



PRACTICE ADVISORY

UPDATED STANDARD – IEEE 1584 - IEEE GUIDE FOR PERFORMING ARC-FLASH HAZARD CALCULATIONS

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This practice advisory has been issued to inform members and licensees of Engineers and Geoscientists BC (Engineering Professionals) about updates to the Institute of Electrical and Electronics Engineers (IEEE) standard titled IEEE 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations. The updated standard and guide, which was published on November 30, 2018, is referred to in this document as IEEE 1584-2018.

IEEE 1584-2018 provides models and an analytical process for calculating the predicted incident energy and the arc flash boundary for energized electrical equipment, where an arcing fault and arc flash event may occur due to an abnormal condition.

The updated IEEE 1584-2018 standard provides updated formulas from the 2002 edition (IEEE 1584-2002) for estimating incident energy produced by arcing fault events to which employees could be exposed during their work on or near electrical equipment. The 2018 updates were developed from further testing organized collaboratively by IEEE and the National Fire Protection Association (NFPA).

Engineering Professionals should ensure that when a new or updated arc flash hazard analysis is required, they perform the analysis to the updated IEEE 1584-2018 standard. Engineering Professionals must not rely on overly conservative enveloping assumptions to simplify their analysis, as to do so may result in significant adverse costs or maintainability effects for clients from unnecessarily onerous increases in personal protective equipment (PPE) requirements and hazard mitigation efforts. Similarly, Engineering Professionals must not assume that calculations based on IEEE 1584-2002 are still appropriate, as calculations based on IEEE 1584-2018 may indicate lower or higher incident energy levels than those calculated based on IEEE 1584-2002. Engineering Professionals should also refer to the Canadian Standards Association (CSA) standard CSA Z462 Workplace Electrical Safety for the recommended frequency of and conditions for when an arc flash hazard incident energy analysis should be performed.

BACKGROUND

The original IEEE 1584 standard, released in 2002, provided interested parties with a consistent method for estimating the incident energy thermal hazard to which employees could be exposed during an arcing fault and arc flash event for 50 Hz to 60 Hz, three-phase, 208 V AC to 15 kV AC electrical equipment. The 2018 update to the standard, published on November 30, 2018, accounts for additional testing and research on arcing faults and arc flash events, and expands the electrical equipment conditions and configurations under which these events can occur and that are accounted for in the calculation models.

The updates are summarized below; however, Engineering Professionals working in this area should refer to IEEE 1584-2018, as specific details in that document cannot be provided in this concise practice advisory. Review of this practice advisory is not a substitute for site- or project-specific interpretation of the standard. Additionally, for specific recommendations for completing the analysis and writing the report, Engineering Professionals should refer to IEEE 1584.1 IEEE Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study in Accordance with IEEE Std 1584.

SUMMARY OF RELEVANT CANADIAN ELECTRICAL CODE REQUIREMENTS, WORKSAFEBC HEALTH AND SAFETY REGULATIONS, AND TECHNICAL SAFETY BC DIRECTIVES

The Province of British Columbia, through WorkSafeBC, provides regulations outlining specific requirements for electrical safety in the Occupational Health and Safety (OHS) Regulation Part 19: Electrical Safety. Employers must inform workers of potential electrical hazards before they work in proximity to energized electrical conductors and equipment.

If it is not possible to completely disconnect low- or high-voltage electrical equipment, as required by Rule 2-304 Disconnection of C22.1-15 Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations (see also the Technical Safety BC Directive D-EL 2016-02, titled BC Electrical Code Section 2 General Rules), energized work tasks must be performed by a qualified and authorized worker and completed in accordance with written safe work procedures. These procedures must specify the requirements for using appropriate PPE and insulated hand tools, to mitigate hazards and risks associated with the voltage of the operating electrical equipment. Minimum warning label requirements are stated in Rule 2-306 of the CE Code, Part 1.

These minimum requirements are further supplemented with recommendations for using detailed Arc Flash and Shock Hazard equipment labels (described in CSA Z462-18 Workplace Electrical Safety, Clause 4.3.5.7) that contain the results of the incident energy study or arc flash PPE category method; however, these recommendations are not discussed in this practice advisory.

UPDATED CALCULATION METHODS AND VOLTAGE RANGE

The updates to IEEE 1584-2018, published on November 30, 2018, are based on extensive collaborative research undertaken by IEEE and NFPA. The original IEEE 1584-2002 model was re-evaluated to consider new technical information related to arcing fault physics. This resulted in a specific review of the test box sizes and electrode configurations. The range of the IEEE 1584 model has been changed and is now segregated into two sets—208 V to 600 V and 601 V to 15 kV—with each set having several parameters, such as bolted fault current and conductor spacing. Engineering Professionals should consult the IEEE 1584-2018 standard for a more detailed review and additional information.

Note that for systems outside the range of the IEEE 1584 model, including DC systems, other methods are available for calculating arc flash hazard incident energy. Several of these methods are summarized in CSA Z462-18 Workplace Electrical Safety, Appendix D, which specifically references the IEEE 1584-2002 standard; therefore, Engineering Professionals are advised to ensure they review the specific technical requirements of the IEEE 1584-2018 standard.

SHORT CIRCUIT AND SYSTEM MODES OF OPERATION

To complete the incident energy analysis calculations, the available range of short-circuit currents at specific locations on electrical equipment within the power system must first be calculated. A single mode of operation (scenario) or multiple modes of operation can be considered, depending on system complexity (for example, bus-tie breakers, utility supply, or emergency generator supply). The Engineering Professional's report should summarize the system modes of operation that were reviewed and indicate the mode(s) that were selected for calculating the incident energy. The fact that the most common operating mode (for example, utility) may provide the lowest incident energy results, and that the worst-case scenario may only exist for specific scenarios (for example, emergency generators on) should be considered.

Engineering Professionals should be familiar with the short-circuit calculation methods provided in IEEE 141-1993 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book). The information input to the short-circuit study should be realistic and should not bias the results towards a higher short-circuit current (as is common in short-circuit calculations for equipment-rating purposes), as that may produce artificially low calculated incident energy and result in inappropriate PPE selection.

PROTECTION AND COORDINATION STUDY

When completing an arc flash hazard incident energy analysis study, a review of the power system protection and coordination will be required. Engineering Professionals should ascertain owner or client preferences and maintenance practices when determining approaches to protection and coordination.

When conducting such a study, Engineering Professionals must ensure electrical equipment protective devices and the configuration for effective coordination are considered. Coordination must balance loading conditions along with quick isolation of faults, because simply reducing trip times to reduce incident energy levels may result in unnecessary trips. It should be recognized that although incident energy reduction methods such as the addition of maintenance mode switches are valid, there is a risk that miscoordination can occur during maintenance activities. The Engineering Professional's report should indicate that protective device fault clearing times are based on manufacturer's time current curves. Additionally, it should be noted that effective maintenance of protective devices is the responsibility of the owner of the electrical equipment, and the results in the report assume that the minimum maintenance was completed by the owner. When incident energy reduction methods are assessed, they may include additional relay protection schemes or arc flash relays.

CONSIDERATIONS AND MODELLING OF EQUIPMENT PHYSICAL CHARACTERISTICS

The most notable change in IEEE 1584-2018 is the ability to account for physical properties of the electrical distribution equipment. This includes the modelling of the conductor gap, the dimensions of the enclosure in which the arcing fault is being calculated, and the physical orientation of the conductors. The effects of enclosure dimension and appropriate application of correction factors, and, most significantly, the effects of the proper selection of electrode configuration, should be thoroughly understood by the Engineering Professional performing these studies.

WORKING DISTANCES

As noted in IEEE 1584-2018, Table 10 – Classes of Equipment and Typical Working Distances, the default working distances listed in the table should be used for the specific electrical equipment being analyzed. Working distances can be altered, based on the specific electrical equipment or on the methods being used to increase the working distance, but the reasons for doing so must be explicitly noted in the Engineering Professional's report.

APPLICABILITY TO LOW VOLTAGE SYSTEMS AND ELECTRICAL EQUIPMENT

The IEEE 1584 standard applies to only three-phase power systems and, as noted above, to 50 Hz to 60 Hz, three-phase, 208 V AC to 15 kV AC power systems. IEEE 1584-2018 does not apply to single-phase 120/240 V electrical equipment, and if the formulas are used for such systems, the incident energy result is expected to be conservative. IEEE 1584-2018 does not apply to DC electrical equipment, and other formulas that are included in power system software should be referenced and used.

Some additional testing for three-phase 208 V AC was completed for IEEE 1584-2018, and the following statement is included in IEEE 1584-2018, Section 4.3 Model Application Overview:

“Sustainable arcs are possible but less likely in three-phase systems operating at 240V nominal or less with available short-circuit current less than 2000A.”

In IEEE 1584-2002, a lower threshold transformer size of less than 125 kVA was provided for sustaining an arcing fault. With IEEE 1584-2018, this transformer kVA rating would be lowered to greater than 30 kVA, depending on the transformer impedance. Note that the CSA Z462 Workplace Electrical Safety standard provides an alternative method to determine additional protective measures for an arc flash risk assessment that an employer can use for 208 V AC three-phase electrical equipment. The Engineering Professional should ensure that if 208 V AC electrical equipment is modelled for electrical equipment serviced by a 30 kVA or larger transformer, then that information must be included in the report along with a reference to the IEEE 1584-2018 statement above.

Regarding distribution equipment operation at 208 V and below, when the short-circuit current is less than 2,000 A, the Engineering Professional should consider the possibility of sustaining an arc; depending on the likelihood of arc occurrence, inclusion in the studies should be considered. This decision should be made in consultation with the owner or client and should not be left to the sole discretion of the Engineering Professional.

Where the electrical equipment voltage is 120/240 V AC, single-phase no-incident energy calculations are required.

REQUIRED UPDATES OF EXISTING ANALYSES

There is no specific guidance that requires prior incident energy analyses and studies to be updated immediately. However, the CSA Z462 Workplace Electrical Safety standard mandates that incident energy analysis be reviewed for accuracy every five years, or updated whenever changes to the electrical system occur that could affect the analysis.

Therefore, given the nature of the updates to the applicable standard, it is probable that arc flash hazard analysis calculations will require updating for maintenance tasks, either where the analysis was previously completed or for new projects in progress.

PRACTICAL CONSIDERATIONS

Engineering Professionals who perform arc flash hazard analysis calculations should:

- review and update any analysis software packages that are being used to perform such analyses, to ensure that they are up to date and include the latest IEEE 1584-2018 formulas; and
- ensure they are sufficiently trained and familiar with the configuration requirements of analysis software and the interpretation and application of the IEEE 1584-2018 standard so they are able to apply it correctly.

Engineering Professionals have an ethical obligation under the first principle of the Code of Ethics of Engineers and Geoscientists BC to hold paramount the safety of the public and to promote health and safety within the workplace. In accordance with this principle, Engineering Professionals should undertake the following activities:

- If they are employed by owners, or are owners themselves, of electrical equipment that presents an arcing fault and arc flash hazard under abnormal operating conditions, Engineering Professionals must initiate a plan to update the arc flash hazard incident energy analysis calculations for such electrical equipment.
- If they have performed or reviewed arc flash hazard incident energy calculations to the previous standard, Engineering Professionals should inform their clients of the existence of the updated standard and the potential safety impacts, and should communicate a recommendation to update any existing incident energy calculations for the affected electrical equipment. Note that in such a case, the client can decide to defer updating their existing studies.
- If they are providing arc flash hazard incident energy calculations to clients, Engineering Professionals should understand the ways in which unnecessarily conservative modelling (for example, defaulting to HCB [horizontal conductors/electrodes in a metal box/enclosure] configuration) creates additional hazards and exposure risks to the qualified electrical worker who consequently has to perform work in excessive PPE.

ARC FLASH AND SHOCK EQUIPMENT LABELS

Engineering Professionals can recommend that owners or clients obtain Arc Flash and Shock equipment labels to apply to electrical equipment.

Detailed content of the equipment label is recommended in CSA Z462 Workplace Electrical Safety, under Clause 4.3.5.7 and Annex Q, but not in IEEE 1584. Note that the default examples in the power system analysis software may not be compliant.

ANALYSIS REPORT ISSUED TO CLIENT

Engineering Professionals are advised that the presentation of their technical analysis in a report issued to the client should meet minimum requirements for good engineering practices.

Engineering Professionals should consult the IEEE 1584 standard, under Section 6 Analysis Process, and IEEE 1584.1-2013 - IEEE Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study in Accordance with IEEE Std 1584.

The IEEE-1584.1 document was published in 2013 and is being updated by the IEEE. Currently, IEEE 1584.1-2013 specifically refers to the IEEE 1584-2002 standard. Therefore, Engineering Professionals should ensure they review the specific technical requirements of the IEEE 1584-2018 standard, but can reference IEEE 1584.1-2013 for requirements for the scope and deliverable, including the recommended detailed content of the authenticated report issued to a client. Specific reference should be made to IEEE 1584.1-2013, Section 10 Report, Results, and Recommendations and Annex B Task Matrix of Work Items for Arc-Flash Analysis.

RELATED DOCUMENTS

Canadian Standards Association (CSA). 2018. C22.1-18 Canadian Electrical Code, Part I (24th edition), Safety Standard for Electrical Installations. www.csagroup.org.

CSA. 2018. Z462-18 Workplace Electrical Safety. www.csagroup.org.

Institute of Electrical and Electronics Engineers (IEEE). 2018. IEEE 1584-2018 - IEEE Guide for Performing Arc-Flash Hazard Calculations. <https://standards.ieee.org/standard/1584-2018.html>.

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Technical Safety British Columbia. 2019. [website]. www.technicalafetybc.ca.

WorkSafeBC. 2019. [website]. www.worksafefbc.com.

VERSION HISTORY

VERSION NUMBER	PUBLISHED DATE	DESCRIPTION OF CHANGES
1.0	November 4, 2019	Initial version.

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