IEEE Guide for Performing Arc-Flash Hazard Calculations

IEEE Industry Applications Society

Sponsored by the
Petroleum and Chemical Industry Committee

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USA

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(Revision of IEEE Std 1584-2002,
as amended by IEEE Std 1584a™-2004
and IEEE Std 1584b™-2011)

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Abstract: This guide provides mathematical models for designers and facility operators to apply in determining the arc-flash hazard distance and the incident energy to which workers could be exposed during their work on or near electrical equipment.

Keywords: arc blast, arc fault currents, arc flash, arc-flash boundary, arc-flash hazard, arc-flash hazard analysis, arc-flash hazard marking, arc in enclosures, arc in open air, electrical hazard, IEEE 1584™, incident energy, personal protective equipment, PPE, protective device coordination study, short-circuit study, working distances

Information related to the topic of this standard is available at https://standards.ieee.org/content/dam/ieee-standards/standards/web/download/1584-2018_downloads.zip and https://ieee-dataport.org/documents/arc-flash-phenomena.

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Introduction

This introduction is not part of IEEE Std 1584-2018, IEEE Guide for Performing Arc-Flash Hazard Calculations.

A technical paper, "The other electrical hazard: electric arc blast burns," by Ralph Lee [B67][1] provided insight that electric-arc burns make up a substantial portion of the injuries from electrical malfunctions. Mr. Lee identified that electric arcing is the term applied to current passing through vapor from the arc terminal conductive metal or carbon material. The extremely high temperatures of these arcs can cause fatal burns at up to about 1.5 m (5 ft) and major burns at up to about 3 m (10 ft) distance from the arc. Additionally, electric arcs expel droplets of molten terminal material that shower the immediate vicinity, similar to but more extensive than that from electric arc welding. These findings started to fill a void created by early works that identified electric shock as the major electrical hazard. Mr. Lee's work also helped establish a relationship between time to human tissue cell death and temperature, as well as a curable skin burn time-temperature relationship. Once forensic analysis of electrical incidents focused on the arc-flash hazard, experience over a period of time indicated that Mr. Lee's formulas for calculating the distance-energy relationship from the source of arc did not serve to reconcile the greater thermal effect on persons positioned in front of opened doors or removed covers, from arcs inside electrical equipment enclosures.

A technical paper, "Predicting incident energy to better manage the electric arc hazard on 600 V power distribution systems," by Doughty, Neal, and Floyd [B29] presented the findings from many structured tests using both "arcs in open air" and "arcs in a cubic box." These three-phase tests were performed at the 600 V rating and are applicable for the range of 16 000 A to 50 000 A short-circuit fault current. It was established that the contribution of heat reflected from surfaces near the arc intensifies the heat directed toward the opening of the enclosure.

The focus of industry on electrical safety and recognition of arc-flash burns highlighted the need for protecting workers from arc-flash hazards. There are limitations in applying the currently known formulas for calculating incident energy and arc-flash boundary as discussed throughout this guide, which uses empirically derived models based on statistical analysis and curve fitting of the overall test data available as well as an understanding of electrical arc physics. This is a guide that can help inform worker and worksite considerations, but specific worksite variables and considerations must be evaluated.

The P1584 working group organized testing and developed a model of incident energy that was published in the 2002 version of this guide. The model detailed in IEEE Std 1584-2002 has been used with success throughout industry. There are numerous variables in addition to those included in the 2002 model that can increase or decrease the value of incident energy from an arcing fault. Other researchers, during their testing, have found significantly different values than those calculated using that model. The updated model of incident energy documented in this guide was developed from further testing organized by the IEEE/NFPA Collaborative Arc Flash Research Project.

[1]The numbers in brackets correspond to those of the bibliography in Annex A.

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1. Overview

1.1 Scope

This guide provides models and an analytical process to enable calculation of the predicted incident thermal energy and the arc-flash boundary. The process covers the collection of field data if applicable, consideration of power system operating scenarios, and calculation parameters. Applications include electrical equipment and conductors for three-phase alternating current (ac) voltages from 208 V to 15 kV. Calculations for single-phase ac systems and direct current (dc) systems are not a part of this guide, but some guidance and references are provided for those applications. Recommendations for personal protective equipment (PPE) to mitigate arc-flash hazards are not included in this guide.

1.2 Purpose

The purpose of the guide is to enable qualified person(s) to analyze power systems for the purpose of calculating the incident energy to which employees could be exposed during operations and maintenance work. Contractors and facility owners can use this information to help provide appropriate protection for employees in accordance with the requirements of applicable electrical workplace safety standards.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 242™, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (*IEEE Buff Book*™).[2,3,4,5]

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[5]IEEE 3004 Standards: Protection and Coordination covers material from IEEE Std 242 (*IEEE Buff Book*) and IEEE Std 1015 (*IEEE Blue Book*).