. One installation included in the table of unsuccessful operations was not having problems but was included in that table because the units had been removed from service and the reporting company did not plan to use this type of unit in the future.

The four installations having problems consisted of a total of 1454 units installed at voltages of 69 kV, 115 kV and 138 kV. The

(Continued on page 99)

CHARACTERISTICS OF FIBERGLASS AND
POLYMER INSULATION

Edward S. Wheeler
Manager-Engineering
Insulator Products Dept.
General Electric Company
Baltimore, Maryland

A Paper Presented at the
Southeastern Electric Exchange
April, 1971 Meeting
Jung Hotel
New Orleans, Louisiana

A COMPARISON OF GENERAL ELECTRIC'S GEPOL INSULATOR AND A. B. CHANCE'S EPOXILATOR

INTRODUCTION

Following a 13 year development program on plastic insulators for outdoor use at high voltages, the General Electric Company introduced its 15 KV Gepol strain insulator in February 1967. It was the first commercially available plastic outdoor insulator in the world; more than 60,000 were ^{shipped} sold to about 400 utilities ^{during} the next 3-1/2 years. Subsequent to introduction there were two changes made, in 1968.

In mid-1970 the A. B. Chance Company announced the commercial availability of a 15 KV plastic strain insulator, which it named the Epoxilator. The outward appearance of the product is very similar to the first version of the 15 KV Gepol.

By late 1970 we were able to obtain published characteristics of the Epoxilator, as well as commercially purchased units for test. Our planned test program covered mechanical, electrical, analytical, and other physical characteristics, based upon the applicable standards for porcelain distribution insulators as well as properties we have found pertinent to plastic insulators.

PUBLISHED CHARACTERISTICS

The published characteristics for strain 15 KV Gepol insulators, Epoxilators, and code requirements are shown in Table I.

TABLE I

PUBLISHED CHARACTERISTICS

Property	Required for 15 KV System	General Electric GEPOL	A.B. Chance EPOXILATOR
Catalog Number		10P012	C654-0000
MEE, ^{l.e.} Lbs.		10,000	10,000
Test, Lbs.		5,000	5,000
Leakage, Distance, In.	12	14	--
60 Hz Flashover, Dry, KV	80	100	100
60 Hz Flashover, Wet, KV	45	75	75
Impulse Flashover, Positive, KV	130	150	140
Impulse Flashover, Negative, KV	155	175	180
60 Hz Positive, KV	115	150	--
RIV @ 15 KV, 1M Hz, ^{HV} Max.	100	50	--
Net Weight, ^{l.e.} lbs.		3-1/4	1-3/4

GEPOL Insulators:
New Levels of Performance,
Electrically and Mechanically

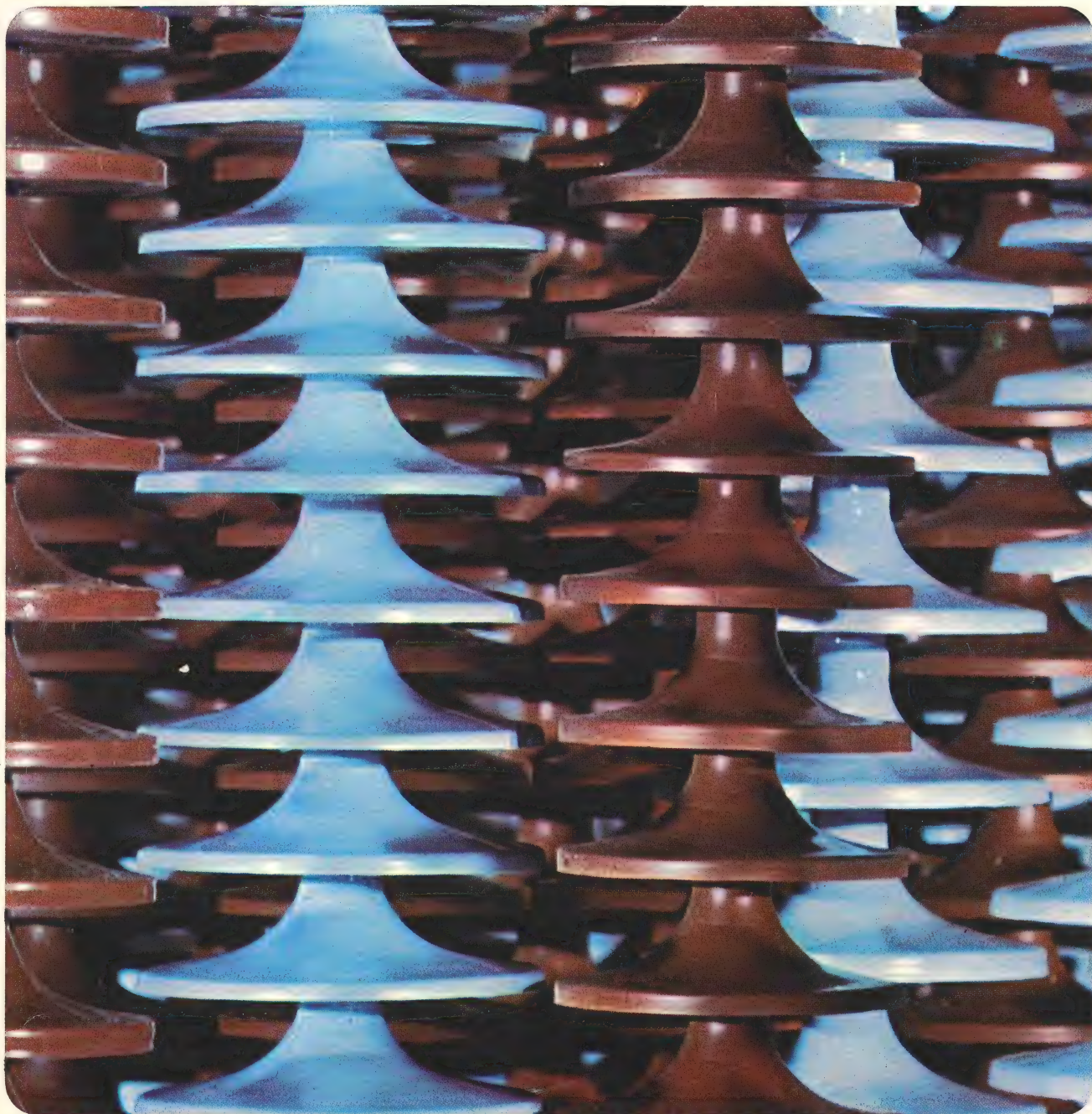
F. C. Vose, Mgr.—Polymer Insulator Engineering Insulator Products Dept., Baltimore, Md.

**Rosenthal
Stemag
Technische
Keramik AG**

Werksgruppe I Selb

**RODURFLEX-
Kunststoffisolatoren
für Freileitungen**

**RODURFLEX Plastics
Insulators for Overhead
Transmission Lines**



A NON-PORCELAIN INSULATOR FOR TOMORROW'S CONSTRUCTION

Recent Materials Developments Make Lightweight Transmission Insulators Feasible

By

J. W. Elrod, EHV Application Engineer

H. G. Menzel, Marketing Manager

The Ohio Brass Company

INTRODUCTION - THE NEED

When the first 765-kv transmission lines were constructed the total weight of the insulator system became a significant factor in the mechanical design of the supporting structures. A quad-bundle tangent tower commonly used close to two tons of insulators. A deadend tower often used eight to nine tons of porcelain along with multi-string connecting hardware.

The next transmission level of approximately 1100-1200-kv can easily require six to eight tons of insulators and hardware per tangent tower. This dead weight required to support a multi-conductor UHV system is costly to install, expensive to support and introduces construction and maintenance problems.

Porcelain is now and has been for decades the accepted standard for high voltage insulation. The weight-to-strength ratio of porcelain was entirely satisfactory at lower transmission voltage levels. When the EHV level became a reality, a serious review was made of the multiple strings and the resulting strength-to-weight ratio requirements. This study clearly indicated that lighter weight and less complicated conductor support systems were not only desirable but were necessary for UHV construction.

Electrical insulation for overhead lines is provided by the surrounding air. The insulators maintain the necessary air flashover distance. The electrical function of an insulator is fulfilled if it does not become conducting under any conditions.

R. Waller

*Note "X" on next to last page.
This will be a very sticky area*

*For us.
BKR 10/9*

October 1st, 1975.

IREQ

Institut de recherche
de l'Hydro-Québec
1800, montée Sainte-Julie
Varenes, Québec, Canada

Members

WG on Testing and Application of Non-Ceramic Insulators

Gentlemen:

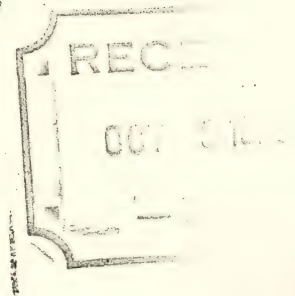
I am enclosing a draft of the minutes of our recent meeting. It is important that any errors or omissions should be reported to me within 3 weeks of receipt of the draft.

Yours sincerely,

G. Karady

DR. G. KARADY
Chairman of the WG

(encl)





NGK INSULATORS, LTD.

MAIN OFFICE
CABLE : NGKINSULATOR
NAGOYA
TELEX : NGK J59928

TOKYO OFFICE
NO. 20 MORI BLDG.
NISHISHINBASHI 2-CHOME
MINATOKU, TOKYO, JAPAN
CABLE : NGKINSULATOR
TOKYO
TELEX : NGKTOK J24250

MIZUHO, NAGOYA, JAPAN.

December 17, 1975

Mr. B.E. Kingsbury
Vice President-Engineering
LOCKE INSULATORS, INC.
2525 Insulator Drive
Baltimore, Maryland 21230
U.S.A.

Dear Bruce:

Subject: Non-Ceramic Insulators W.G.

Thank you for your letter of October 13, 1975 which enclosed the minutes of the two IEEE Working Groups on Non-Ceramic Insulators and Contamination.

Non-ceramic (polymer) outdoor insulators have long been the subject of top importance in our research and development programs. As you are well aware, the work covers a very wide range of study and requires patient tests and trials of many years. We have not yet reached any conclusive results on materials, designs or test methods to be applied to the polymer outdoor insulators.

I will try my best to outline for you our thinking and works presently underway on these insulators.

1. We think that the prospect of these insulators exists in two different areas of application. The one is the application where a very high mechanical strength is required, because of its easiness to attain such a strength with comparatively light weight. The other relates to a special structural application, taking an advantage of its easiness to design long structural members of small diameter, light weight and high strength.
2. The long term reliability, life and cost are the decisive factors in evaluating these insulators. At present, no one expects that these insulators has a perpetual life a life equivalent to that of existing ceramic insulators. Also, the environmental and application conditions are far more influential in the life of these

POLYMERIC INSULATORS

MR. R. WELLER
LOCKE INSULATORS
2525 INSULATOR DRIVE
BALTIMORE, MD 21230



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Dr.-Ing. Ewald A. Bauer

c/o.

Rosenthal
technik

rosenthal technik ag • 8672 selb • postfach 1508

To All Members of
WG on Non-Ceramic and
Composite Insulators for
Transmission Lines

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vorsitzender des aufsichtsrats:
philip rosenthal
vorstand:
heinz greiffenberger
oskar eckert

ihr zeichen

ihre nachricht

unser zeichen

M-Dr.Ba/Kb

direktwahl

09287/76- 370

datum

29th June, 1976

Re : Mechanical Rating of Non-Ceramic Composite Longrod Insulators

Gentleman :

/ Enclosed please find a Paper "A Contribution Regarding Mechanical Rating of Non-Ceramic Composite Longrod Insulators".

This paper will be discussed on the occasion of the Portland Meeting on 19th July, 1976, as decided during our Winter Meeting.

Very truly yours,

En



SUSPENSION INSULATORS

Hi*Lite published mechanical values inaugurate a new system of strength ratings stated as MAXIMUM DESIGN TENSION. The insulator may be worked at any mechanical load up to the maximum design tension shown below and on the nameplate.

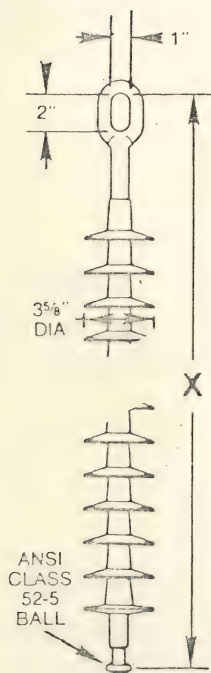


Figure 1
10,000 Lbs.
Maximum
Design
Tension
Rod DIA $\frac{5}{8}$

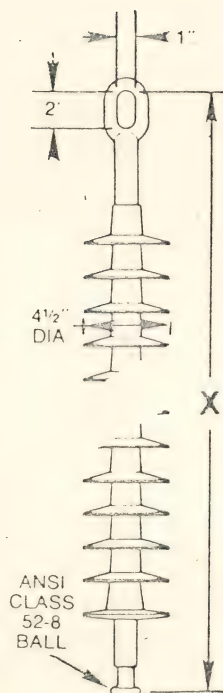


Figure 2
20,000 Lbs.
Maximum
Design
Tension
Rod DIA $\frac{7}{8}$

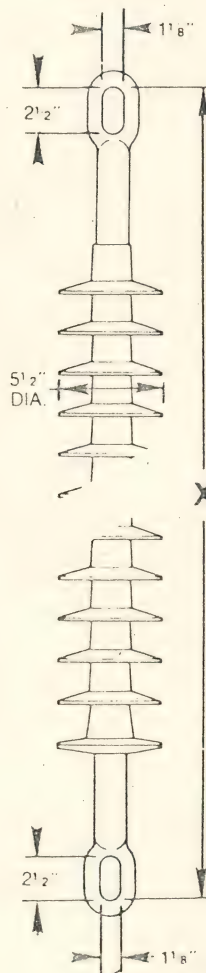


Figure 3
40,000 Lbs.
Maximum
Design
Tension
Rod DIA $1\frac{1}{4}$

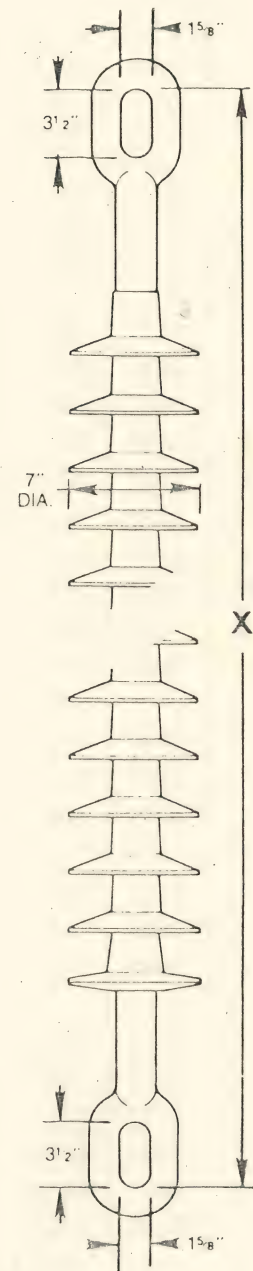


Figure 4
80,000 Lbs.
Maximum
Design
Tension
Rod DIA $1\frac{3}{4}$

NOTE: In Figures 1 and 2, an eye similar to top connection may be substituted for the ball when specified.

MAX DESIGN TENSION $\approx \frac{1}{3}$ UTS OF COMPLETE ASSEMBLY

can be attributed to the measuring-cable changes rather than to components. Solid dielectric cables were less affected by pulses than the composite air-plus-type cable.

Adams¹¹⁰ presented data on the evaluation of insulated wires and cables under simulated space conditions (including the lunar environment). Reduction in weight and size is a primary target of this wire- and cable-development activity. In many applications, signal leads constitute the bulk of the hook-up wire used. AWG #32 copper wire is adequate, based on electrical requirements, but mechanical considerations dictate the use of AWG #24. New alloys of copper with zirconium and cadmium show promise of increasing the durability with little sacrifice in resistance. Another approach to the mechanical strength problem would be to fuse the wires into a monolithic structure as in present flat and contour cables. In general, TFE-insulated wire is best for all-around use in aerospace, but where outgassing or flammability are not problems, irradiated polyethylene could be used.

Klein and Scheiber¹¹¹ calculated the pressure differences for the insulation of an oil-filled pressure cable with fluted sheath, and the results were compared with those in a cable with a smooth sheath.

Erskine, Ricks, and Rudd¹¹² described the experience of the British Electricity Board with plastic-insulated cables for low-voltage distribution. Milne, Bates, and Gorham¹¹³ reported on extensive trials the Electricity Board made on low- and medium-voltage, plastic-insulated-mains cables and on the limited trials with high-voltage, plastic-insulated-mains cables. Some of the methods used in the application of accessories were tried to simplify jointing procedure.

Stutz¹¹⁴ discussed the replacement of cable-distribution-steel cabinets by reinforced-fiber-glass houses.

Neher¹¹⁵ gave several families of curves, developed on a digital computer, which help determine the transient temperature rise of a buried-cable system.

V. Capacitors, Switchgear, and Insulators

Vail¹¹⁶ reviewed the application requirements for dc filter and energy-storage capacitors.

Lengyel and Mitra¹¹⁷ measured the electrical conductivity of thin, oil-impregnated, paper-insulated capacitors at high-electric fields as a function of temperature and voltage. They developed a theory which gave the approximate determination of the mobility of the charge carriers, assuming that the dominant part of the conduction in the oil takes place by means of ions.

Wehe and McMahon¹¹⁸ described the development of a low-loss, polycarbonate-stripped-film capacitor. Its advantages are that it has low loss, approaching polystyrene, but is much smaller in size, and less sensitive to temperature, with an operating range between at least -78° and 125°C. The capacitors are "self-healing" and have long life under adverse conditions of temperature and voltage. An example of the size of one such hermetically sealed capacitor is .075 cubic inches in volume and 1/10 oz. in weight.

Johnston¹¹⁹ related the experience of an explosion of flammable gases which occurred in August 1962 in a 161-kv oil circuit-breaker at the Oak Ridge gaseous-diffusion plant. He cites this as an example of flammable gases which might be produced by the decomposition of solid insulation and insulating oil as a result of faults in electrical equipment.

Kane and Colclaser¹²⁰ described a single-tank circuit-breaker, using SF₆ as the interrupting medium, and listed the test procedures used in life testing, voltage testing, and interruption testing.

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volta
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R&D Industry Developments

Test Proves Silicone Okay For HVDC Insulators

The Los Angeles Department of Water and Power has been testing a silicone compound on its HVDC transmission line. The tower for the test is about one mile from the Sylmar Converter Station and part of the 845-mile-long Pacific Intertie HVDC transmission line.

Although Sylmar is not considered an area of heavy contamination the insulators of the HVDC line collect

particles and become dirty faster than the insulators on the comparable ac transmission lines. The particulate problem is aggravated by fog or nightly moisture condensation which makes the pollutant-soluble particles conductive and allows a leakage current over the insulator strings.

It is believed that some of the particulates are organic pollutants

from vehicle exhausts on nearby freeways and that smog carries other pollutants from industrial facilities that are up to 60 miles away.

The Department tests were to de-

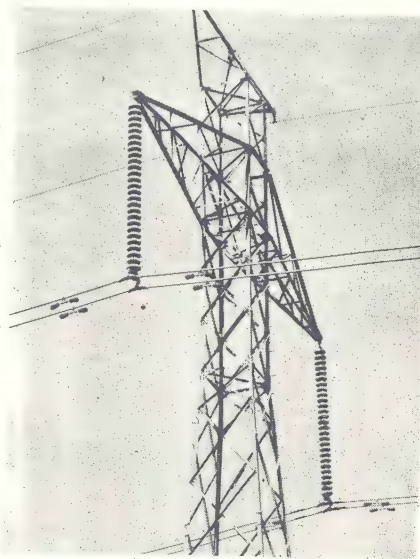
Synthetic Insulators Used on 735-kv Line

Hydro-Quebec recently installed 240 synthetic insulators on 40 of the towers on the 735-kv transmission line between Laurentides and Levis substations, near Quebec City.

Using these new insulators on a transmission line exposed to severe weather marks the final phase of a test program undertaken in 1973. In the coming year, the utility expects to verify advantages of the new insulators ascertained in the laboratory.

The synthetic insulator is made of a fiber-glass rod encased in polymer

to form a single unit. The synthetic insulators are said to weigh less than porcelain insulators and possess superior mechanical and electrical characteristics. For example, the equivalent synthetic insulation for two strings of conventional insulators weighing 548 kilograms is a single unit weighing only 32 kilograms. The new insulators also provide equal mechanical strength and cost less. A single unit of synthetic insulators has a diameter of only 13 centimeters, compared with 30 centimeters for each string of insulators.



A 60-day insulator wash schedule is used on this tower in the 15-mile section of HVDC transmission line in Sylmar. Los Angeles Department of Water and Power selected the tower for long-term tests of silicone-coated insulator strings.

termine the approximate length of time that the compound could be expected to prevent insulator flash-over.

Dow Corning 3099 high voltage insulator compound was hand-applied in a nominal $\frac{1}{8}$ - to $\frac{1}{4}$ -inch thickness on glazed porcelain suspension insulators in each of two strings.

After a 3-year test period, the high voltage silicone insulator compound had successfully protected the HVDC insulators from flashover. The compound was still hydrophobic, i.e., water would still bead up on its surface, but the compound had developed on the top side of the insulators a firm surface layer which no longer encapsulated atmospheric particles.

A major factor still to be determined is the difference in cost between washing the insulator strings every 60 days and the cost of applying the silicone compound to each of the strings.



On Hydro-Quebec's 735-kv transmission lines a single element synthetic insulator weighing only 32 kilograms may replace two-string porcelain insulators (right) weighing 548 kilograms.

April 1, 1971

CC: Manager-Manufacturing
Manager-Quality Control
Manager-Planning

Dear Sirs:

In reference to the ultimate goal of improving the operation and output of the GB-4 glaze machine, we have checked the glaze thickness of fifty Magnavalves -- twenty-five pieces picked at random from two cars dated March 15, 1971 and March 22, 1971 respectively. Four areas on each piece were checked using our newly acquired Hand Optical Reticle Comparitor. From the data generated, a computer program was written. The results of this program indicate that the GB-4 machine is capable of maintaining a glaze thickness within statistical limits. Of the four areas checked, only one failed to stay within statistical limits.

Now that we have tentatively proven the capability of the machine, the one area that shifted makes it apparent that there are some functions requiring more study before MSNs covering corrective action by the operator can be written. The data indicates that one or more of the glaze guns covering the top area of the Magnavalve either physically shifted in direction, or the rate of flow of glaze in these same guns changed. Insofar as the gun fixtures are concerned, I recommend that adjustments in elevation and transverse motion be made, to be fixed in direction after optimum position is determined. A number of things could cause the rate of flow of glaze to change, such as:

1. Gun stopped up by
 - a. particles of hard glaze
 - b. pieces of foreign material

April 1, 1971

CC: Manager-Manufacturing
Manager-Quality Control
Manager-Planning

Dear Sirs:

In reference to the ultimate goal of improving the operation and output of the GB-4 glaze machine, we have checked the glaze thickness of fifty Magnavalves -- twenty-five pieces picked at random from two cars dated March 15, 1971 and March 22, 1971 respectively. Four areas on each piece were checked using our newly acquired Hand Optical Reticle Comparitor. From the data generated, a computer program was written. The results of this program indicate that the GB-4 machine is capable of maintaining a glaze thickness within statistical limits. Of the four areas checked, only one failed to stay within statistical limits.

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1. Gun stopped up by
 - a. particles of hard glaze
 - b. pieces of foreign material

Transactions Paper

(Reviewed and Accepted for Publication)



THE LIGHTNING STROKE - II

C. F. Wagner
Fellow AIEE

A. R. Hileman
Member AIEE

Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE South East-South Central District Meeting, New Orleans, La., April 5-7, 1961. Manuscript submitted January 9, 1961; made available for printing March 3, 1961.

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Paper No.

61-488

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H. A. EREY

DATA FOLDER No. 53849

Subject STEEP FRONT IM PULSE TESTS WITH
SERIES INDUCTANCE IN PLACE OF SERIES
RESISTANCE

Issued by HIGH VOLTAGE ENGR. Date FEB. 7, 1949
LAB. PITTSFIELD WORKS
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Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 13, 1970.



TRANSIENT IMPEDANCE OF HIGH VOLTAGE IMPULSE GENERATING SYSTEMS

F. C. Creed
Senior Member IEEE

M. M. C. Collins
Member IEEE

Both of:
National Research Council of Canada
Radio & Electrical Engineering Div.
Ottawa, Ontario, Canada.

A paper recommended by the IEEE Power System Instrumentation and Measurements Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 25-30, 1970. Manuscript submitted September 12, 1969; made available for printing November 3, 1969.

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Paper No.

70 TP 27 - PWR

Transactions Paper

(Reviewed and Accepted for Publication)

*Impulse
Measurement*



MEASUREMENTS OF STEEP-FRONT IMPULSE WAVES WITH AN ISOLATED SCREEN ROOM INSTALLATION

C. J. Miller, Jr.
Fellow AIEE

J. F. Wittibschlager
Associate Member AIEE

Both of:
The Ohio Brass Co.
Barberton, Ohio

A paper recommended by the AIEE Special Instruments and Auxiliary Apparatus Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 15, 1957; made available for printing October 29, 1957.

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58-18

Discussion in Duplicate Due February 19, 1958.

November 1953
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Discussion for publication

must be postmarked on or before

February 3, 1954.

*Mr. V. ...
" Kengsbury*

VOLTAGE DIVIDER FOR MEASURING IMPULSE VOLTAGES ON TRANSMISSION LINES

S. B. Griscom
Fellow AIEE

B. L. Lloyd
Associate Member AIEE

A. R. Hileman
Associate Member AIEE

All of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

Advance Copy
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Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 19, 1971.



FIRING AND VOLTAGE SHAPE OF MULTISTAGE IMPULSE GENERATORS

F. W. Heilbronner
Hochspannungsinstitut, Technical University
Munich, Germany

A paper recommended by the IEEE Power System Instrumentation & Measurements Committee of the IEEE Power Engineering Society for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 31-February 5, 1971. Manuscript submitted September 15, 1970; made available for printing December 8, 1970.

Price: \$1.35
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Paper No.

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Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 19, 1971.



SHAPING CIRCUITS FOR HIGH VOLTAGE IMPULSES

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Senior Member IEEE

M. M. C. Collins
Member IEEE

Both of:
National Research Council of Canada
Radio & Electrical Engineering Division
Ottawa, Ont., Canada.

A paper recommended by the IEEE Power System Instrumentation & Measurements Committee of the IEEE Power Engineering Society for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 31-February 5, 1971. Manuscript submitted September 16, 1970; made available for printing November 25, 1970.

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Transactions Paper

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DISCUSSION IN QUADRUPLICATE DUE February 19, 1971.



BREAKDOWN CHARACTERISTICS OF A SPHERE-PLATE TRIGGERED AIR SPARK-GAP

B. C. Papadias
Member IEEE
Athens National Technical University
Athens, Greece

A paper recommended by the IEEE Power System Instrumentation & Measurements Committee of the IEEE Power Engineering Society for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 31-February 5, 1971. Manuscript submitted September 16, 1970; made available for printing December 11, 1970.

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Paper No.

71 TP 125 - PWR

INSULATOR DEPARTMENT
GENERAL ELECTRIC COMPANY
Baltimore, Maryland

Technical Report No. 645-DR
May 20, 1958.

SUBJECT

Suspension and Switch Insulator Electrical Data
And
Miscellaneous Electrical Information

This report contains:

List of Tables
List of Figures
Appendices
24 Typewritten Pages.
34 Curves

Signed

B. E. Kingbury

Approved

Fred C. Vase

A CONSIDERATION OF THE RADIO-FREQUENCY
VOLTAGES ENCOUNTERED BY THE INSULATING
MATERIAL OF BROADCAST TOWER ANTENNAS

BY

GEORGE H. BROWN

Reprinted from Proceedings of the I.R.E.
Vol. 27, No. 9, September, 1939.

PRINTED IN THE U.S.A.

To R. L. McLoe
Courtesy
A. H. Buchanan
10/

GENERAL ELECTRIC

ELECTRONICS DEPARTMENT

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR M. E. Gurtin	SUBJECT CLASSIFICATION Shock and Vibration	NO. R57EML38 DATE 31 Dec. 1957
TITLE Procedure for Running Shock and Vibration Tests		
ABSTRACT This report outlines general procedures which will assist the environmental engineer in running vibration and shock tests. A study is made of proper jig design, and proper instrumentation and calibration procedures.		
G.E. CLASS 1	REPRODUCIBLE COPY FILED AT Technical Information Center LMEE Department P. O. Box 459, Utica, N. Y.	NO. PAGES ii + 28
GOV. CLASS. Unclassified		
CONCLUSIONS		

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents—drawings, photos, etc. and for distribution see next page (AO-147-A).

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DIVISIONS LMEE Department LOCATION French Road, Utica, New York

TECHNICAL INFORMATION

**SHORT-CIRCUIT CURRENTS IN LOW AND MEDIUM
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ENGINEERING APPLICATION DATA

INDUSTRIAL ENGINEERING DIVISIONS

GENERAL  ELECTRIC

MECHANICAL STRESSES IN BUSBAR SUPPORTS DURING SHORT CIRCUITS

by

O. R. Schurig

M. F. Sayre

Presented at Midwinter Convention of the AIEE - New York, NY
February 9-12, 1925

MECHANICAL STRESSES IN BUSBAR SUPPORTS
DURING SHORT CIRCUITS

By

O. R. SCHURIG

and

M. F. SAYRE

1925

NATURAL FREQUENCIES OF INSULATOR_MOUNTED BUS BARS

H. PORITSKY

H.D. SNIVELY

1939

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SHORT CIRCUITS

O.R. SCHURIG

and

M.F. SAYRE

1925

EQUIVALENT ELECTRICAL AND MECHANICAL DOUBLE FREQUENCY SYSTEMS
WITH SPECIAL APPLICATION TO SHORT CIRCUIT STRESSES IN SIMPLE
DUE STRUCTURES

by

E. W. Boehne
General Electric Co - Philadelphia, PA

1925

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BEHAVIOR OF HIGH VOLTAGE BUSSES AND
INSULATORS DURING SHORT CIRCUITS

R. M. Milton Fred Chambers

1954

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PRELIMINARY REPORT ON
CALCULATION OF LATERAL STRESSES
IN HIGH TENSION BUS INSULATORS DURING
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APPARATUS

FOR

PRELIMINARY REPORT ON
CALCULATION OF LATERAL STRESSES
IN HIGH TENSION BUS INSULATORS DURING
SHORT CIRCUITS

Information Prepared By: Electric Utility Engineering
C. G. Adams
R. A. Schmidt
J. I. Whittlesey

Date: March 4, 1955

APPARATUS DEPARTMENT
GENERAL  ELECTRIC
C O M P A N Y

Conference Paper



SAG AND TENSION CALCULATIONS BY THE NOMOGRAPHIC METHOD

Robert H. Sarikas
Member AIEE
Illinois Power Company
Decatur, Ill.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 28-February 2, 1962. Manuscript submitted October 30, 1961; made available for printing December 20, 1961.

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Paper No. **CP**

62-107

Transactions Paper

(Reviewed and Accepted for Publication)



PHASE-TO-PHASE SWITCHING SURGES ON LINE ENERGIZATION

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R. F. Silva
Associate Member AIEE
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Storrs, Conn.

D. D. Wilson
Associate Member AIEE
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R. F. Silva was formerly with the General Electric Company.

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Transactions Paper

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SWITCHING SURGE AND DYNAMIC VOLTAGE STUDY OF ARIZONA PUBLIC SERVICE COMPANY 345 KV PROPOSED TRANSMISSION SYSTEM UTILIZING MINIATURE ANALYZER TECHNIQUES

W. H. Croft
Member AIEE
Arizona Pub. Service Co.
Phoenix, Ariz.

R. H. Hartley
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Associate Member AIEE
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Schenectady, N. Y.

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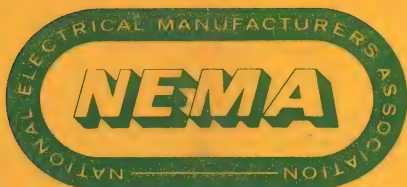
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STANDARDS PUBLICATION

HIGH-VOLTAGE INSULATORS

ENGINEERING LABORATORY

Plastics

EPOXY RESIN DEVELOPMENTS AND APPLICATIONS
IN PETERBOROUGH WORKS

BY

DQF58AD-7

R.W. PARNELL

28 FEBRUARY 1958

CANADIAN GENERAL ELECTRIC COMPANY LIMITED

APPARATUS DEPARTMENT

The A, B, C of QUALITY CONTROL

By J. M. JURAN

ASSISTANT TO THE ADMINISTRATOR, FOREIGN ECONOMIC ADMINISTRATION, WASHINGTON, D. C. MEMBER A.S.M.E.

MANUFACTURE begins with a specification of the product to be made. This specification is a piece of industrial legislation, drafted by the design engineers, who are the legislators of the industrial world. The making of products to conform to this legislation is the joint responsibility of the manufacturing engineers and factory personnel who collectively constitute the executive branch of the industrial world. The inspectors perform the judicial function of the industrial world. They compare the product with the specifications to see whether there is conformance. The cycle is completed when the inspection data are used by the design engineers for design modification.

While these three functions of specification, operation, and inspection are clearly separable, they must be co-ordinated if the conformance of product with specification is to be achieved at minimum cost. Conformance of product with specification can be achieved even when functional lines are too tightly drawn. However, overfunctionalization increases the cost of securing conformance. Only through co-ordination of these three functions can minimum cost of conformance be achieved.

THE INSPECTION ACT AND THE PURPOSES OF INSPECTION

The management tool which we have come to know as "quality control" can make an important contribution toward achieving this co-ordination between specification, operation, and inspection. But what do we mean by inspection? Actually there are four different purposes which can be served by what we call "inspection." Yet the steps followed by the inspector "at the bench" are basically unvarying, no matter what the purpose of the inspection he performs. In all cases, the inspector functions as follows: (a) Interprets the specification; (b) measures the product; (c) compares the product with the specification; (d) judges conformance; (e) disposes of the product; (f) records the resultant data. This series of steps we shall call the "inspection act."

While the inspection act is fundamental to all inspection, the purposes served by inspection can be classified into four basic groups:

Acceptance Sampling. This is an inspection on a sampling basis to distinguish acceptable lots of product from non-acceptable lots. Acceptance sampling has for its primary purpose the grading of lots of product. The data obtained are incidental, but can often be put to effective use.

Control Sampling. This is an inspection on a sampling basis, for the purpose of securing data for exercising control. Sampling to regulate the manufacturing process, to rate quality of product, to rate quality performance of operators, or to measure accuracy of inspectors are all instances of control sampling.

¹ Derived from "Control Sampling," chapter 6 of "Management of Inspection and Quality Control," by J. M. Juran, to be published by Harper & Bros., New York, N. Y., in the fall of 1944. For other chapters from this book see "Management Problems of Measurement in the Inspection Function," *Advanced Management*, July-Sept., 1943, pp. 86-91, 103; and "Management Problems in Judging Quality Conformance in the Inspection Function," *MECHANICAL ENGINEERING*, vol. 63, 1943, pp. 805-808.

Contributed by the Management Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19-22, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Here the purpose of the inspection act is to obtain data which can form the basis of management control. Any grading or sorting of product is incidental.

Operational Sorting. This is a manufacturing operation which has the outward appearance of a detail inspection. The purpose is to sort good pieces from bad. The necessity for the sorting arises from the fact that the manufacturing process delivers defective pieces to an extent too great to permit acceptance on a sampling basis. The question of good or poor performance on the part of the operators is not present. For example, the final performance test of a transformer or a generator is an operational sorting. The various operators cannot know whether their collective efforts have resulted in a finished product which meets the tests.

Corrective Sorting. This is also a sorting of the product but arises from the fact that through failure on the part of the operators the product contains defects to an extent too great for acceptance on a sampling basis. For example, a detail inspection for adjustment is necessary only if the operators fail to adjust properly. In such cases the operators are equipped with a full complement of gages, and so forth. They must themselves test to see whether the product is adjusted, for without such test they do not know when to stop adjusting.

Corrective sorting is, for the most part, a "needless" loss. In many shops it is confused with operational sorting and permitted to go on year after year. Furthermore, existence of such sorting is a symptom of an even greater loss—the loss of material plus the time to make good the defectives.

HOMOGENEITY THROUGH MIXTURE AND THROUGH COMMON ORIGIN

In mass production the product can be considered as a stream emerging from the creating source. This stream may be a true stream of liquid or gas, or it may be a continuous solid like an extrusion, or it may be a series of discrete pieces. No matter which of these forms the product takes, there are impinging upon each element of the product, at the time of its creation, the numerous variables in the process. The final characteristics of the product are the result of the combined effect of these variables.

In many cases there is close relation between inspection of product in fluid or continuous form and inspection of product in discrete pieces. For example, measurement of a coil of cold-heading wire for diameter presents much the same problem as the subsequent measurement, for diameter, of the screw blanks cut from that coil of wire. The measurement, for thickness, of a load of spring-steel sheets is a problem much like that of measurement, for thickness, of the steel springs punched from those sheets. The coil of wire and the sheet of steel are each, in a sense, a great many pieces all connected together, and requiring an operation to disjoint them into discrete pieces.

It is valid, even when the product is a continuous or disjointed solid, to consider all product as consisting of a stream flowing from the creating origin. The validity of this concept is in the existence of a reservoir or process which can pour out product. The reservoir pouring out the product may contain much of the product during the pouring process, as in the case of a tank car of gasoline, or the reservoir may be empty, but

AIEE

Miscellaneous Paper

49-200

June 1949
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POSTWAR PLANNING FOR HIGH VOLTAGE TRANSMISSION IN NORTHERN CALIFORNIA

W. R. Johnson
Member AIEE
Pacific Gas and Electric Company
San Francisco, Calif.

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November 1950
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Bob McLaughlin

THE 300/315 KV EXTRA HIGH VOLTAGE TRANSMISSION SYSTEM OF THE AMERICAN
GAS AND ELECTRIC COMPANY

Philip Sporn
Fellow AIEE

E. L. Peterson
Member AIEE

I. W. Gross
Fellow AIEE

H. P. St. Clair
Fellow AIEE

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New York, N. Y.

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LOCKE INSULATOR COMPANY
Baltimore

B.E.K.

Technical Report No. 501

Subject

The Analysis of Internal Mechanical
Stresses By An Electrical Analogy

This report contains:

2 Typewritten Pages

Signed

W. T. J. J.

Approved

W. T. J. J.

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Hm

Kingsbury
Vose

Lightning - Theory

Conference Paper



EFFECT OF PREDISCHARGE CURRENTS UPON LINE PERFORMANCE

C. F. Wagner
Fellow AIEE

A. R. Hileman
Member AIEE

Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

Submitted in abstract or outline form only to the AIEE Transmission and Distribution Committee for presentation at the AIEE Summer General Meeting, Denver, Colo., June 17-22, 1962. Manuscript submitted April 11, 1962; made available for printing April 12, 1962.

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Paper No. **CP**

62-1181

Conference Paper



RELATION BETWEEN STROKE CURRENT AND VELOCITY OF THE RETURN STROKE

C. F. Wagner
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Summer General Meeting, Denver, Colo., June 17-22, 1962. Manuscript submitted March 21, 1962; made available for printing April 25, 1962.

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Paper No. **CP**

62-1094

*Lightning
Theory*

Transactions Paper

(Reviewed and Accepted for Publication)



MONTE CARLO COMPUTER CALCULATION OF TRANSMISSION LINE LIGHTNING PERFORMANCE

J. G. Anderson
Member AIEE
General Electric Company
Pittsfield, Mass.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N.Y., January 29-February 3, 1961. Manuscript submitted October 26, 1960; made available for printing November 25, 1960.

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H. A. FREY

Paper No.

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Thury

Transactions Paper

(Reviewed and Accepted for Publication)



A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES --

PART III. A SIMPLIFIED METHOD - STROKE TO TOWER

C. F. Wagner
Fellow AIEE

A. R. Hileman
Member AIEE

Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

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APR 14 1960

H. A. FREY

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE North Eastern District Meeting, Providence, R. I., May 2-4, 1960. Manuscript submitted January 6, 1960; made available for printing March 21, 1960.

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Paper No.

60-658

Discussion in Duplicate Due May 18, 1960.

Transactions Paper

(Reviewed and Accepted for Publication)



A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES - II

Healy

C. F. Wagner
Fellow AIEE

A. R. Hileman
Member AIEE

Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Middle Eastern District Meeting, Baltimore, Md., May 19-21, 1959. Manuscript submitted February 19, 1959; made available for printing March 27, 1959.

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Paper No.

59-644

Discussion in Duplicate Due June 4, 1959.

Thru

Transactions Paper

(Reviewed and Accepted for Publication)



DETERMINATION OF THE WAVE FRONT OF LIGHTNING STROKE CURRENTS FROM FIELD MEASUREMENTS

C. F. Wagner
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

RECEIVED

APR 14 1960

H. A. EREY

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Paper No.

60-657

Discussion in Duplicate Due May 18, 1960.

AIEE CONFERENCE PAPER NO. 59-341

3
Thurcy

DETERMINATION OF LIGHTNING RESPONSE
OF TRANSMISSION LINES BY MEANS OF
GEOMETRICAL MODELS

F.A. Fisher
Associate Member - AIEE

J.G. Anderson
Member - AIEE

J.H. Hagenguth
Fellow - AIEE

January 21, 1959

Technical Report LK-857

VISUAL CORONA AND RIV TESTS

on

(6) 345 KV LINE ASSEMBLIES

Customer: Consumers Power (Mr. D. Bennett-Inspector)

Vendor: Bethea Co., Inc.

Author:

C. H. Matthews

C. H. Matthews
Manager-High Voltage & Mechanical
Laboratory

Approved:

E. S. Wheeler 12/20/67

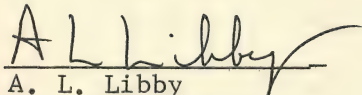
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Manager - Engineering

General Electric Company
Insulator Department
November 20, 1967

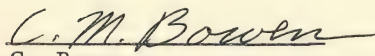
7

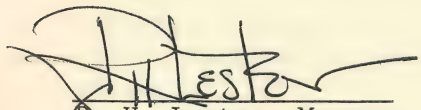
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THERMAL ENDURANCE TESTS
ON
SUSPENSION INSULATORS
FOR
CONEMAUGH PROJECT


A. L. Libby
Product Engineer


R. Weller
Product Engineer


C. Bowen
Baltimore Gas & Electric Co.


R. H. Lester, Manager
Ceramic Insulator Engineering

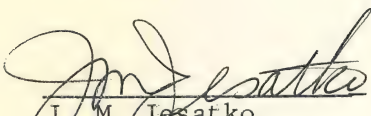
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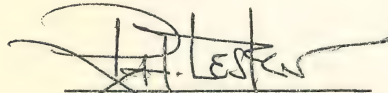
BALTIMORE, MARYLAND
December 2, 1968

TECHNICAL REPORT LK-974-DR
EVALUATION OF 15 KV SWITCH AND BUS INSULATORS

Author:


J. M. Jesatko
Product Engineer

Approved:


R. H. Lester, Manager
Ceramic Insulator Engineering

Distribution:

ES Wheeler
AL Libby
R Weller
CD Croskey

INSULATOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC COMPANY

BALTIMORE, MARYLAND
April 1, 1971

file
Letter
attached

GENERAL ELECTRIC COMPANY

INSULATOR DEPARTMENT

Technical Report No. LK-664-DR

March 8, 1960

SUBJECT

Investigation of Catalog No. 29153
Insulators from Alabama Power Company

R. Weller

This Report Contains:

5 typewritten pages
4 tables
4 figures and photographs

Baltimore, Maryland

Signed

Rene Weller

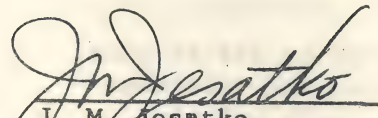
Approved

Fred C. Vasey

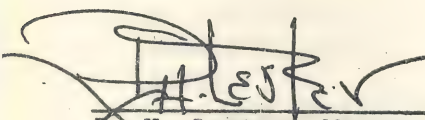
TECHNICAL REPORT LK-970-DR
Supplement #1

DIELECTRIC STRENGTH CHARACTERISTICS
OF CERAMIC COMPOSITIONS

Author:


J. M. Desatko
Product Engineer

Approved:


R. H. Lester, Manager
Ceramic Insulator Engineering

Distribution:

ES Wheeler
TH Dressel
PB Horton
BE Kingsbury
RH Lester
AL Libby
R Weller

File
Test Reports

INSULATOR DEPARTMENT
GENERAL ELECTRIC COMPANY
Baltimore Maryland

TECHNICAL REPORT NO. LK-840

60 CYCLE ARCOVER CURRENT TESTS ON INSULATORS

15 KV GEPOL - Cat. No. 10P012

15 KV Suspension (Porcelain)
Cat. No. 16583-G11
(Two in Series)

Author:

C. H. Matthews

C. H. Matthews, Manager-High
Voltage & Mechanical Lab.

Approved:

E. S. Wheeler

E. S. Wheeler, Manager-Engineering

May 25, 1967

NGK TRIP REPORT

February 21 through 25, 1972

G. R. MacDonald
J. Kelenfy
B. E. Kingsbury

GENERAL  ELECTRIC

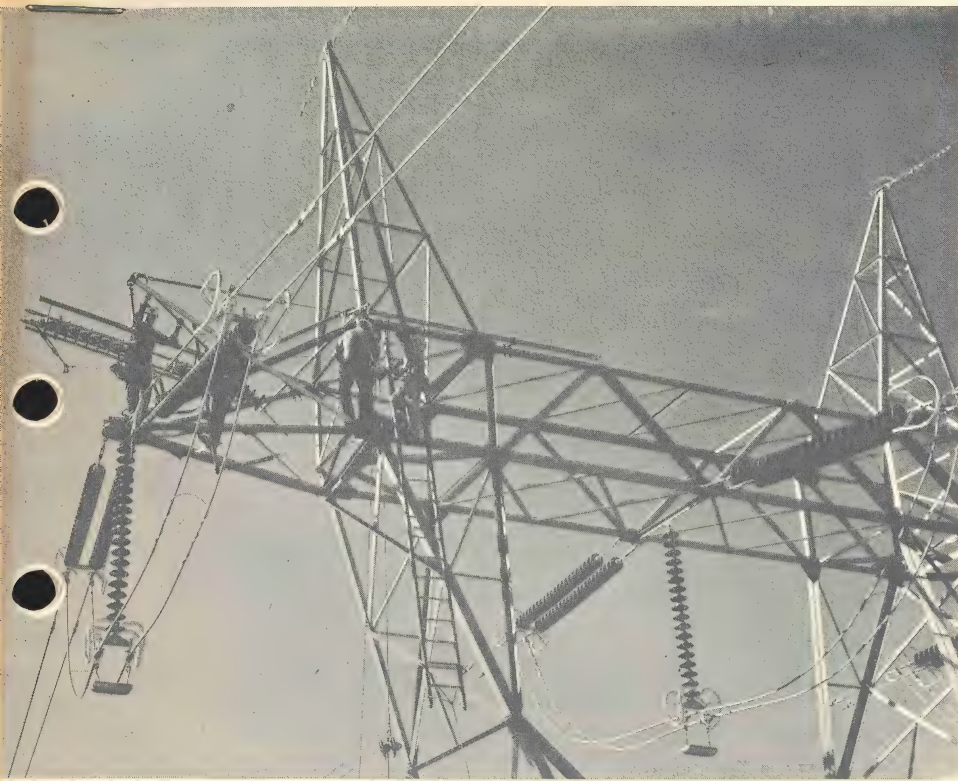
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by

O. G. ANDERSON
A. B. CHANCE COMPANY
Centralia, Missouri

EHV Lines Engineered for Safe-Efficient Maintenance

PEA MEETING

Skytop

Pocono Mts., Pennsylvania

MAY 19, 1967



TRASER

Laser Current Devices For HV & EHV Systems

by

R. F. SWOISH

*Manager - Product Application
Circuit Breakers*

**Allis-Chalmers Boston Plant
Boston, Massachusetts**

Presented before

**PENNSYLVANIA ELECTRIC ASSOCIATION
ELECTRICAL EQUIPMENT COMMITTEE**

**October 14, 1965
York, Pennsylvania**

Not released for publication except by permission of Allis-Chalmers, Technical Press Bureau, Milwaukee, Wis.



THE ELECTRICAL PERFORMANCE OF CERAMIC DIELECTRICS

AT ELEVATED TEMPERATURES

- o o o -

It is well known that the electrical resistance of most of the commonly used insulating materials diminishes with increasing temperature. The actual performance of ceramic insulating materials at temperatures above the normal atmospheric level, and the factors affecting the ultimate breakdown at these temperatures, has not been the subject of much investigation. Recent requirements for insulators to operate at high temperatures and high voltages have indicated the need for such information.

Apparatus and Method.

It was necessary to provide a suitable test chamber in which the specimens could be mounted and held at any desired temperature while voltage was applied. Accordingly, a thermally insulated box or furnace was built. The electrical heating elements in the back of the box were separated from the test chamber by a one inch thick thermally insulating partition in order to prevent direct heating of the specimens by radiant heat. The heated air was circulated by means of a fan thru ports at each end of the test chamber. The fan also served to maintain air turbulence in the test chamber and thus prevent stratification. Temperature measurements were by commercial gas thermometer and automatic controls were provided for holding any desired temperature between minus 100 degrees Fahrenheit and 1000 degrees Fahrenheit. With this arrangement temperatures could be held within five degrees Fahrenheit of the desired level. Provision was also made for removing the heating elements from the back of the box and substituting racks of dry ice in order to obtain low temperatures.

Most of the tests were made with d-c voltage in order to eliminate the difficulty of separating conduction currents from charging currents. The voltage source was a full wave high voltage kenetron rectifier with suitable capacitors for the elimination of the sixty cycle pulse.

The d-c voltages were measured by means of a suitable known resistance connected in series with a microammeter.

Most of the test specimens were prepared in the form of plates of various thicknesses. Some specimens were made from standard suspension insulator shells using the head section, ground down to the desired thickness, as the test area.

Electrodes of circular shapes were applied to the opposite sides of each test specimen. Guard rings were also provided to eliminate the effect of surface leakage and corona, and to preserve a more nearly uniform field thru the test zone. The electrodes and guard rings were of silver ceramically bonded to the surface of the dielectric to avoid entrapped air between the dielectric and its electrode.

ELECTRICAL WORLD

A McGraw-Hill Weekly

November 15, 1965

SAVE

Do Not Throw Out.

Massive NE Outage
page 44 A

EHV • Today's Designs
• Tomorrow's Plans



A. J. PEZDER
INSULATOR DEPT-GEN ELEC
2525 INSULATOR DR
BALTIMORE MD 21230 C-3

Mr Kingsbury

GENERAL ENGINEERING LABORATORY

DIELECTRIC MATERIALS IONIZATION STUDY
for

U. S. NAVY DEPARTMENT BUREAU OF SHIPS
Washington, D. C.

INTERIM ENGINEERING REPORT NO. 2

October 31, 1955

Attention Code 817

Index No.: NE-111273, Subtask 3

Contract No.: GE-70779

Customer Order No.: NOBSR-64657

GE Requisition No.: W-88882

GENERAL  ELECTRIC

Ref:
Bruce Knopfling

L.J. Stevens
Insulator Dept.
Transformer Div.
General Electric Co.
Baltimore, Md.

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SEP 2 1956

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GENERAL ELECTRIC
Research Laboratory

*Equipment
Testing*

CAPACITANCE BRIDGE BALANCER

by

D. A. Felton and P. G. Frischmann

Report No. 56-RL-1616

September 1956

CLASS 2

SCHENECTADY, NEW YORK

GENERAL **ELECTRIC**
Research Laboratory

VACUUM ARC RECOVERY PHENOMENA

BY

J. A. RICH and G. A. FARRALL

SCHENECTADY, NEW YORK

~~Mr. Van
" Kingsbury~~

~~H. A. Frey~~
Locke Dept.
Baltimore, Md

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H. A. FREY

GENERAL ELECTRIC
Research Laboratory

Dielectric

THE ELECTRIC STRENGTH OF SATURATED HYDROCARBON GASES

by

J. C. Devins and R. W. Crowe

Report No. 56-RL-1481 January 1956

CLASS 1

SCHENECTADY, NEW YORK

Mr. Kingsbury

*H A Frey
Locke Dept
Baltimore, Md*

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GENERAL ELECTRIC
Research Laboratory

Dielectric

FORMATIVE TIME LAGS IN THE ELECTRIC BREAKDOWN
OF LIQUID HYDROCARBONS

by

R. W. Crowe

Report No. 55-RL-1432 November 1955

CLASS 1

SCHENECTADY, NEW YORK

NATIONAL RADIO INSTITUTE

Established 1914

WASHINGTON, D. C.

DISCUSSION SHEET - FOLD AND PLACE WITH LESSON 9FR

There are several places in this lesson where the material is presented in a way that is a decided departure from the conventional manner. For example, we teach you that electromagnetic induction from the primary to the secondary of a transformer is the result of changing flux linkages. While engineers have been talking in terms of flux linkages for years, writers of text books in general have stuck to the old manner of speaking and they talk about conductors cutting lines of force.

Of course we mention this too, but the idea we want you to have after studying this lesson is that changes in flux linkages are responsible for all induced e.m.f.'s. This is all brought out clearly in Figs. 2, 3, 4 and 5. You will notice that we can change the flux linkages in several ways - by moving one of the coils within the other, by moving the larger coil, or by causing the current flowing through one coil to change in magnitude. In any case, there is motion.

Now refer to Fig. 4c. There should of course be a battery in the buzzer circuit. When the switch is closed the buzzer will alternately close and open the circuit and cause the flux about the larger coil to increase and decrease. As the flux moves up and down, its linkages with the smaller coil change and an alternating voltage is induced in the smaller coil.

On page 4 there is a misprint. In the sixth line starting with the last word, change to "The second coil has 100 magnetic lines of force threading through it when maximum current flows in the first coil." On page 6 in the tenth line, we speak of the plate of a tube as a source of e.m.f. You will often see a vacuum tube referred to as a generator of e.m.f. and as the output of the tube is considered as the plate current, the meaning of the sentence will be perfectly clear.

In the seventh line of page 7, change to "lines 1, 2, 3 and 4." Of course, "4" in the next line should be omitted.

Near the bottom of the same page we talk about a complete magnetic circuit. Figure 6b will make clear what is meant. The iron core on which the windings are placed, is closed and the flux can flow right around it, just as current flows in a complete circuit.

In the fourth line of page 9, the statement is made that "The power must be the same." This is true only if there are no losses present in the core. However, there are always some losses so that the output power is always less than the input power. The important thing is that it can't be greater.

On the next page, change 100 in the third and fifth lines to 110 and in the fourth line change 11.5 to 13.6 turns.

The letter L in the fourth line of page 12 refers to the total inductance, including the inductance L_1 , L_2 and the mutual inductance.

On page 15, cross out the whole third sentence under the illustration.

In the eighth line from the bottom of page 19, the printer left out part of the sentence. It should read, "But capacitive reactance shifts phase in a direction opposite to the shift caused by inductive reactance."

On page 24 you will notice the abbreviation μ f used twice. This is the same as mfd. In your general reading you will find microfarad abbreviated both ways. On page 28, line fifteen, Fig. C refers to Fig. 21C.

J. A. Dowie, Chief Instructor,
National Radio Institute.

U.S. NAVY
NAVAL SUPPLY DEPOT
5801 TABOR AVENUE
PHILADELPHIA, PA., 19120

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- NOTE: Private industry must submit requests via the contracting officer.
- ☐ B. Item temporarily not in stock. Will be supplied upon receipt of material (approximately 30 days). No further follow-up required by requester.
- ☐ C. Since invitations for bid and contracts are not held at this office, documents required cannot be determined without specific document identification numbers. See attached instructions.
- ☐ D. Item not stocked at NSD, Phila. Request you refer to original source of information for clarification of availability.
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- ☐ F. Item is classified. Authority for issue must be endorsed by the cognizant Department of Defense Inspection Office in your area for certification of your "need to know," facility clearance, and storage facilities.
- ☐ G. Quantity reduced. Maximum of 25 copies allowed.
- ☐ H. List one item per line. See attached instructions.
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- ☐ J. Specifications/Standards are not issued in complete sets. See attached instructions.
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- ☐ DEFENSE ELECTRONICS SUPPLY CENTER, 1507 WILMINGTON PIKE, DAYTON, OHIO, 45420
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 - ☐ COMMANDER, NAVAL ORDNANCE SYSTEMS COMMAND, WASHINGTON, D.C., 20360
 - ☐ COMMANDER, NAVAL SHIP SYSTEMS COMMAND, WASHINGTON, D.C., 20360
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 - ☐ COMMANDING GENERAL, U.S. ARMY ELECTRONICS COMMAND, 225 S. 18TH ST., PHILADELPHIA, PA., 19103
 - ☐ COMMANDING GENERAL, HQ QM R&E CENTER, U.S. ARMY, NATICK, MASS., 01760
 - ☐ COMMANDING OFFICER, U.S. NAVAL ORDNANCE PLANT, CENTRAL TECHNICAL DOCUMENT OFFICE, LOUISVILLE, KY., 40214.
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345 E. 47TH STREET
NEW YORK, N.Y., 10017 |

MILITARY SPECIFICATION

RUBBER SHEETS, STRIPS, AND GASKETS;

SOLID, SYNTHETIC, MEDIUM AND MEDIUM HARD

This amendment, which forms a part of Military Specification MIL-R-1149A, 9 April 1956, has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy and the Air Force.

Page 3, paragraph 3.6.1: Delete and substitute:

"3.6.1 The hardness of the synthetic rubber shall have indentation values within the following ranges. The approximate shore "A" durometer values are included for convenient reference.

Hardness, all classes.

Thickness nominal	Type I		Type II	
	Indentation	Shore "A" durometer	Indentation	Shore "A" durometer
Inch	Millimeters		Millimeters	
1/4	1.12 - 1.42	47 - 56	0.66 - 0.96	62 - 72
5/16	1.14 - 1.44	47 - 55	.68 - .98	61 - 72
3/8	1.16 - 1.46	46 - 55	.68 - .98	61 - 72
7/16	1.18 - 1.48	45 - 54	.70 - 1.00	60 - 71
1/2	1.20 - 1.50	45 - 53	.70 - 1.00	60 - 71

Page 3, paragraph 3.6.2.4: Delete.

Page 3, paragraph 4.1.2, line 2: Delete "inspection" and substitute "examination".

Page 3, paragraph 4.1.2.1, first sentence: Delete and substitute: "For the examination specified in 4.2.1, representative samples shall be selected from different portions of each lot in accordance with table III."

MILITARY SPECIFICATION

RUBBER SHEETS, STRIPS, AND GASKETS; SOLID,
SYNTHETIC, MEDIUM AND MEDIUM HARD

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

1. SCOPE

1.1 **Scope.**—This specification covers synthetic rubber compounds for medium and medium hard synthetic rubber gaskets except for hatches, airports, and watertight and airtight doors for shipboard use.

1.2 **Classification.**—Synthetic rubber shall be of the following types and classes as specified (see 6.1):

Type I—Medium.

Class 1—Compound utilizing polymerized chloroprene as the basic material.

Class 2—Compound utilizing a copolymer product of butadiene and styrene as the basic material.

Class 3—Compound utilizing a copolymer product of isobutylene and isoprene.

Class 5—Compound utilizing a copolymer product of butadiene and acrylonitrile nitrile of the basic material.

Type II—Medium Hard.

Class 1—Compound utilizing polymerized chloroprene as the basic material.

Class 2—Compound utilizing a copolymer product of butadiene and styrene as the basic material.

Class 3—Compound utilizing a copolymer product of isobutylene and isoprene.

Class 5—Compound utilizing a copolymer product of butadiene and acrylonitrile nitrile of the basic material.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on date of invitation for bids, form a part of this specification:

SPECIFICATIONS

FEDERAL

NN-B-591	—Boxes, Fiberboard, Wood-Cleated (for Domestic Shipment).
NN-B-621	—Boxes, Wood, Nailed and Lock Corner.
LLL-B-631	—Boxes; Fiber, Corrugated (for Domestic Shipment).
LLL-B-636	—Boxes, Fiber, Solid (for Domestic Shipment).
PPP-B-601	—Boxes, Wood-Cleated-Plywood.
PPP-B-585	—Boxes; Wood, Wire-bound.

FED. SUP. CLASS.
5330, 9320

24 May 1961

Superseding

MIL-B-16540 (EuOrd)

17 August 1951

MILITARY SPECIFICATION

BRONZE, PHOSPHOR: CASTINGS

This specification has been approved by the
Bureau of Naval Weapons, Department of the Navy

1. SCOPE

1.1 Scope. - This specification covers phosphor bronze sand castings containing a controlled lead content.

1.2 Classification. - Phosphor bronze castings covered by this specification shall be of the following grades (see 6.2):

Grade A

Grade B

1.3 Condition. - Phosphor bronze castings shall be furnished in the "as cast" condition.

2. APPLICABLE DOCUMENTS

2.1 The following specifications, standards and publications, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

FEDERAL

PPP-B-585 - Boxes, Wood, Wirebound.

PPP-B-601 - Boxes, Wood, Cleated-Plywood.

PPP-B-621 - Boxes, Wood, Nailed and Lock-Corner.

MILITARY

MIL-C-132 - Crate, Wood, Open; Maximum Capacity
2,500 Pounds.

MIL-R-114 PA
AMENDMENT - 2

NAVAL SUPPLY DEPOT
5801 TABOR AVENUE
PHILADELPHIA, PA. 19120
OFFICIAL BUSINESS

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NAVY DEPARTMENT

General Electric Co.
Mr. A. L. Libby,
Product Engineer
2525 Insulator Drive
Baltimore 30, Maryland

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ENG.

REQUISITION NUMBER (For Local Convenience)

Please self-address the above label. Forward this form to the address shown herein. A window envelope may be used. Your request submitted on this form will speed service. Reorder forms will be enclosed with each shipment.

SPECIFICATIONS AND
STANDARDS REQUISITION

IFB, RFQ OR RFP CLOSING DATE

Send one copies of the below listed documents which are listed in the DD Index of Specifications and Standards.

STANDARDIZATION
DOCUMENT SYMBOL

TITLE
(From DD Index of Specifications and Standards)

~~MIL-B-994A~~

~~"Phosphor-Bronze"~~

MIL-B-16541

"Brass"

~~MIL-B-1644~~

~~"Brass"~~

JAN-R-1149A

"Neoprene"

MIL-B-16540

"Title Unknown"

SIGNATURE

A. L. Libby

DATE

August 29, 1966

DD FORM 1425 MAR 65 Stock No. 0101-807-190

REPLACES AND NSD 5200/1 WHICH MAY BE USED
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TO: COMMANDING OFFICER
U.S. NAVAL SUPPLY DEPOT
5801 TABOR AVENUE
PHILADELPHIA, PA. 19120

STA 1
STA 11
STA 13

n
meter

ore "A"
ometer

2 - 72
1 - 72
1 - 72
0 - 71
0 - 71

itute

representative samples selected
accordance with table III.

FSC 5330

QQ-B-637

APRIL 10, 1961

SUPERSEDING

Fed. Spec. QQ-N-35

October 23, 1957

(See section 6)

FEDERAL SPECIFICATION

BRASS, NAVAL: ROD, WIRE, SHAPES, FORGINGS, AND FLAT PRODUCTS WITH FINISHED EDGES (BAR, FLAT WIRE, AND STRIP)

This specification was approved by the Commissioner, Federal Supply Service, General Services Administration, for the use of all Federal agencies.

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers leaded and nonleaded naval-brass rod, wire, shapes, forgings, and flat products with finished edges (flat wire, strip, and bar).

1.2 Classification.

1.2.1 Compositions. The naval brass covered by this specification shall be furnished in the compositions shown in table I. Unless otherwise specified in the contract or order, composition 1 shall be furnished.

1.2.2 Forms and tempers. The naval brass covered by this specification shall be furnished in the following forms and tempers, as specified (see 6.2) :

Form	Temper
Bar and rod	As extruded
	Soft
	Cold-heading
	Half-hard or light annealed
	Hard

Wire

Soft

Cold-heading

Half-hard or light annealed

Hard

Strip and flat wire

Soft

Half-hard

Hard

Shapes

As extruded

Soft

Drawn

Forgings

As forged

When temper is not specified, rod, wire, and flat products (flat wire, strip, and bar) shall be furnished in the half-hard temper. Round rod over 1/2 inch in diameter may be furnished as standard shafting; round rod over 1 inch in diameter may be furnished for special shafting (see 6.2). Shafting is available with or without piston finish (see 3.6).

2. APPLICABLE SPECIFICATIONS, STANDARDS, AND OTHER PUBLICATIONS

2.1 Specifications and standards. The following specifications and standards of the

570405/61/302

1

FSC 9525

9530

9535

9540

Maintaining SCIENTIFIC TOLERANCES by INSPECTION

By WILLIAM B. RICE

DEPARTMENT OF STATISTICS AND REPORTS, FLOMB TOOL COMPANY, LOS ANGELES, CALIF.

FOLLOWING in the footsteps of Shewhart (1),¹ Simon (2), Wilks (3), and others, the author suggested in a recent article (4) that design tolerances for manufactured products be determined from factual data, analyzed statistically as to:

- (a) The characteristics required by users of the products.
- (b) The characteristics of the manufacturing process by which the products are made.

When it has been determined that the process is capable of producing, at a satisfactory cost, a product which meets consumer requirements, the next problem is how to hold the process at the desired level. This is basically an inspection problem.

Before the manufacturer's inspection can succeed in maintaining the characteristics he wants in his product, three requirements must be met:

1 The manufacturer needs to know that his process can be depended upon, that no unpredictable changes occur during production, that he is actually producing what he intends to produce. These requirements can be met only with a statistically controlled process, as evidenced by the use of quality-control charts (5).

2 The manufacturer needs to know that his specifications are practical and profitable, that they will meet consumer demands at a profit to him. A method of meeting this requirement was suggested in the author's previous article (4).

3 The manufacturer needs to know that his inspection procedures are adequate, that from his inspection records he can draw sound and correct conclusions about that part of his product which he does not inspect, in order to be sure that the first and second requirements are being met.

This third requirement is the subject of the present article.

CONCEPTS INVOLVED

Before proceeding with the discussion it seems advisable to give a brief summary of the concepts involved in setting tolerances by statistical methods:

1 Recognition that all things vary and that variability can best be analyzed with statistical techniques. Tolerances should therefore be expressed in statistical terms, such as $\bar{X} \pm \sigma$, rather than in absolute dimensions such as A, B .

2 Recognition that, in general, no tolerance limits can be set which will always include all pieces produced; that is, tolerances should be considered as probability limits, not absolute limits.

3 Recognition that tolerance limits vary in strictness, depending upon the seriousness of out-of-tolerance work, that more out-of-tolerance work can be permitted for minor defects than for major defects. In other words, specifications may be written $\bar{X} + \sigma, \bar{X} - s\sigma$, the value of s being different for each

type of defect; larger for more serious than for less serious defects.

In the author's previous article (4), an illustration was given of the torque required for an open-end wrench; a "consumer" tolerance of 1500 in-lb, a process capable of holding 2100 in-lb and a design specification of 2000 in-lb, which the process was able to meet and which gave a $33\frac{1}{3}$ per cent margin of safety over the consumer requirement.

How should inspection be set up so as to be sure that the wrenches produced are satisfactory? Several possible methods present themselves. Torque tests could be made on every wrench, i.e., 100 per cent inspection; however, such inspection would be not only expensive but also inefficient because unnecessary. With a $33\frac{1}{3}$ per cent margin of safety, an occasional failure below the 2000-in-lb specification could be permitted.

Alternatively, sample torque tests could be performed. Assuming lots of 5000 wrenches, with 0.5 per cent defective permitted, the sample would have to be about 1000 pieces out of each lot (6). Such an inspection plan would still be quite expensive and would not give much information except to assure the desired quality level.

Yet another method would be to apply destructive torque tests to a small sample from each lot of 5000 wrenches, the torque being increased until the wrench broke. In this case the sample would have to be quite small for reasons of economy, so small in fact that sound judgments about the remaining wrenches could not be made on the basis of the single small sample.

CONTROL-CHART INSPECTION

All the objectionable features of the methods just proposed can be avoided, and practical certainty of a satisfactory product can be had by adapting the control-chart technique in somewhat the way used by Lieut. Col. Simon at the Aberdeen Proving Ground (2).

Five wrenches from each 1000 can be tested destructively and the readings recorded on control charts (5). As long as the process remains in "statistical control" at a satisfactory level (say, between 2100 and 2400 in-lb), only a small sample of 50 to 100 need be nondestructively tested for conformance to specifications in order to assure satisfactory outgoing quality.

Control charts can simplify and economize inspection procedures in this way because, with a "controlled" process, the manufacturer can be sure that his production methods are turning out a product with consistent characteristics, i.e., with only chance variations; he can be certain that no unknown or unexpected accidents are producing erratic and unpredictable results. Therefore, with this confidence and with the facts revealed by his control charts, he can safely depend upon a mere check test at final inspection.

The design specifications for this wrench should be so written as to provide for the correct inspection procedure. For instance, the upper tolerance limit could be omitted, but the

¹ Numbers in parentheses refer to the Bibliography at the end of the paper.

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Information Sciences Laboratory

Report No. 70-C-323

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by

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Dr. M. B. Wilk, Bell Telephone Laboratories

Mrs. H. J. Chen, Bell Telephone Laboratories

Report No. 65-C-112

December 21, 1965



GENERAL ELECTRIC COMPANY
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Schenectady, N.Y.

A REVIEW AND COMPARISON OF METHODS FOR
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Information Science and Engineering

Report Number 71-C-196

July 1971

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**STUDY OF STATIC AND DYNAMIC
SEALS AND SEALING MECHANISMS**

EDITED BY

A. J. ORSINO

REPORT NO. 65GL36

MAY 31, 1965

GENERAL  ELECTRIC

May 1946



THE ELECTRICAL PERFORMANCE OF CERAMIC DIELECTRICS
AT ELEVATED TEMPERATURES

H. A. Frey

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Baltimore, Md.

Advance Copy

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A paper recommended by the AIEE committee on power transmission and distribution for presentation at the AIEE summer convention, Detroit, Mich., June 24-28, 1946. Manuscript submitted March 5, 1946; made available for printing May 8, 1946.

PRICE: 30¢ PER COPY BY MAIL
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THE ELECTRICAL PERFORMANCE OF CERAMIC DIELECTRICS

AT ELEVATED TEMPERATURES

- o o o -

It is well known that the electrical resistance of most of the commonly used insulating materials diminishes with increasing temperature. The actual performance of ceramic insulating materials at temperatures above the normal atmospheric level, and the factors affecting the ultimate breakdown at these temperatures, has not been the subject of much investigation. Recent requirements for insulators to operate at high temperatures and high voltages have indicated the need for such information.

Apparatus and Method.

It was necessary to provide a suitable test chamber in which the specimens could be mounted and held at any desired temperature while voltage was applied. Accordingly, a thermally insulated box or furnace was built. The electrical heating elements in the back of the box were separated from the test chamber by a one inch thick thermally insulating partition in order to prevent direct heating of the specimens by radiant heat. The heated air was circulated by means of a fan thru ports at each end of the test chamber. The fan also served to maintain air turbulence in the test chamber and thus prevent stratification. Temperature measurements were by commercial gas thermometer and automatic controls were provided for holding any desired temperature between minus 100 degrees Fahrenheit and 1000 degrees Fahrenheit. With this arrangement temperatures could be held within five degrees Fahrenheit of the desired level. Provision was also made for removing the heating elements from the back of the box and substituting racks of dry ice in order to obtain low temperatures.

Most of the tests were made with d-c voltage in order to eliminate the difficulty of separating conduction currents from charging currents. The voltage source was a full wave high voltage kenetron rectifier with suitable capacitors for the elimination of the sixty cycle pulse.

The d-c voltages were measured by means of a suitable known resistance connected in series with a microammeter.

Most of the test specimens were prepared in the form of plates of various thicknesses. Some specimens were made from standard suspension insulator shells using the head section, ground down to the desired thickness, as the test area.

Electrodes of circular shapes were applied to the opposite sides of each test specimen. Guard rings were also provided to eliminate the effect of surface leakage and corona, and to preserve a more nearly uniform field thru the test zone. The electrodes and guard rings were of silver ceramically bonded to the surface of the dielectric to avoid entrapped air between the dielectric and its electrode.

Porcelain for High Voltage Insulators

In this paper the mechanical failure of porcelain is discussed with special reference to 3 seldom recognized characteristics: the effect of the porcelain surface on the strength, the apparent anomalous distribution of individual mechanical test values, and the effect of time on mechanical strength. A method of evaluating the result of these factors on electrical insulator performance is suggested.

By
D. H. ROWLAND
ASSOCIATE A.I.E.E.

Locke Insulator Corp.,
Baltimore, Md.

THERE CAN BE little argument as to what mechanical characteristics are desirable in high voltage insulators, but the factors which contribute to such characteristics are concealed, more often than not, by an extraordinary amount of sophistic data. Modern high voltage insulators on

the average have improved enormously in the past decade. This improvement has been brought about in most cases by expensive and tedious cut and try tests conducted on assembled insulators. The procedure has been to assume that certain features of the completed units such as mechanical strength, ability to withstand immersion first in boiling water and then in ice water, imperviousness to moisture, and other qualities would insure insulators capable of standing up in service, which, after all, is the only real criterion of insulator worth. Finally specifications such as the A.I.E.E. Standards No. 41 for the testing of high voltage insulators were evolved and it may here be stated, unequivocally, that insulators which will successfully pass these specifications will give an unusually good account of themselves in the field. However, just because 2 groups of insulators of different manufacture successfully pass a certain specification it cannot be assumed that their maintenance cost in the field will be the same. How will they stand up under mechanical shock such as the impact from stones or bullets? What effect will time under load have upon their life? What is the maximum load that they will withstand? Is actual experience over a period of years the only way to find out? The purpose of this discussion is to provide engineers with a greater insight into some of the more recently investigated and rather peculiar mechanical characteristics of ceramic materials with the hope that an understanding of this work will help them to answer these questions and to point out that some of the characteristics which have been viewed with alarm by the uninitiated are really a true part of the whole scheme while other factors which have been unknown, or neglected, have been of major importance. A realization of this is bound to lead to still greater efficiency of systems dependent on the insulating qualities of such materials.

A paper recommended for publication by the A.I.E.E. committee on power transmission and distribution, and scheduled for discussion at the A.I.E.E. summer convention, Pasadena, Calif., June 22-26, 1936. Manuscript submitted March 25, 1936; released for publication April 23, 1936.

10. For numbered references see list at end of paper.

Hydro-Quebec

of 200-Mva summer loading, Haberl said. But the 100-ton shipping limit will restrict collector-station units to about 170 Mva.

Despite the industry trend to 3-phase power transformers, V. B. Ross, CGE, told another session, shipping limitations will favor single-phase units for EHV. One reason is the "enormous external phase-to-phase spacing required—27 ft for 700 kv. The problems of designing an economic tank having three bushings each 30 ft long and with adequate clearance to ground are close to being insurmountable."

Weight is saved by using high-temperature insulation, said R. A. Veitch, Canadian Westinghouse, as well as by forced-air cooling and use of grain-oriented steels.

Structures for EHV lines reflect a continuous quest for economy, said V. F. Crowley, Shawinigan Engineering Co. The most recent design, known as the "Y" tower, will be used for the first 50 miles of Ontario Hydro's 500-kv extension south of Sudbury.

In discussion, H. B. White, Alcan, indicated that rather high aluminum Y towers weigh about 61% as much as rigid self-supporting structures, vs 75% for the guyed-V.

Boosts Continental Grid

"We have heard a great deal about the interconnection of transmission systems across Canada," CEA Pres. R. E. Tweeddale told a dinner session. He suggested that concentrated study would show economies in such ties, and "ties across the international boundary would result in a complete transmission grid of the entire continent."

"The recently announced policy change with respect to the export of surplus power to the US will have a very important bearing on the electrical industry in Canada by making possible an accelerated development of our remaining hydro potentials. It is in the national interest", he continued, "to develop these as rapidly as possible."

"A total of 1.6 million kw is available from full development of the St John River," Tweeddale added. "It would involve a large dam in Maine providing down-

GENERATION AT FIVE HYDRO PLANTS on Manicouagan and Outardes rivers will be collected via 300-kv links and sent at 700 kv to four receiving stations

stream regulation for plants in New Brunswick and on-site installation of 700,000 kw. This would require integrated operation between systems in Maine and New Brunswick." But it could be followed, he suggested, by large-scale development of tidal power with interconnections throughout the Maritimes, Quebec, and New England.

Thus Canada has more need for EHV transmission than any other country except possibly Russia, Tweeddale continued, as a continental grid would make her hydro sites valuable for peaking.

At another session, G. A. Ewald, Public Service E&G Co, told of his company's gains from aerial-cable distribution in New Jersey. Outages

with the new construction are at a rate less than a fifth those experienced with open-wire, he said, and the cost has averaged only about 3% more.

Original installations were at 4 kv but recent developments have permitted extension to 13 kv, he continued. The higher-voltage system is designed with automatic reclosers and tie switches between adjacent circuits to hold outage exposures to the equivalent of 4-kv circuits and provide service of comparable reliability. Construction of 13-kv circuits generally resembles that developed for 4 kv except that insulation is boosted to 156 mil of butyl rubber and 65 mils of neoprene strung in ceramic spacers.



700-Kv Transmission Planned for

Canadian Electrical Association told of project to deliver 6,000 Mw to Montreal and Quebec, hears plea for international development of St John River and continental grid

Transmission at 700/735 kv ac was selected by Hydro-Quebec's EHV Project Group as the best way to convey nearly 6 million kw from hydro plants on the Manicouagan and Outardes rivers 400 miles to Montreal, Project Chairman H. W. Haberl told the Canadian Electrical Association recently at Quebec. This voltage was selected, he said, as "the highest . . . possible at this time," considering that manufacturers must start to deliver equipment next year for service in 1965.

Other sessions of the four-day conference covered national and international grids, hydro and thermal generation, overhead and underground distribution, and many other utility subjects.

Backbone of the 700-kv project, Haberl explained, will be three 700-kv lines, two crossing the St. Lawrence near Quebec and following the south shore to a new receiving station at Boucherville, opposite Montreal. The third will run entirely north of the St. Lawrence and terminate at the existing Bout de l'Île Substation on Montreal Island. All

three circuits must also span the 6,000-ft-wide Saguenay.

Boucherville and Bout de l'Île substations will be linked by a ten-mile 700-kv tie and will deliver Manicouagan power to the existing 300-kv system through nine 600-Mva banks. A similar link near Quebec will link Levis Substation with the third 700-kv circuit and existing 300 kv lines at Laurentides Substation; Levis will have four 400-Mva banks for 230-kv load.

Input to the 700-kv lines will be collected at two transformer stations in the Manicouagan-Outardes area. The first, to be known as Manicouagan because of its proximity to the 1,016-Mw Manicouagan 2, will also gather 1,123-Mw from Manicouagan 3 via four 38-mile lines, 642 Mw from Outardes 3 via two 28-mile lines, and 300 Mw from a later development. All gathering circuits will operate at 300 kv. This station will feed about 3,000 Mw to the two south-shore 700-kv lines.

The other collector station, to be built about 40 miles up the watershed near Outardes 4, from which

it gets its name and 596 Mw, will also pick up 1,344 Mw from Manicouagan 5 via four 69-mile 300-kv circuits. Outardes' 2,000-Mw output will flow to Quebec and Montreal via the third 700-kv circuit; it will also have a 700-kv link with Manicouagan Collector Station.

Corona loss will be no greater than that of the existing 300-kv Bersimis lines, Haberl said. Final design will provide four-conductor bundles of the same Bersimis conductor at 18-in. spacing with phase spacings greater than 50 ft. Clearance to steel at each tower must be about 200 in. requiring strings of 35 insulators. Such lines will be rated at 2,000 amp continuous but would be "capable of much more."

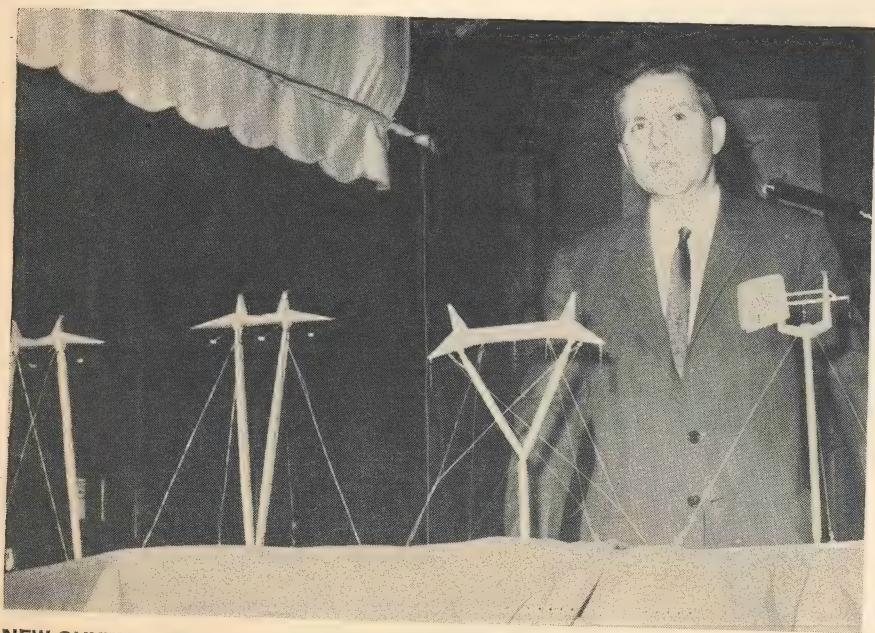
Voltage Limited by Reactors

Overvoltages on lines and equipment will be reduced considerably, Haberl said, by permanently connecting 330-Mva shunt reactors to each 226-mile circuit at the collecting stations and at the receiving stations near Quebec. The shorter lines from Quebec to Montreal will have 165-Mva reactors at each end. Maximum dynamic overvoltage on load rejection, with these reactors, he said, will not exceed 1.5 times normal. Switching surges from line energization are also reduced and will not exceed 2.1 times normal. Consequently, he said, BIL requirements will be 2,000 to 2,500 kv, but without reactors they would be "very difficult."

Total current drawn by the shunt reactors will neutralize two-thirds of line-charging current, he continued, and generators and additional lower-voltage switched reactors will be used to hold down light-load voltage. Switched capacitors on receiving-end 300-kv buses will neutralize shunt-reactor current during full-load operation.

Stability requirements of the 6,000-Mw system will be met by clearing line-to-ground faults in six cycles and reclosing in 25 cycles. The shunt reactors completely discharge the 700-kv line during 25 cycles of dead time, Haberl said.

Power transformers for receiving stations with rail access will be banks of single-phase units capable



NEW GUYED-Y TOWER for 500-kv lines (second from right) is compared with more conventional guyed structures by V. F. Crowley, Shawinigan Engineering Co.

Mr. H. A. Frey
"Kongelund"

**GENERAL
ENGINEERING
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Contamination

TC-2C AND TC-15 MEETINGS - VÄSTERÅS, SWEDEN 1958

by

K. N. Mathes

Report No. 58GL332 December 5, 1958

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H. A. FREY

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EXTRA HIGH VOLTAGE TRANSMISSION

IN THE

CENTRAL STATES REGION

REPORT NO. 1

R.D. Webster
General Electric Company
Chicago Office
January 2, 1964

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THEORY OF THE TENSILE TEST

by

E.W. Hart, Metallurgy and Ceramics Laboratory

Report No. 66-C-222 June 1966

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ENG. DEPT.

*Photo
This would be of interest
of a design and the order
H. H.*

*Equipment
Testing*

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General Engineering Laboratory

AN ADJUSTABLE RATE OF RISE CONTROL SYSTEM FOR DIELECTRIC STRENGTH TESTING

By

R. N. Bushman

SCHENECTADY, NEW YORK

May 1951
Litho in USA



SOME ENGINEERING APPLICATIONS OF THE ELECTROLYTIC FIELD-ANALYZER

H. K. Farr
Member AIEE

General Electric Company,
Pittsfield, Mass.

W. R. Wilson
Member AIEE

General Electric Company,
Philadelphia, Pa.

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Dielectric

GENERAL ELECTRIC
Research Laboratory

PULSE MEASUREMENT TECHNIQUES FOR THE STUDY OF
SECONDARY ELECTRON-EMISSION PROPERTIES OF INSULATORS

by

A. B. Laponsky and N. R. Whetten

Report No. 56-RL-1660

November 1956

CLASS 1

SCHENECTADY, NEW YORK

Seelectrics

TECHNICAL INFORMATION SERIES

TECHNICAL INFORMATION SERIES		
Title Page		
AUTHOR	SUBJECT CLASSIFICATION	NO.
R.E. Plump T. W. Liao	Gaseous Insulation	57TP517
TITLE		DATE
Progress in Gaseous Insulation		2/14/58

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR R.E. Plump T. W. Liao		SUBJECT CLASSIFICATION Gaseous Insulation		NO. 57TPS17
				DATE 2/14/58
TITLE Progress in Gaseous Insulation				
ABSTRACT Theoretical, experimental, and practical developments in gaseous dielectric phenomena are reviewed from recent literature. Chemical and physical properties of gases and their effects, are also discussed. (113 references.) The report was originally written for Heywood & Co. of London as a chapter for a book on Progress in Dielectrics.				
G.E. CLASS II		REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS		NO. PAGES 33
GOV. CLASS None		Pittsfield Data Bureau		
CONCLUSION Interest in gaseous insulation is world-wide, and much progress has been made in the past decade. Areas in this field include rotating machinery, power apparatus, switchgear, cables, etc. Theoretical and experimental advances have been made toward more understanding of the requirements of particular applications. A distinction between electronegative gases and all others appears to be firmly established. Lighter gases such as hydrogen and helium still retain much usefulness for heat transfer in rotating machinery, but the chemistry and physics of heavier gases are favorable for many other applications.				

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR General Information

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BUILDING and ROOM No. _____

B - 202 (Liao)

B - 503 (Plump)

LOCATION

Pittsfield, Massachusetts

Mr. Vadnagara requests additional information as to the capacitance of the test circuit for the current-limiting fuses. The normal test circuit would have an inherent shunt capacitance of several thousand picofarads, the exact amount depending on whether high-voltage transformers with capacitance graded bushings, actual length of buswork, and impedance loading were used. This capacitance would be in the range of normal overhead distribution.

Typical installations using underground cable would have a shunt capacitance of much higher value. These values could range from 0.1 to 0.5 μF . Since the normal test setup does not utilize any shunt capacitance of these values, a special test was made to determine whether it would be an appreciable factor. One size (15.5 kV 10 amperes) NX fuse was tested on a circuit with an available fault current of 12 kA at the fuse design voltage. A shunt capacitance (in addition to the normal circuit capacitance) was varied from

0.075 to 0.53 μF during the test sequence. The peak arc voltage was found to be slightly higher (2.5 to 5 percent) with the larger shunt capacitance value than the maximum obtained with no added shunt capacitance. I would attribute this to a slight interaction between the circuit inductance and the shunt capacitance when the fuse element melts and introduces a rapid resistance into the circuit; but the same resistance quickly dampens any oscillatory effects and prevents higher overshoot of the voltage.

Mr. Bronikowski's supposition regarding the use of ribbon-element NX fuses at lower circuit voltages with a corresponding reduction of maximum arc voltage is correct. Also, with this type of element, the maximum arc voltage remains independent of the fault current. This characteristic permits more versatility of application as Mr. Bronikowski mentions, especially as related to coordination with lightning arresters.

Testing EHV Station Insulation for Performance in Contaminated Conditions

JAMES D. M. PHELPS, MEMBER, IEEE, JAMES B. OWENS, SENIOR MEMBER, IEEE, AND AREM FOTI, SENIOR MEMBER, IEEE

Abstract—This technical paper deals with two phases of wet testing of EHV station insulators; one for conventional rainfall tests with prescribed rate of precipitation and water resistivity and the other for artificial contamination or pollution tests under wet conditions. The authors recommend a change in USA Standards for rate of precipitation and resistivity of water and offer supporting test data confirming the ability to distinguish between satisfactory and unsatisfactory insulator designs as a result of employing their new proposal. They also offer a proposed contamination test procedure which is convenient to use, which gives reproducible results, and which is sufficiently flexible for use in varying the severity of the applied artificial contaminant according to user requirements. The artificial contamination, or pollution, test may be used in rating insulator designs concerning performance under contaminated and wet conditions.

INTRODUCTION

INSULATION systems for outdoor stations have traditionally been designed using stacking apparatus insulators. Porcelain elements with appropriate joining hardware have been assembled into columns to provide adequate height and insulation performance. When insulation systems have been designed for extra high voltage (EHV) stations rated 345 kV and higher, it has been observed that incremental increases in the height of insulator columns do not produce a corresponding or proportionate increase in the insulating value achieved. This is particularly

true when insulation is subjected to long-duration switching surge voltages. Extra care in testing and evaluation of test information has been required to insure the desired reliability of EHV station insulation performance.

In the design of 500- and 765-kV stations for operation in coastal or industrial environments, it is particularly important that insulation performance be evaluated with a proper simulation of the variety of conditions that will exist in service. Consideration must be given to the effects of rain, fog, and moisture condensation on clean and contaminated insulator surfaces.

Tests have been conducted leading to the establishment of new performance criteria for wet testing to evaluate insulation performance during rainfall conditions. In addition, work has been done to develop a technique for the simulation of heavy surface contamination wetted by fog or mist. The work was undertaken because there was no recognized system of evaluation from which reliable and repeatable results could be obtained and related to field experience.

WET OR RAIN TESTING

The current standards of the U.S.A. Standards Institute^[1] specify that outdoor station apparatus insulators be subjected to a wet test using water of 17 800 ohm-cm resistivity falling at a rate which will allow an accumulation of 5.08 mm/min. The standards of the International Electrotechnical Commission (IEC)^[2] specify that wet testing be conducted with 9000–11 000 ohm-cm water and a rainfall rate of 3 mm/min. These are exceedingly heavy rates, corresponding to an accumulation of 7–12 inches per hour or 17–29 feet per day. Such rates of rainfall rarely, if ever, occur in outdoor station operating environments.

The resistivity of the water specified in the U.S.A. standards is substantially higher than the resistivity of rain water that has fallen through normal city or industrial atmospheres during the early portion of rain incidents.^[3] IEC requirements more closely

Paper 31 TP 67-98, recommended and approved by the Switchgear Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N. Y., January 29–February 3, 1967. Manuscript submitted October 31, 1966; made available for printing August 30, 1967.

J. D. M. Phelps is with the American Electric Power Service Corporation, Canton, Ohio.

J. B. Owens and A. Foti are with the I-T-E Circuit Breaker Company, Greensburg, Pa. 15601

TRANSMISSION SYSTEM CONTAMINATION SYMPOSIUM

September 22 and 23, 1969
Holiday Inn, Lenox, Mass.

OBJECT: To allow interested General Electric Departments an opportunity to discuss common and individual problems with respect to increasing contamination consideration by our customers and standardizing bodies.

September 22, 1969

2:00 P.M. Meet for coffee at the High Voltage Laboratory (Bldg. 9)
2:15 P.M. Demonstration of flow-on method of contamination testing - HVL.
3:00 P.M. Tour of outdoor research area of HVL.
3:45 P.M. Tour of Project UHV facilities - Lenox.
5:30 P.M. - Informalities at the Holiday Inn.
6:30 P.M.
6:30 P.M. Dinner (Dutch Treat)

September 23, 1969 - Holiday Inn, Lenox, Mass.

8:30 A.M.	Welcome	A. Glassanos, Mgr. Engr. Power Transformer Dept.
8:45 A.M.	Test Methods and Standards for Contamination	G.W.Alexander - Mgr.HVL Power Transformer Dept.
	High Voltage Techniques for Testing	F.J.Turner - HVL
	Correlation of Test Methods with Natural Contamination	M. Kawai - Project UHV
	Standardization Activities in NEMA, IEEE, IEC, CIGRE	J.G.Anderson A.F.Rohlf's Dr. T.W.Liao
10:00 A.M.	Coffee Break	
10:15 A.M.	Design of Apparatus to Withstand Contamination	J.G.Anderson - Mgr. Project UHV - Electric Util. Engr. Opr.
	Lightning Arresters	E.C.Sakshaug
	Bushings	J.K.Easley
	Power Circuit Breakers	C.M.Ratliff
	Instrument Transformers	
	Power Line Carrier Current Equpt.	

AL Libby

INSULATOR CONTAMINATION - PROBLEMS AND TESTS

F. J. Turner

I. INTRODUCTION

II. GENERAL PROBLEMS

- A. To Simulate or Not to Simulate Nature
- B. Measurements of Degree of Contamination
- C. Selection of Contamination Materials *CONDUCTIVITY MATTERS MOST*
- D. Method of Moisture Application *- REPEATABILITY*

III. POPULAR PRESENT DAY CONTAMINATION TEST METHODS

- A. Salt Fog Test *- DEVELOPED IN ENGLAND*
- B. Predeposit Test
 - 1. German method
 - 2. Dipping method
 - 3. Flow-coating
- C. ASEA Test Method
- D. Wet Contaminant Method

IV. SUMMARY

- A. Utility of Various Test Methods
- B. Correlation With Natural Conditions
- C. Need for Both Development & Practical Test Methods

TRANSMISSION SYSTEM CONTAMINATION SYMPOSIUM

September 22 and 23, 1969
Holiday Inn, Lenox, Mass.

OBJECT: To allow interested General Electric Departments an opportunity to discuss common and individual problems with respect to increasing contamination consideration by our customers and standardizing bodies.

September 22, 1969

2:00 P.M. Meet for coffee at the High Voltage Laboratory (Bldg. 9)
2:15 P.M. Demonstration of flow-on method of contamination testing - HVL.
3:00 P.M. Tour of outdoor research area of HVL.
3:45 P.M. Tour of Project UHV facilities - Lenox.
5:30 P.M. - Informalities at the Holiday Inn.
6:30 P.M.
6:30 P.M. Dinner (Dutch Treat)

September 23, 1969 - Holiday Inn, Lenox, Mass.

8:30 A.M. Welcome A. Glassanos, Mgr. Engr.
Power Transformer Dept.
8:45 A.M. Test Methods and Standards for G.W.Alexander - Mgr.HVL
Contamination Power Transformer Dept.
High Voltage Techniques for Testing F.J.Turner - HVL
Correlation of Test Methods with
Natural Contamination M. Kawai - Project UHV
Standardization Activities in NEMA,
IEEE, IEC, CIGRE J.G.Anderson
A.F.Rohlfs
Dr. T.W.Liao
10:00 A.M. Coffee Break
10:15 A.M. Design of Apparatus to Withstand J.G.Anderson - Mgr.
Contamination Project UHV - Electric
Util. Engr. Opr.
Lightning Arresters E.C.Sakshaug
Bushings J.K.Easley
Power Circuit Breakers C.M.Ratliff
Instrument Transformers
Power Line Carrier Current Eqpt.

Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 14, 1969.



A NEW CONTAMINATION TEST METHOD

B. Macchiaroli
Inst. of Electrical Engineering
University of Naples
Naples, Italy.

F. J. Turner
Senior Member IEEE
General Electric Company
Pittsfield, Mass.

A paper recommended by the IEEE Transmission & Distribution Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 26-31, 1969. Manuscript submitted September 17, 1968; made available for printing October 23, 1968.

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69 TP 14 - PWR

Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE July 11, 1969.



A STUDY OF SOME VARIABLES AFFECTING CONTAMINATION TESTING USING THE WET CONTAMINANT METHOD

B. Macchiaroli
Institute of Electrical Engineering
University of Naples
Naples, Italy.

F. J. Turner
Senior Member IEEE
General Electric Company
Pittsfield, Mass.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, Dallas, Texas, June 22-27, 1969. Manuscript submitted February 17, 1969; made available for printing April 15, 1969.

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INSULATOR CONTAMINATION - PROBLEMS AND TESTS

F. J. Turner

I. INTRODUCTION

II. GENERAL PROBLEMS

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FIELD AND LABORATORY TESTS OF CONTAMINATED INSULATORS
FOR THE DESIGN OF THE STATE ELECTRICITY COMMISSION OF VICTORIA
500 KV SYSTEM

J. Johnson*

R. T. Henderson*

W. S. Price**

D. E. Hedman***

F. J. Turner****

In recent years, the control of switching surges by circuit breaker resistors, and the use of shielding angles adequate to reduce lightning impulse flashovers, has made possible appreciable reduction in transmission line insulation levels and cost, particularly on EHV lines. As this process continues, additional design data will be required for the power frequency withstand of line insulators exposed to contamination, if future line designs are to be both successful and economical.

Although extensive investigations have been made during the past two decades on the power frequency performance of contaminated insulators, the basic mechanism is so complex, and there are so many parameters, known and unknown, in the problem that much work remains to be done to permit optimum line design.

Since the future 500 kv transmission system of the State Electricity Commission of Victoria must traverse a very severe contamination area, as indicated by present 220 kv line performance, a very extensive investigation has been made, including both field and laboratory work. This work provided a substantial amount of new design information for the 500 kv system. Details of this study are presented in this paper, for comparison with previous investigations, and possibly to serve as a basis for future research.

FIELD EXPERIENCE

The State Electricity Commission of Victoria supplies virtually all the electric power in the State of Victoria, an area of some 88,000 square miles in the southeastern corner of Australia. Apart from small hydroelectric stations contributing to peak load demands, and a low load factor entitlement from the Snowy Mountains Scheme, the bulk of the power is generated by base load thermal stations situated on the very extensive lignite brown coal fields of the Latrobe Valley, about 90 miles east of the capital city of Melbourne.

Since the first thermal station was installed in 1924, the total capacity of the Latrobe Valley generation has grown to its present level of some 1,400 MW, with a further 1,700 MW of plant under construction or on order, and the probability of extensive additions in the future.

* State Electricity Commission of Victoria, Melbourne, Australia.

** Bechtel Corporation, San Francisco, California.

*** General Electric Co., Schenectady, New York.

**** General Electric Co., Pittsfield, Massachusetts.

INSULATOR BEHAVIOR IN CONTAMINATED ATMOSPHERES

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Senior Member IEEE
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M.Kawai
Member IEEE
General Electric Co.
Pittsfield, Mass.

J.Kaminski, Jr.
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STANDARDIZATION
OF
POLLUTION TESTS IN IEC TC 42

IEC TC 42, High Voltage Testing Techniques, has adopted the following clauses for contamination testing. These have been approved to be sent out to the National Committees under the six-months rule.

3.4 Artificial pollution tests

Artificial pollution tests are intended to provide information on the behaviour of external insulation under conditions simulating pollution in service.

The basic objective is usually to verify that the test object will withstand a specified amount of pollution at a given test or operating voltage.

For comparison tests and for research, the objective may be either to determine the degree of pollution that the test object can withstand with a given probability at a given test voltage, or to determine the withstand voltage for a specified degree of pollution. For comparison tests, the former procedure is preferable.

The procedure to be adopted must give reproducible results, taking into account the statistical nature of the flashover mechanism.

The result of an artificial pollution test is dependent mainly on the following factors:

- the installation of the test object
- the procedure for applying the pollution
- the amount, conductivity and distribution of the pollution
- the amount of moisture deposit
- the manner in which the test voltage is applied.

3.4.1 Test procedures

3.4.1.1 Installation

The test object should be tested in a position (horizontal, vertical or inclined) corresponding to actual working conditions. The clearance to entraneous structures (see Clause 3.1) need not exceed 1.0 S and may even be reduced below this, without affecting the validity of results, provided risk of flashover of the clearance is avoided.

The insulator shall be in thermal equilibrium with the air in the chamber at the start of the test. The ambient temperature at the start of the test shall be not less than 5°C or greater than 30°C.

Survey of Literature in 1968 by W.T. Starn

The state of understanding of the mechanism of flashover of polluted insulation is revealed by Zoledziowski's paper (1), and the discussion following it. Z. fits his data to the equation $(V^2 - V_0^2)t = \frac{Ce}{3} r^2 L^3$ where V is the applied unidirectional voltage, V_0 is the minimum voltage below which a flashover will not occur, t is the time to flashover, C is a constant, e is the energy needed for discharge production, r is the pollution resistance per unit length, and L is the distance between electrodes. Zoledziowski believes that the discharge propagates in air, not steam, that a dry band is not required for discharge initiation, and that the discharge starts to propagate at zero time.

Salthouse (2) has studied the processes which result in the initiation of dry bands on polluted insulators. Above a critical temperature rise (ΔT_c) which is less than 1°C , the resistance in one location increases much more rapidly than in others. ΔT_c corresponds to a power dissipation density of about 5mW/cm^2 .

Kawai (3) has studied the natural conditions of humidity, fog and temperature which precipitate flashover and has determined withstand voltage of a variety of types of suspension insulators as a function of salt deposit density. Light rain or fog after several hours of high humidity minimizes flashover voltage. A steam fog artificially reproduces this condition.

Johnson et al (4) have reported on an intensive study of the conditions leading to flashover of heavily contaminated insulator strings leading to design criteria for a 500 kV line in Victoria. Contamination is by a salt laden smoke and fog, underside contamination controls. KV/insulator for 60 Hz flashover varies linearly with the logarithm of salt concentration being 1.3 in/Kv at 0.2 and 2.1 in/KV at 10 mg/cm^2 . A mechanism is suggested and results of high speed motion picture correlation with surging currents are described.

Conference Paper



COMPARISON OF INSULATOR TYPES
BY THE
WET CONTAMINANT AND CLEAN FOG TEST METHODS

B. Macchiaroli
Inst. of Electrical Engineering
University of Naples
Naples, Italy

F. J. Turner
Senior Member IEEE
General Electric Company
Pittsfield, Massachusetts

Paper No.

69 CP 176 - PWR



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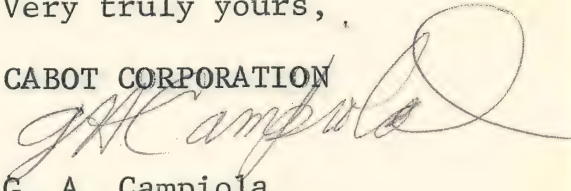
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Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 14, 1969.



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Paper No.

69 TP 14 - FWR

CAB-D-SIL - HS-5

MEMORANDUM

August 21, 1969

PROCEDURE FOR CONDUCTING CONTAMINATION TESTS ON SUSPENSION INSULATORS

A. GENERAL

At the present time there is a great need for an artificial contamination test for high voltage suspension insulators for use in polluted areas. In such areas the behavior of suspension insulators is frequently the limiting factor in determining the size and type of insulator to be used.

B. WITHSTAND VOLTAGE TEST

The object of this test is to determine the maximum withstand voltage at a given reference layer conductivity. A series of tests shall be conducted as prescribed in this memorandum on an insulator, or insulators, with specified reference coatings. The insulator withstand voltage is the maximum value of voltage which may be applied to a test specimen on three consecutive trials without flashover at a given level of layer conductivity.

C. SCOPE OF TESTS

1. The procedure outlined in this memorandum applies to the testing of porcelain suspension insulators of nominal voltages greater than 1 KV, which are used outdoors and exposed to polluted atmospheres. At present, this procedure is limited to A.C. voltage tests, and is not intended to be used for insulators of organic material or to determine the efficiency of different surface treatments, such as silicone compounds. The general procedure is known as the wet-contaminant method and is generally in agreement with that described by F. J. Turner and B. Macchiaroli.¹

The voltage source used in making these tests should have a short circuit current not less than 5 amperes RMS.

2. Cleaning of Insulators

The insulators shall be carefully cleaned so that all traces of grease are removed. Detergent may be used, after which the insulator surface shall be thoroughly rinsed with clear water to remove remaining traces of any ionizing material. The surface of the insulator is deemed sufficiently clean and free from any grease if large continuous wet areas are observed. After washing, insulators shall be dried by blowing compressed air on the surfaces.

¹IEEE Paper No. 69-TP-692 "A Study of Some Variables Affecting Contamination Testing Using the Wet Contamination Method" B. Macchiaroli and F. J. Turner.

IEEE Paper No. 69-TP-14 "A New Contamination Test Method" B. Macchiaroli and F. J. Turner.

July 1951
Litho in USA



TRAVELING WAVE RELATIONS APPLICABLE TO POWER-SYSTEM FAULT LOCATORS

Laurel J. Lewis
Member AIEE
University of Washington
Seattle, Wash.

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Not Released for Publication

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oregon, August 20-23, 1951. Manuscript submitted May 22, 1951; made available for printing July 10, 1951.

PRICE: 30¢ To Members
60¢ To Nonmembers

FINAL REPORT

PHYSICAL PROCESSES IN CONTAMINATION
FLASHOVER OF HIGH VOLTAGE
INSULATION

June 1975

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SCHOOL OF ENGINEERING

617 253-4630

ELECTRIC POWER SYSTEMS ENGINEERING LABORATORY

CAMBRIDGE, MASSACHUSETTS 02139

Room 7-005
May 5, 1975

To Locke

For your reference

TO: Members of the Contamination Working Group

On May 30, 1975 MIT will host an informal seminar on contamination flashover. Interested members of the Working Group as well as other interested persons are welcome to attend. The major purpose of the seminar will be to present results of the NSF sponsored flashover study.

The presentation will include:

1) Presentation of theoretical results.

→ 2) Presentation of methods found to control flashover, including one method for which a patent has been filed. High speed motion pictures of these methods preventing flashover will be shown.

→ 3) A discussion of surface wetting effects.

→ 4) Results of tests on semiconducting glaze units.

5) A demonstration of a computer simulation of flashover.

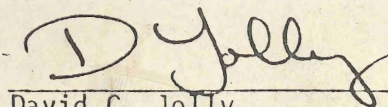
6) A tour of the laboratory, and flashover demonstrations.

→ In connection with the topic of surface wetting, Mr. Tom Kell, President of Silibond Products, Inc. will discuss a new water repellant coating for insulators. It is far more repellant than Teflon or Silicone. The coating is in the development stage and has been successfully tested at MIT. A coated suspension insulator will be available for inspection.

Also participating in the presentation will be Mr. Ed Los of the G.E. High Voltage Laboratory, and hopefully Professor T.C. Cheng of the University of Southern California, who conducted research while a student here, and is now carrying out contamination research at USC.

The meeting will be from 9:00 a.m. to about 4:00 p.m. Reservations should be made directly with one of the hotels listed on the attached sheet. The Hotel Sonesta is recommended as being near MIT, but may fill up shortly. The meeting has been scheduled on Friday so that persons so desiring can spend a weekend in the Bicentennial City. For those who think they are young enough, we hope to have an optional "night on the town" after the Seminar.

Please let us know if you plan to attend so that we can plan ahead and also send further details.



David C. Jolly
Staff Engineer
Division of Sponsored Research

DCJ/s
enc:

MAY 7 1975