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Historical Reliability Data for IEEE 3006 Standards: Power Systems Reliability

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Historical Reliability Data for IEEE 3006 Standards: Power Systems Reliability

Compiled by the

Technical Books Coordinating Committee
of the
IEEE Industry Applications Society

Abstract: Reliability data gathered from equipment reliability surveys and analyses over a period of 35 years or more is summarized in this collection. Equipment surveys conducted prior to 1976, detailed reports on the surveys and data collection efforts, and extensive lists of references on equipment reliability are presented. The collection provides the analyst with options for determining reliability parameters for older electrical systems.

Keywords: commercial power systems, electrical interruptions, IEEE Gold Book™ annex, historical reliability data, IEEE 3006, industrial power systems, outage data, power systems reliability, reliability analysis, reliability survey

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Foreword

Compiled in this collection of historical reliability data is invaluable information supporting the planning and design of industrial and commercial electric power distribution systems. It is a compilation of historical survey information collected through the efforts of Don Koval and Charles Heising over a period of approximately 35 years. This is a tribute to them and all of the contributors that made IEEE Std 493™ *(IEEE Gold Book™)* one of the best in what was the IEEE Color Book® series.

This collection summarizes the reliability information collected from equipment reliability surveys over a period of 35 years or more. It consists of equipment surveys conducted prior to 1976, detailed reports on the surveys and data collection efforts, and extensive lists of references on equipment reliability. Selected reliability and availability numeric from the survey efforts are also presented in this document.

This document provides the analyst with options for determining reliability parameters for older electrical systems. Data not found anywhere else is the cornerstone of this document, with some surveys spanning many years. In addition, there is utility numeric critical to facility assessments that identifies available power.

Robert G. Arno, *Senior Member of IEEE*

This collection is respectfully dedicated to Don Koval and Charles Heising,
who devoted countless hours to compiling this data for the benefit of the industry.

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Reliability of Electrical Equipment

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Cost of Power Outages, Plant Restart Time, Critical Service Loss Duration Time, and Type of Loads Lost Versus Time of Power Outages

Part III
Causes and Types of Failures of Electrical Equipment, the Methods of Repair, and the Urgency of Repair

By
Reliability Subcommittee
Industrial and Commercial Power Systems Committee
IEEE Industry Applications Society

W. H. Dickinson, *Chair*

P. E. Gannon
M. D. Harris
C. R. Heising
D. W. McWilliams
R. W. Parisian
A. D. Patton
W. J. Pearce

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Report on Reliability Survey of Industrial Plants, Part I: Reliability of Electrical Equipment

IEEE COMMITTEE REPORT

Abstract—An IEEE sponsored survey of electrical equipment reliability in industrial plants was completed during 1972. The results are reported from this survey which included a total of 1982 equipment failures that were reported by 30 companies covering 68 plants in nine industries in the United States and Canada.

Introduction

A KNOWLEDGE of the reliability of electrical equipment is an important consideration in the design of power distribution systems for industrial plants. It is possible to make quantitative reliability comparisons between alternative designs of new systems and then use this information in cost–reliability tradeoff studies to determine which type of power distribution systems to use [1]–[10]. The cost of power outages at the various plant locations can be factored into the decision as to which type of power distribution system to use. These decisions can then be based upon total owning cost over the useful life of the equipment rather than first cost.

In 1969 a Reliability Working Group was formed under the Industrial Plants Power Systems Subcommittee, Industrial and Commercial Power Systems Committee. In 1972 the activity was changed to a Reliability Subcommittee under the same Committee. One of the major activities of the Reliability Working Group and the Reliability Subcommittee has been to conduct a survey of equipment reliability in industrial plants. This survey was conducted during the latter half of 1971 and the early part of 1972 and attempted to update a similar survey [11] which had been conducted eleven years ago. The results from the present survey contain data on failure rate and average downtime per failure for 74 equipment categories. The Reliability Subcommittee also felt that additional information was needed in the present survey beyond what was collected twelve years ago. Some of the additional information is the following:

1) cost of power outages of industrial plants;
2) plant restart time;
3) critical service loss duration time;
4) type of loads lost versus time of power outages;
5) repair or replacement time data;
6) repair urgency information;
7) causes and types of failures;
8) maintenance data and policies.

Paper TOD-73-158, approved by the Industrial and Commercial Power Systems Committee of the IEEE Industry Applications Society for presentation at the 1973 Industrial and Commercial Power Systems Technical Conference, Atlanta, Ga., May 13–16. Manuscript released for publication November 5, 1973.

Members of the Reliability Subcommittee of the IEEE Industrial and Commercial Power Systems Committee are W. H. Dickinson, *Chairman*, P. E. Gannon, M. D. Harris, C. R. Heising, D. W. McWilliams, R. W. Parisian, A. D. Patton, and W. J. Pearce.

It is not practical to publish all the results contained in the survey in a single paper. They will be presented in six separate parts. The first three parts are published at this time

Part 1: Reliability of Electrical Equipment;
Part 2: Cost of Power Outages, Plant Restart Time, Critical Service Loss Duration Time, and Type of Loads Lost Versus Time of Power Outages [11];
Part 3: Causes and Types of Failures, Methods of Repair, and Urgency of Repair [12].

A major part of the data in these three papers are presented in summary form. It is expected that the additional three papers will be presented at a later date and will contain further in-depth information where questions have been raised to point out the need for such data.

Survey Form

The survey form is shown in Appendix A. Three types of cards were used for reporting the information.

Card type 1 asks for data on plant identification and other general plant information.

Card type 2 asks for data on a specific equipment class, including the total number of installed units, on their failure experience, on maintenance practices, and on estimated repair times of failed equipment.

Card type 3 asks for data on each individual failure reported on a card type 2.

It was necessary to provide definitions for "failure" and "repair time."

A *failure* is defined as any trouble with a power system component that causes any of the following to occur:

1) partial or complete plant shutdown, or below-standard plant operation;
2) unacceptable performance of user's equipment;
3) operation of the electrical protective relaying or emergency operation of the plant electrical system;
4) de-energization of any electric circuit or equipment.

A failure on a public utility supply system may cause the user to have either 1) a power interruption or loss of service, or 2) a deviation from normal voltage or frequency of sufficient magnitude or duration to disrupt plant production. A failure on an in-plant component causes a forced outage of the compo-