EC&M WEBINAR, OCTOBER 18, 2018 - Q&A

IEEE 1584 Revisions

Significant Changes on the Way for Arc Flash Calculation Analysis

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Have the IEEE 1584 2.0 changes already been distributed to the major software vendors? (ETAP, SKM etc.)
Yes. All of the major North American power analysis software companies were part of the IEEE Working Group and contributed to the process of creating the new model.

Are ETAP, SKM and other software developers going to implement these changes in their calculations and upgrade software?
Yes. It is our understanding that they are in the process to make these changes

Much of the presentation puts the responsibility for calculations on the "software supplier." Has the Working Group / standards writers discussed the proposed standards with the "software" vendors?
Yes. All the major North American power analysis software companies were part of the IEEE Working Group and contributed to the process of creating the new model. It should be noted that the complexity of the calculations is not problematic for the software.

How do I obtain a copy of the newest version of the IEEE Guide?
It is available from the IEEE at
https://standards.ieee.org/standard/1584-2002.html

Is there a timeline for DC arc flash hazard guidelines?
Not currently. The research has not started.

To comply with 70E, does a residential electrical inspector need to have a rated face shield, etc. to unbolt the panel cover and open an existing single-family dwelling's electrical panel to inspect it after new electrical work has been done and the electrician who did the work is not on site?
If an electrical inspector is performing an inspection at a residence, the residence is considered the workplace and 70E is applicable. From a safety perspective, a more pertinent question may be:

> If someone opens an energized residential electrical panel, will they be exposed to an electrical hazard, either shock or arc flash? And if so what precautions should be taken?

If exposed parts exist, then protection from shock and arc flash are needed. A face shield, an appropriate level of hand protection, sleeve protection and torso protection are advisable. A residential load center poses a 208 to 240V hazard with up to 10-22kA available. Though sustaining an arc may be difficult, it is not impossible. Per the new IEEE calculation, appreciable incident energy may be possible, in addition to shrapnel and molten metal that may be sprayed. A new, untested and uninspected installation could increase the risk of an incident.

Do the new arc flash calculations consider currently available mitigation methods such as photo sensing devices?
Arc Flash calculations do not consider mitigation methods. They only consider the time it takes to stop the flow of current in the arc.

Would a 3-phase pad-mount transformer with horizontal live front bushings be considered as "aimed" at the operator?
Yes, if the bushings are horizontal and the electrician is in front of them, the current path before the arcing point is horizontal and, potentially, "aimed" at the electrician working in front of the transformer.

Typically, an engineer doing the AF study is working from data given for a SC and coordination study, and there is NO information provided for the various physical electrode layouts in the power system. How can the study be performed?
There is not enough data to perform an AF study without information about gaps, electrode orientation and configuration as well as enclosure sizes. An effort to obtain this data will be needed, or conservative assumptions may need to be made.

What is the expected release date for the new IEEE 1584 standard?
It is our understanding it will be available in the near future.

If we analyze a 4160V system, do we interpolate between 2700V and 14300V?
Follow the method in the guide. Calculations will be done at 3 voltages and the interpolation is from those calculations. When using 3rd party analytical software, all this will be done by the software.

What is the smallest box size value allowed in order to model a small fused disconnect?
A "minimum" box size in not defined, however, there are some dimensional guidelines:

- A depth of less than 8 inches is considered a "shallow" box and this affects calculations
- The width of the enclosure must be ≥ 4 times the gap. This should be easily achievable if the gaps are within the normal expected range and the box is grounded metallic.

Is DC arc flash a prevalent issue? I haven't heard of any incidents in trade literature.
The IEEE working group created a list of potential guide expansions and voted to prioritize the list. DC Arc Flash was the top category, and this was agreed upon by IEEE leadership. There are some applications in industry that implement large battery banks, for example data centers.

Is single-phase calculation is required by code?
The requirements for calculation come from NFPA 70E and the need to perform good risk assessment. Three-phase calculations for energy will provide a conservative result, but the calculation for arcing current should consider that single-phase arcing current is lower because the driving voltage is lower, and symmetrical analysis calculations for single-phase bolted fault current will yield 13% lower I_{bf}.

What software was discussed, and where is it available?
http://www.skm.com/
https://etap.com/
https://www.easypower.com/

Could a single-phase arc be less than the minimum tolerance three-phase arc and not be picked up by a circuit breaker, producing a much higher hazard? Even if they propagate to three-phase within 300ms, could single-phase arcs be more hazardous, especially in the case of an unbalanced fault through a delta-wye transformer where the upstream protective device may not react until 158% of its regular time? What are some references that are accepted in the industry that might address these topics?
These are very valid points! When calculating arc flash for a single-phase event or attempting to improve the probabilities that a protection scheme will sense a single-phase arcing event, one needs to estimate the minimum single-phase arcing-current. The lowest arcing current may be from a ground fault. The fact that arcing ground faults may be very low and may persist for a long time is well known in the industry, and has been the subject of many IEEE articles dating back to the 50's, 60's and 70's. This concern supports the case for fast, sensitive ground-fault protection, or differential protection, as well as for light-based protection.

An interesting read on this subject may be found here: Arcing fault current and the criteria for setting ground fault relays in solidly-grounded low voltage systems; by K. Malmedal ; P.K. Sen; 2000 IEEE Industrial and Commercial Power Systems Technical Conference. Conference Record (Cat. No.00CH37053)

Will part of the data collection now need to include box dimensions? Perhaps this was required for the old model, but I don't recall...
Yes, or a conservative estimate would be needed.

What was justification for eliminating grounding as a factor for arc flash calculations?
Data did not demonstrate a correlation.

Are there any suggestions for managing a redo of arc flash calculations, considering the variability? How can we be consistent across the industry?
This is a very good question, for which there is no formally provided answer within the IEEE guide. However, we would point to accepted risk assessment procedures (NFPA 70E-2018 110.1(H) and risk management practices that would indicate if a change in the hazard is known, or expected, it should be considered in a timely basis.

How does the increased frequency, for example >1200hz, affect the potential energy?
IEEE 1584 addresses 50 and 60 hertz systems only. However, it is well known that traditional circuit breakers that operate well at 50 or 60 hertz are much less capable at higher frequencies. This would tend to indicate that arcing currents may be harder to interrupt, and hence may be more stable. This may indicate that energy at higher frequency may be higher.

How accurate are the data on arc flash labels created using IEEE 1584? I assumed from your presentation that they are obsolete and could represent high risks for the electricians.
The new calculations can yield different arcing current and different energy than the previous calculations, assuming the interruption time is the same. However, if arcing current is lower, interruption time may be significantly longer. Best practices would suggest that prior to using values on a label, review the arc flash study that was used to generate that label and understand if the assumptions used for the label are applicable based on the new standard. If not, determine if the difference could result in higher incident energy. If so, act accordingly to add the necessary precautions needed to control the risk.

What is the difference between arc current and bolted fault current?
Bolted fault currents are the values of current normally calculated via a short circuit study. These calculations are based on certain assumptions about system impedances and are usually designed to err on the high side– they tend to "overestimate" fault current. Arcing fault currents are similar but include the additional impedance of the electrical arc, which is known to be resistive, chaotic and difficult to predict.

Do the new arc flash formulas have an input for staggered LV bushings in a three-phase transformer? I assume it is different than an in-line LV bushing configuration (horizontal bushings).
No. The protection engineers or person responsible for performing the risk assessment will need to determine the effect the actual configuration will have relative to the one modelled by the IEEE method.

Is the 2002 model based on the VCB orientation?
Yes

Does the calculation take into account transparent equipment shields with port holes for servicing? These shields limit an electrician's exposure to the size of the port holes.
We are not aware that the shields described are considered adequate protection from an arc flash perspective. However, they may mitigate the risk of accidental contact or the probability of an incident due to inadvertent contact. Such analysis would be part of the risk assessment, but not part of the arc flash calculation.

Would it be reasonable to call a lighting and appliance panelboard VCBB, based on various wire insulations and branch circuit breakers in the panel, even if it is main lugs only?
Probably, however an inspection of the actual panel may be appropriate to ensure there are no unexpected variations.

Can you give an example of an actual VCCB type of arrangement in equipment that might be encountered?
Almost any equipment could provide that type of arrangement, especially motor control centers, panelboards and control panels.

What is the best reference for arc flash energy of 240V single-phase systems with transformer <125kVA?
The new calculations will determine the range of possible arc flash energy based on available bolted fault current. The stated minimum is 2000A.

Will the specter of increased incident energies prompt full reviews/updates at 5-year intervals?
This is a very good question, for which there is no formally provided answer within the IEEE 1584 guide. However, we would point to accepted risk analysis and risk management practices that would indicate if a change in the hazard is known, or expected, it should be considered in a timely basis. Since an arc flash study cannot be replaced instantaneously, the potential effect of the new IEEE guide should probably be considered when executing task planning.

Was a test conducted with a Lexan (transparent) panel in front of live buses (ex. medium voltage), a Lexan panel separating the worker from the bus area, with a worker having a visual at the buses?
No. We are not aware that the shields described are considered adequate protection from an arc flash perspective. However, they may mitigate the risk of accidental contact or the probability of an incident due to inadvertent contact. Such analysis may be part of the risk assessment, but not part of the arc flash calculation.

As a Consultant Engineer, what should we specify in our equipment specifications to cover these changes?
Specifications on how to perform a study 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(TM)

The specifications should include a clause that requires that the latest version of the guide should be used if published before the final study is provided to the client. All information used for the calculations should be clearly identified, including the source of the information used as an input variable in the calculations. The arc flash study should be conducted by engineering staff who are regularly engaged in performing system studies such as short circuit, coordination and arc flash studies for at least 3 years, and with field engineering staff able to verify information used in the study in the field, if so required.

What is recommended for existing arc flash labels created based on 2002 standard calculations?
The new calculations can yield different arcing current and different energy than the previous calculations, assuming interruption time is the same. However, if arcing current is lower, interruption time may be significantly longer. Prior to using values on a label, it would probably be wise to review the arc flash study that was used to generate the label and understand if the assumptions used for the values on the label are reasonable based on the new standard. If not, determine if the difference could result in higher incident energy. If so, act accordingly to add the necessary precautions to control the risk.

Is box depth used in the box correction factor?
The calculations include a step where depth is considered. Enclosures that are shallower than 8 inches and those that are deeper are treated differently.

Is it necessary to calculate arc flash protection for switchgear under solid dielectric technology and vacuum? For example: switchgear using Elastimold (ABB) Molded Vacuum Interrupters (MVI) and Molded Vacuum Switches (MVS). They can work from 5kV to 38kV and operate a nominal current of approximately 600A. The symmetrical/asymmetrical currents can go from 12.5/20kA to 25/40kA, depending on the MVS and MVI models used.
Solidly insulated equipment, buses and mechanisms may be considered to have a reduced risk of an arc flash event. However, each individual assembly should be evaluated to determine that no exposed live buses exist (i.e. cable terminations) and that the insulation is robust and in good condition. The manufacturer of the equipment should be consulted to determine if the insulation is sufficient to make the claim that the risk of arc flash is sufficiently controlled.

If the position of the worker may differ relative to the electrodes, should there be two labels, or should only the most conservative situation be listed?
Since the label applies to no specific task, it should reflect reasonably conservative values. In the case described, the higher of the two incident values would be recommended.

What is the current (NEC) code governed requirement for arc flash labels?
The NEC has two text sections, A and B, and an alternative within B (a 3rd label) that deal with arc flash expressly mentioned in article 110.16 of the 2017 NEC.

(A) General and **(B) Service Equipment.** The requirement within the “general” section is for a simple label, defined in 110.21(B) to identify that a hazard may exist within equipment that has a likelihood of being worked on or inspected while energized. The requirement for “service equipment” requires specific information that matches the information required to apply the NFPA 70E Task based method tables 130.7(C)(15)(a), or as an alternative (3rd label identified) a fully compliant NFPA 70E compliant label as defined in 130.5(H) of NFPA 70E.

Where can I download the presentation slides and any resource articles to investigate arc flash calculation changes?
Information regarding the new arc flash calculations is available on the websites of the various software providers.
http://www.skm.com/
https://etap.com/
https://www.easypower.com/

Is there a way to properly calculate the hazard downstream of a VFD, which is a DC source mimicking an AC source?
See NFPA 70E Appendix D for a description of various DC AF calculations methods.

Are there any new labeling standards available?
There are three labels that deal with arc flash expressly mentioned in article 110.16 of the 2017 NEC.

(A) General and **(B)** Service Equipment. The requirement within the "general" section is for a simple label, defined in 110.21(B) to identify that a hazard may exist within equipment that has a likelihood of being worked on or inspected while energized. The requirement for "service equipment" requires specific information that matches the information required to apply the NFPA 70E Task based method tables 130.7(C)(15)(a), or as an alternative (3rd label identified) a fully compliant NFPA 70E compliant label as defined in 130.5(H) of NFPA 70E.

Using existing calculations' higher voltages normally yielded lower arc flash. However, slide 42 suggest going to lower voltages. Please comment.
With everything else staying the same, higher driving voltage can be expected to result in higher arcing current and higher incident energy.

Will we need to know what direction the contractors are laying pipe to connect distribution panels?
All potentially uninsulated live conductors are a possible ignition point for an electrical arc. Depending on the source direction of power and the orientation of the conductors, the arcing electrode configuration could vary. It is advisable to understand the orientation of all conductors within an enclosure when evaluating the associated hazard.

Will IEEE 1584 address voltages > 15KV in the future? If not, are there any suggestions for higher voltages?
IEEE 1584 is not expected to address higher voltages in the near future. Consider consulting one of the power analysis software companies about how to understand the hazard associated with higher voltage equipment. There are various methods practiced in the industry and each may be appropriate for different conditions and voltage ranges.

Which is more stringent - NFPA70E or IEEE 1584?
They are different documents that were created for different purposes and they complement each other. A qualified electrical worker must be familiar with NFPA70E and should at least be familiar with IEEE 1584.

Will there be recommendations to include arc quenching devices in power distribution equipment?
There is no specific recommendation with IEEE 1584. However, the concept of prevention through design would indicate that when designing an installation and selecting equipment, every effort should be made to mitigate the electrical hazards. Using arc quenching devices, such as the GE Arc Vault or the ABB UFES could be a consideration. It may be good practice to confer with the manufacturers to ensure that protection devices are selected and applied properly so that they provide the maximum possible speed (minimum clearing time) at expected arcing current levels.

How may an engineer obtain a copy of IEEE 1584 at a reasonable cost?
Copies of IEEE standards may be acquired from the IEEE at the following link; https://standards.ieee.org/standard/1584-2002.html.

Is an arc resistant switchgear type necessary if the switchgear is already equipped with a maintenance switch?
These are two different methods to mitigate hazard. One (maintenance switch) lowers the potential severity of an arc flash event. Arc resistant equipment may provide an effective barrier between arcing fault and personnel standing outside the equipment. Each method has benefits and draw-backs and they are not mutually exclusive. In many situations it would be recommended to install both simultaneously.

Should there be an arc flash warning for temporary service installations?
Yes, if there is a likelihood that it may be approached or worked on live.

Can you describe some specific examples of horizontal arrangements in low voltage applications?
- Run backs in the rear of switchgear
- Connections in the rear of a cubicle where a circuit breaker is drawn in
- The end of a horizontal bus at the sides of gear
- Anywhere bus is bent to accommodate connections

Will NFPA70E issue an interim revision based on the new IEEE 1584?
NFPA publishes relevant standards (3) every 3 years, 1 per year. NFPA has a policy of not referencing unpublished standards. Public comments were provided for this next draft, but if any referenced the new IEEE 1584 they would have been rejected on principle. The committee is well aware of the new guide and importance of the changes. They made changes in the first draft that would allow them, per NFPA procedures, to modify the text in the 2nd draft to accommodate the new IEEE guide, which is expected to be published by the time the 2nd draft is written.

What about industrial control panels like VFD, UPS for arc flash data?
Each panel or equipment must be independently analyzed for arc flash based on the source of power, its electrode configuration and enclosure characteristics.

IEEE 1584 still doesn't address arc blast (pressure) effect; it only addresses the thermal part of the hazard, correct?
That is correct. IEEE 1584 only addresses heat from the event on a plane that is a defined distance away from the arc.

Does the new standard require measuring the gap between buses and enclosure sizes to do an arc flash study?
That would be the implication. However, in some case it may be possible to make conservative estimates. Note that a conservative estimate for arcing current is one that yields lower current, while a conservative estimate for incident energy is one that yields higher energy. Any one set of assumed input conditions may not be conservative for both arcing current and incident energy. To obtain conservative results, it may be required to run calculations for a range of input variables or conditions.

Is it possible for metal clad 15kV ANSI switchgear for the breaker compartment (HCB) to have a different label or solution than the cable termination compartment (VCB?)
If the compartments are sufficiently separated, such as front and rear, it may be appropriate to have labels with different values on each side. It would be more appropriate to perform a risk analysis based on the specifics of the equipment, installation, tasks planned, qualifications of the workers and any other applicable factors. This type of analysis would provide information for the best labelling strategy.

Is it true that for both ANSI (UL1558) switchgear and UL 891 switchboards, if a fault occurs on the line side of the main breaker in one cubicle, the arc flash can propagate to an adjoining cubicle and both cubes would need to have the same PPE level of protection?
Energized conductors that are in proximity to each other should be considered capable of having an arc ignited from an arc in any other proximate conductor. It is best to consider the maximum level of energy for any mix of conductors within an enclosure. If two enclosures or cubicles are proximate without robust barriers or enough distance between them, the conservative course of action may be to consider that an arc could propagate from one to the other.

Is updated 1584 standard available online?
It is our understanding the updated standard will be available in the near future. IEEE standards may be acquired at this link:
https://standards.ieee.org/standard/1584-2002.html

How do vertical and horizontal connections affect panel board arc flash calculations?
Each task or each hazard should be individually evaluated. Panelboards are likely to present mostly "vertical" configurations; however, each should be evaluated to ensure that.

How should switchboards be modeled, VCB or HCB?
Each task or each hazard should be individually evaluated. Switchboards are likely to present mostly "vertical" configurations; however, each equipment should be evaluated to ensure the electrode configurations are understood and properly modeled. The rear of a switchboard may be different than the front, where the large circuit breakers or switches are mounted may be different than where small group devices are mounted, etc.