

1366™

IEEE Guide for Electric Power Distribution Reliability Indices

IEEE Power Engineering Society

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IEEE Guide for Electric Power Distribution Reliability Indices

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IEEE Power Engineering Society**

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Pages 28–30 of the June 2001, Edison Electric Institute 2000 Reliability Report.

Abstract: Distribution reliability indices and factors that affect their calculations are defined in this guide. The indices are intended to apply to distribution systems, substations, circuits, and defined regions.

Keywords: circuits, distribution reliability indices, distribution systems, electric power, reliability indices

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Introduction

(This introduction is not part of IEEE Std 1366-2003, IEEE Guide for Electric Power Distribution Reliability Indices.)

This Guide has been updated to clarify existing definitions and to introduce a statistically based definition for classification of major event days. The working group created a methodology, 2.5 Beta Method, for determination of major event days. Once days are classified as normal or major event days, appropriate analysis and reporting can be conducted. After this document is balloted, the working group will continue to investigate the major event definition by reviewing catastrophic events and days with zero events to determine if enhancements are warranted.

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CONTENTS

1.	Overview.....	1
1.1	Scope.....	1
1.2	Purpose.....	1
2.	References.....	1
3.	Definitions	2
4.	Reliability indices	4
4.1	Basic factors.....	4
4.2	Sustained interruption indices.....	5
4.3	Load based indices.....	7
4.4	Other indices (momentary)	7
4.5	Major event day classification	8
5.	Application of the indices	11
5.1	Sample system	12
5.2	Calculation of indices for a system with no major event days	13
5.3	Examples.....	14
6.	Information about the factors which affect the calculation of reliability indices	17
6.1	Rationale behind selecting the indices provided in this guide.....	17
6.2	Factors that cause variation in reported indices.....	17
	Annex A (informative) Survey of reliability index usage	18
	Annex B (informative) Major events definition development.....	27
	Annex C (informative) Internal data subset.....	35
	Annex D (informative) Bibliography	36

IEEE Guide for Electric Power Distribution Reliability Indices

1. Overview

1.1 Scope

This guide identifies distribution reliability indices and factors that affect their calculation. It includes indices, which are useful today, as well as ones that may be useful in the future. The indices are intended to apply to distribution systems, substations, circuits, and defined regions.

1.2 Purpose

The purpose of this guide is twofold. First, it is to present a set of terms and definitions which can be used to foster uniformity in the development of distribution service reliability indices, to identify factors which affect the indices, and to aid in consistent reporting practices among utilities. Secondly, it is to provide guidance for new personnel in the reliability area and to provide tools for internal as well as external comparisons. In the past, other groups have defined reliability indices for transmission, generation, and distribution but some of the definitions already in use are not specific enough to be wholly adopted for distribution. Users of this guide should recognize that not all utilities would have the data available to calculate all the indices.

2. References

The following standards shall be used, when applicable, in preparing manuscripts. When the following standard is superseded by an approved revision, the revision shall apply.

IEEE Std. 859™-1987(R2002), IEEE Standard Terms for Reporting and Analyzing Outage Occurrences and Outage States of Electrical Transmission Facilities.^{1, 2}

IEEE Std 493™-1997(R2002), Recommended Practice for Design of Reliable Industrial and Commercial Power Systems.

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3. Definitions

Definitions are given here to aid the user in understanding the factors that affect index calculation. Many of these definitions were taken directly from *The Authoritative Dictionary of IEEE Standards Terms*, 7th Edition [B9]³. If there is a conflict between the definitions in this document and the dictionary, the definitions in this document take precedence. Others are given because they have a new interpretation within this document or have not been previously defined.

3.1 connected load: Connected transformer kVA, peak load, or metered demand (to be clearly specified when reporting) on the circuit or portion of circuit that is interrupted. When reporting, the report should state whether it is based on an annual peak or on a reporting period peak.

3.2 customer: A metered electrical service point for which an active bill account is established at a specific location (e.g., premise).

3.3 customer count: The number of customers either served or interrupted depending on usage.

3.4 distribution system: That portion of an electric system that delivers electric energy from transformation points on the transmission system to the customer.

NOTE—The distribution system is generally considered to be anything from the distribution substation fence to the customer meter. Often the initial overcurrent protection and voltage regulators are within the substation fence and are considered to be part of the distribution system.

3.5 forced outage: The state of a component when it is not available to perform its intended function due to an unplanned event directly associated with that component.

3.6 interrupting device: An interrupting device is a device whose purpose is to interrupt the flow of power, usually in response to a fault. Restoration of service or disconnection of loads can be accomplished by manual, automatic, or motor-operated methods. Examples include transmission circuit breakers, feeder circuit breakers, line reclosers, line fuses, sectionalizers, motor-operated switches or others.

3.7 interruption: The loss of service to one or more customers connected to the distribution portion of the system. It is the result of one or more component outages, depending on system configuration. *See also:* outage.

3.8 interruption duration: The time period from the initiation of an interruption to a customer until service has been restored to that customer. The process of restoration may require restoring service to small sections of the system (see 5.3.2) until service has been restored to all customers. Each of these individual steps should be tracked collecting the start time, end time and number of customers interrupted for each step.

3.9 interruptions caused by events outside of the distribution system: Outages that occur on generation, transmission, substations, or customer facilities that result in the interruption of service to one or more customers. While generally a small portion of the number of interruption events, these interruptions can affect a large number of customers and last for an exceedingly long duration.

3.10 lockout: Refers to the final operation of a recloser or circuit breaker in an attempt to isolate a persistent fault, or to the state where all automatic reclosing has stopped. The current-carrying contacts of the overcurrent protecting device are locked open under these conditions.

3.11 loss of service: A complete loss of voltage on at least one normally energized conductor to one or more customers. This does not include any of the power quality issues such as: sags, swells, impulses, or harmonics.

³The numbers in brackets correspond to those of the bibliography in Annex D.

3.12 major event: Designates an event that exceeds reasonable design and or operational limits of the electric power system. A Major Event includes at least one Major Event Day (MED).

3.13 major event day: A day in which the daily system SAIDI exceeds a threshold value, T_{MED} . For the purposes of calculating daily system SAIDI, any interruption that spans multiple calendar days is accrued to the day on which the interruption began. Statistically, days having a daily system SAIDI greater than T_{MED} are days on which the energy delivery system experienced stresses beyond that normally expected (such as severe weather). Activities that occur on major event days should be separately analyzed and reported. (See 4.5.)

3.14 momentary interruption: A single operation of an interrupting device that results in a voltage zero. For example, two circuit breaker or recloser operations (each operation being an open followed by a close) that momentarily interrupts service to one or more customers is defined as two momentary interruptions.

3.15 momentary interruption event: An interruption of duration limited to the period required to restore service by an interrupting device.

NOTE—Such switching operations must be completed within a specified time of 5 min or less. This definition includes all reclosing operations that occur within five minutes of the first interruption. For example, if a recloser or circuit breaker operates two, three, or four times and then holds (within 5 min of the first operation), those momentary interruptions shall be considered one momentary interruption event.

3.16 outage (electric power systems): The state of a component when it is not available to perform its intended function due to some event directly associated with that component.

NOTE—

- (1) An outage may or may not cause an interruption of service to customers, depending on system configuration.
- (2) This definition derives from transmission and distribution applications and does not apply to generation outages.

3.17 planned interruption: A loss of electric power that results when a component is deliberately taken out of service at a selected time, usually for the purposes of construction, preventative maintenance, or repair.

NOTE—

- (1) This derives from transmission and distribution applications and does not apply to generation interruptions.
- (2) The key test to determine if an interruption should be classified as a planned or unplanned interruption is as follows: if it is possible to defer the interruption, the interruption is a planned interruption; otherwise, the interruption is an unplanned interruption.

3.18 planned outage: The state of a component when it is not available to perform its intended function due to a planned event directly associated with that component.

3.19 reporting period: The time period from which interruption data is to be included in reliability index calculations. The beginning and end dates and times should be clearly indicated. All events that begin within the indicated time period should be included. A consistent reporting period should be used when comparing the performance of different distribution systems (typically one calendar year) or when comparing the performance of a single distribution system over an extended period of time. The reporting period is assumed to be one year unless otherwise stated.

3.20 step restoration: A process of restoring interrupted customers downstream from the interrupting device/component in stages over time.

3.21 sustained interruption: Any interruption not classified as a part of a momentary event. That is, any interruption that lasts more than 5 minutes.

3.22 total number of customers served: The average number of customers served during the reporting period. If a different customer total is used, it must be clearly defined within the report.

3.23 unplanned interruption: An interruption caused by an unplanned outage.

4. Reliability indices

4.1 Basic factors

These basic factors specify the data needed to calculate the indices.

i denotes an interruption event

r_i	=	Restoration Time for each Interruption Event
CI	=	Customers Interrupted
CMI	=	Customer Minutes Interrupted
E	=	Events
T	=	Total
IM_i	=	Number of Momentary Interruptions
IM_E	=	Number of Momentary Interruption Events
N_i	=	Number of Interrupted Customers for each Sustained Interruption event during the Reporting Period
N_{mi}	=	Number of Interrupted Customers for each Momentary Interruption event during the Reporting Period
N_T	=	Total Number of Customers Served for the Areas
L_i	=	Connected kVA Load Interrupted for each Interruption Event
L_T	=	Total connected kVA Load Served
CN	=	Total Number of Customers who have Experienced a Sustained Interruption during the Reporting Period
$CNT_{(k>n)}$	=	Total Number of Customers who have Experienced more than n Sustained Interruptions and Momentary Interruption Events during the Reporting Period.
k	=	Number of Interruptions Experienced by an Individual Customer in the Reporting Period
T_{MED}	=	Major event day identification threshold value.

4.2 Sustained interruption indices

4.2.1 System average interruption frequency index (SAIFI)

The system average interruption frequency index indicates how often the average customer experiences a sustained interruption over a predefined period of time. Mathematically, this is given in Equation (1).

$$\text{SAIFI} = \frac{\sum \text{Total Number of Customers Interrupted}}{\text{Total Number of Customers Served}} \quad (1)$$

To calculate the index, use Equation (2) below.

$$\text{SAIFI} = \frac{\sum N_i}{N_T} = \frac{\text{CI}}{N_T} \quad (2)$$

4.2.2 System average interruption duration index (SAIDI)

This index indicates the total duration of interruption for the average customer during a predefined period of time. It is commonly measured in customer minutes or customer hours of interruption. Mathematically, this is given in Equation (3).

$$\text{SAIDI} = \frac{\sum \text{Customer Interruption Durations}}{\text{Total Number of Customers Served}} \quad (3)$$

To calculate the index, use Equation (4).

$$\text{SAIDI} = \frac{\sum r_i N_i}{N_T} = \frac{\text{CMI}}{N_T} \quad (4)$$

4.2.3 Customer average interruption duration index (CAIDI)

CAIDI represents the average time required to restore service. Mathematically, this is given in Equation (5).

$$\text{CAIDI} = \frac{\sum \text{Customer Interruption Duration}}{\text{Total Number of Customers Interrupted}} \quad (5)$$

To calculate the index, use Equation 6.

$$\text{CAIDI} = \frac{\sum r_i N_i}{\sum N_i} = \frac{\text{SAIDI}}{\text{SAIFI}} \quad (6)$$

4.2.4 Customer total average interruption duration index (CTAIDI)

This index represents the total average time in the reporting period that customers who actually experienced an interruption were without power. This index is a hybrid of CAIDI and is similarly calculated except that those customers with multiple interruptions are counted only once. Mathematically, this is given in Equation (7).

$$\text{CTAIDI} = \frac{\sum \text{Customer Interruption Duration}}{\text{Total Number of Customers Interrupted}} \quad (7)$$