EC&M

EXECUTIVE SUMMARY

IEEE 1584 Revisions: Significant Changes on the Way for Arc Flash Calculation Analysis

- The new IEEE 1584 should be more accurate but will be more complex than the 2002 version.
- The new version of the guide adds three new electrode configurations.
- The new model introduces a new calculation method.
- IEEE 1584 2.0 has a number of new variables improving calculation accuracy.
- Considerations for implementing the new IEEE 1584 in the real world.

OCTOBER 18, 2018

Marcelo E. Valdes, P.E., Electrical Products division, ABB

in partnership with

ABB

EXECUTIVE SUMMARY

IEEE 1584 Revisions: Significant Changes on the Way for Arc Flash Calculation Analysis

Overview

In 2002, the Institute of Electrical and Electronics Engineers (IEEE) developed a model for incident energy, which was published in IEEE 2002: Guide to Arc Flash Calculations. The IEEE is now in the process of updating that guide, with the new IEEE 2.0 expected to be released in late 2018 or early 2019.

The new guide is expected to be more accurate than the original version, accounting for more variables within the hazard environment. Although it is more representative of actual conditions, it may not account for all real-world situations and use cases that can occur.

Context

Marcelo Valdes reviewed the major changes in the new IEEE 2.0 and shared considerations for implementing the new guide in the real world.

Key Takeaways

The new IEEE 1584 should be more accurate but will be more complex than the 2002 version.

When it was released in 2002, IEEE 1854 defined the science of arc flash for the process of risk assessment when working near electrical energy operating below 15,000 volts. But this was not intended to be a perfect definition of all real-world situations. It was an estimating tool for situations, most applicable where the situation was similar to the test protocol used. The new testing project had increased funding and more tests, and allowed for a more varied set of test protocols. This led to a more complete, more accurate, but more complex model that improves upon the science, yet still has the potential for accurately reflecting real-world situations in some cases.

Testing and Complexity Differences in IEEE 1854

Area of Difference	2002 Version	Version 2.0
Funds for testing	$100,000	Several million dollars
Number of experiments	< 300	Approximately 2,000
Pages of math formulas	Approximately 3 page of math formulas	17 pages of formulas, coefficients, and exponents
Variables		Includes more variables for a more representative model of actual conditions

[IEEE 2.0] will not be a perfect replica of the real world. It's important that people realize what the potential errors are and how they relate to the real-world situation.

Marcelo E. Valdes

The new version of the guide adds three new electrode configurations.

The biggest difference between the current model of IEEE 1854 and the new model is the number of electrode configurations: the electrical conductors that can sustain the electric arc. Three new configurations were added, along with a new direction allowing for horizontal electrodes.

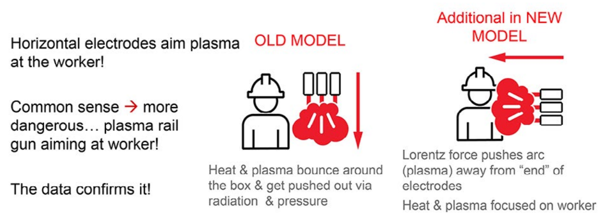
IEEE 1584 Revisions: Significant Changes on the Way for Arc Flash Calculation Analysis

Five Electrode Configurations and Considerations

Electrode Configuration	Considerations
Vertical electrodes inside a metal box enclosure (VCB)	– Assumes the arc is aimed within the box, reflecting heat and smoke created by the event within the box, with the plasma not directed at the worker – No attempt was made to take into account materials within the box, such as cables and insulating materials, that could impact the direction of the energy, or possibly creating more hazard than the model predicts
Vertical electrodes terminated in a barrier inside a closed box (VCBB) – *New*	– Assumes electrodes are near the bottom of the enclosure or there is a barrier, constricting the arc, generally resulting in a higher level of energy directed toward the worker
Horizontal electrodes inside a metal box (HCB) – *New*	– Common in larger equipment, an example may be switchgear runbacks – In this configuration the electrodes act to propel the arc (plasma) toward the worker
Vertical electrodes in open air (VOA)	– Typically used outside, such as in outdoor switch yards – Electrodes are vertical, but the worker may be directly beneath them; whether the electrodes are perpendicular or parallel to the worker may be more important than whether they are vertical or horizontal!
Horizontal electrodes in open air (HOA) - *New*	– Tested with electrodes in a horizontal row – An example of where real world is different may be transformer terminals arranged in a triangular pattern. The arc may be more stable, will the energy be more? How much more if so? The guide does not address this!

The old model focused only on vertical electrodes, while the new model adds in horizontal electrode configurations and vertical with constricted space at the end. With horizontal configurations, the worker is expected to be perpendicular to the electrodes and more likely to be in the direct path of the plasma in an arc flash event. The worker is parallel to the electrodes in most, but maybe not all, vertical configurations, which can decrease the impact of the heat and plasma.

In any one cubicle or space the worker is exposed to there may be multiple electrode configurations, each with different arcing current and incident energy predictions. Each may need to be considered for proper risk management implementation.



The new model introduces a new calculation method.

The new model uses a two-step process to calculate arcing current, incident energy, and arc flash boundary. The calculation uses a different method for 600 volts (V) and higher, and 208V to 600V. Similar in concept to the old model, which set the threshold at 1000V and lower, and 1000V and higher, this new model differs in that the results are not discontinuous as they were previously. The new calculation also allows for correction factors for enclosure size variation from the normalized values used for the initial prediction.

IEEE 1584 Revisions: Significant Changes on the Way for Arc Flash Calculation Analysis

Working distance guidance is similar to that from before but a clear definition of a minimum distance for which the calculations are applicable was added (12 inches). For most work, the recommendation is that the working distance should be 18", since 24" implies the electrodes are deep within a cubicle where they are hard to reach. A risk assessment can best determine the right working distance, which should be no less than 12".

Working Distance Guidance

- 36" for hot stick work
- 24" for deep cubicles
- 18" for most manual work (recommended)
- 12" minimum

When developing new labels, it should be considered that the label is valuable data to be used for a future risk assessment and PPE selection. Confusion caused by multiple labels or excess information or complexity may increase the risk of an error. The label should generally reflect a realistic and conservative assumption of the worst-case scenario for that piece of equipment.

IEEE 1584 2.0 has a number of new variables improving calculation accuracy.

The new model includes a number of new variables, as well as some changes to existing variables, that improve the overall accuracy of calculation.

Calculation Variable Differences: Current Model vs. New Model	
Existing variables	– Gap, typically equipment-driven – Working distance – Operating voltage – Available short current – Box (yes/no) – Grounding
New variables	– Electrode orientation – Electrode environment; e.g., barriers – Box size considerations – More variable gap considerations – Arcing current – Incident energy – Approach boundary
Removed variables from 2.0	– Grounding; determined not to have an impact

The new model will still yield an arcing current, incident energy, and an approach boundary, just like in the old model, but with more accuracy.

Considerations for implementing the new IEEE 1584 in the real world.

Guidance in the new IEEE 1584 is more accurate because of the significant number of tests run to develop the new standard. However, even with updates and changes in the model, it does not completely reflect all real-world applications. A number of ways to approach application in the real world are:

- Understand the test protocol and model and how they compare to the real world and the real equipment that needs to be modeled.

IEEE 1584 Revisions: Significant Changes on the Way for Arc Flash Calculation Analysis

- **Understand the direction of possible error** and the effect of the difference, and determine how to take that into account.
- **Know that protection sensitivity and speed** become more important, especially as some modes of arcing faults will yield more energy and potentially less arcing current.
- **Decrease exposure** of workers and keep them further away from live conductors, when possible, using communications, a human machine interface (HMI), diagnostics, controls, and conditioned-based maintenance.
- **Use Prevention through Design (PtD)** techniques, products, and processes.
- **Turn off equipment,** use proper lock out and tag-out techniques. Look to personal protective equipment (PPE) as the last resort.

> *Realize that the investments you make to increase safety can also result in better maintenance, communications, HMIs, diagnostics, and controls..*
>
> Marcelo E. Valdes

Mr. Valdes also recommends using the hierarchy of hazard control measures from the American National Standards Institute (ANSI), focusing on the top three for automatic or permanent hazard reduction.

Other Important Point

- Direct Current (DC) is not yet included in the guide but is under consideration. Those interested in this topic should contact the IEEE 1584 working group to provide input.

Hierarchy Hazard Controls and Examples of Arc Flash Incident Energy Control

Hierarchy of Hazard Control Measures (ANSI Z10) *From most effective (1) to least effective (6)*	**Examples of Arc Flash Incident—Energy Control Mechanisms**
1. Elimination of the hazard	Secured and verified de-energization
2. Substitution of less hazardous equipment or materials	Smaller transformers, lower voltage, insulated bus bars, internal barriers
3. Engineering control to reduce exposure or severity	Faster overcurrent protection, energy shunting devices
4. Warnings, signs, and other communicators	Signage, training, indicating lights
5. Administrative control, including safe work practices	Maintenance switch, specific work practices
6. PPE	PPE per applicable standards, temporary barriers

IEEE 1584 Revisions: Significant Changes on the Way for Arc Flash Calculation Analysis

Biography

Marcelo E. Valdes, P.E.
Electrification Products division, ABB

Mr. Valdes was with GE 41 years in field engineering, sales, product management, marketing and application engineering. Since July 2018 he is with ABB's Electrical Products division. Mr. Valdes is past chair of various IEEE PES and IAS chapters in Northern California as well as past chair of the 2014 IEEE Electrical Safety Workshop (IEEE-ESW). Mr. Valdes chairs the IEEE 1683-2014 working group "IEEE P1683 Guide for Specification and Selection of Low Voltage Motor Control Centers with Enhanced Safety Features" and is active in various other IEEE working groups, mostly in electrical safety and electrical systems protection.