IEEE 1584 – IEEE GUIDE FOR ARC-FLASH HAZARD CALCULATIONS

A lot has happened since September 23, 2002 when IEEE 1584 – IEEE Guide for Arc-Flash Hazard Calculations was first published. At the time of its introduction there were no other technical standards available that provided equations to calculate the arcing short circuit current, prospective incident energy and the arc flash boundary. Since it's introduction, IEEE 1584 has gained widespread global use for conducting arc flash studies and the equations are often at the heart of arc flash software.

By Jim Phillips, P.E.

The development of this land mark standard included conducting over 300 arc flash tests (considered a lot back in its day) which were used to create the empirically derived equations. Applicable for three phase systems and voltages ranging from 208 volts to 15,000 volts, there are four main calculation methods:

- Arcing short circuit current - systems less than 1000 V
- Arcing short circuit current - systems from 1000 to 15,000 V
- Incident Energy
- Flash Hazard Boundary (known today as the Arc Flash Boundary)

Although the 2002 edition was the first generation arc flash standard and included many factors such as the effect of equipment types, conductor gap distances, differences in the rate of decay of incident energy with distance and more, it was still the first generation and there was room for improvement. Global experts such as Dr. Sweeting of Australia pointed out some of the areas where further research was needed for the next edition.

One area is that the arc flash tests used for the 2002 edition were based on the electrodes placed in a vertical configuration as shown to Figure 1. Questions were raised about other electrode configurations such as horizontal instead of vertical orientation and vertical electrodes terminating in a barrier such as Figure 2. The effect of the enclosure size was also a question. The effort for the next edition was quickly growing into a more daunting task.

Since the new research and testing would require significant financial resources, a collaborative effort was developed between IEEE and NFPA. This new collaboration, combined with the financial support from many companies in the industry would result in almost two thousand new arc flash tests and a project spanning many years.

As part of the collaboration, leading global arc flash experts such as Dr. Sweeting were invited to participate as technical advisors in order to provide guidance for the next generation of testing.

NEW ELECTRODE / BUS ORIENTATION

When an arc flash occurs using the original model with three electrodes in a vertical orientation, the arc plasma is driven towards the bottom of the box and often spills out of the front. Subsequent research has shown that incident energy can be influenced by the electrode orientation. As a result, the project team conducted many new tests using electrode orientations that include both a horizontal configuration and vertical electrodes that terminate into an insulating barrier.

When the electrodes are placed horizontally, the arc plasma is directed from the ends of the electrodes outward. Research has also indicated that if vertical electrodes are terminated into an insulating barrier, the arc hits the barrier and the plasma cloud is directed more towards the enclosure opening. The barrier configuration represents conditions that may occur such as when conductors terminate into a terminal block or other device.

A total of five different bus configurations have been included in the testing program which include:

- Vertical Electrodes in a Cubic Metal Box
- Vertical Electrodes in a Cubic Metal Box terminated into a Barrier
- Horizontal Electrodes in a Cubic Metal Box
- Vertical Electrodes in Open Air
- Horizontal Electrodes in Open Air

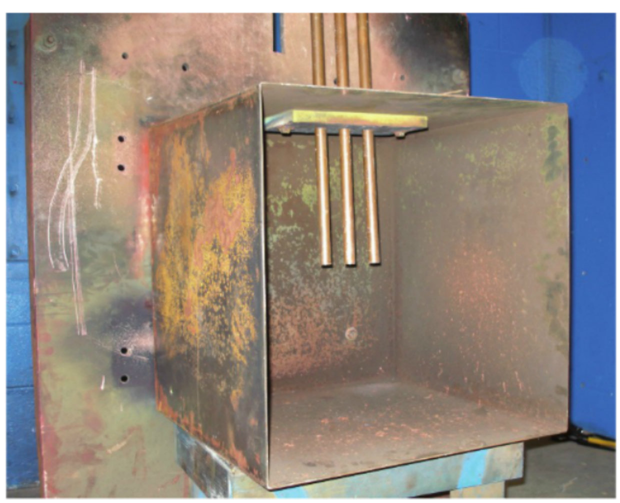

Figure 1 *Vertical Electrodes*

Figure 2 *Vertical Electrodes Terminating in an Insulating Barrier*

The results of the new arc flash tests have been used to develop the next generation of IEEE 1584 arc flash equations.

More than just Incident Energy

Historically, the main focus of arc flash calculations was to predict the prospective incident energy. With the more current IEEE/NFPA research, other areas have also been investigated.

Blast Pressure – The blast pressure from an arc flash can also create a significant hazard. More recent testing has been conducted to evaluate blast pressure from an arc flash. A few specific data points from this data indicates blast pressures upwards of 100 to 250 pounds per square foot. Although this pressure may not necessarily result in a crushing blow, it could knock a worker backwards or off an elevated platform or ladder possibly contributing to other injuries.

Sound Pressure - The "loudness" of a given sound is related to the amplitude of the pressure wave striking the ear and is expressed in decibels (dB) which is a logarithmic scale not linear. Using a logarithmic scale, doubling the dB value from 60 to 120 does not double the sound pressure. It actually increases by a factor or 1000!

A few arc flash tests have recorded sound pressure upwards of 170 dB. Well beyond where mechanical damage to the ear could occur.

Light - When an arc flash occurs, there can be a blinding flash of light that can cause eye injury and blindness. As part of the testing program, some light (luminance) measurements have been performed. As a frame of reference, it has been stated that the luminance level on a bright summer day will have a midday ground level illumination on the order of 100,000 lux where lux is a measure of light intensity. By comparison, the light intensity of an arc flash 3 meters from the source is over 1 million lux and a more recent arc flash test recorded 13.1 million lux - approximately 130 times brighter than direct sunlight!

Enclosure Size - It is widely accepted that the incident energy from an arc flash can also be influenced by the enclosure size. The next edition of IEEE 1584 includes an enclosure correction factor to adjust the calculations for different dimensions.

DC Arc Flash

Large rectifiers, DC traction power systems and large battery systems are just a few of the possible sources of a DC arc flash. Although the 2002 Edition of IEEE 1584 did not consider DC arc flash, there has been some private testing and technical papers developed on the subject. The hope is that DC arc flash testing as well as a subsequent standard will be developed as a future project.

125 kVA Exception

Often referred to as the "125 kVA Exception", the 2002 Edition of IEEE 1584 contains language that permits a study to exclude calculations on circuits with voltages less than 240 volts and fed by transformers 125 kVA and smaller. This exception was based on a few tests that indicated if an arc flash occurs at lower voltages and also with a lower magnitude of short circuit current, it would be difficult to sustain the arc and would result in a lower level of incident energy. However, since 2002, there has been significant testing that indicates under certain conditions, it is possible to sustain an arc flash at much lower levels of short circuit current.

A Long Journey

Although the next edition of IEEE 1584 has not yet received final approval, after 16 long years it is in the final stages and will hopefully be published in the near future.

During those years, the IEEE/NFPA collaboration along with global experts and the IEEE 1584 working group have all joined forces for a common goal. To take arc flash calculations to the next level with the next edition of IEEE 1584.

The next edition of IEEE 1584 will provide more options for modeling equipment

Setting up an arc flash test on actual equipment - NEMA (U.S.) panelboard

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