EC&M held a webinar sponsored by GE on Arc Flash Codes & Compliance with industry experts Tim Ford, GE Global Product Manager MCCB and Randy Barnett CESCP, NFPA Certified Electrical Professional, to gain insights on options and trade-offs of electrical systems that are code compliant and meet the needs of your application. This document addresses the questions and answers for this topic in detail.

EC&M WEBINAR – April 26, 2018

Arc Flash Codes & Compliance

What you need to know to deliver both protection and performance

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Q & A

Does a maintenance switch allow you to change the incident energy value on the warning label? It appears it would be a very inexpensive solution, correct?

It may not be a good practice to use the incident energy values associated with a maintenance switch (ERMS per the NEC) on the 70E Arc Flash Label. The label usually reflects the worst-case value a worker may be exposed to under possible power system conditions. To produce an arc flash label an arc flash hazard analysis should be performed. Work tasks should be planned to use the information in that analysis. If an ERMS is available, the associated procedure to implement it should be part of the planned task, and then the associated incident energy may be considered in planning hazard control measures such as PPE.

There are some cases where labeling on equipment may reflect the worst-case value of incident energy, and the value after the ERMS is enabled. However, that may introduce the risk of a worker not planning a task appropriately and using the wrong incident energy value, or PPE description to determine required PPE. Therefore, putting both values on one label is not, generally, recommended.

Furthermore, when applying an AF label, it is important to consider all the possible levels of exposure within the labelled equipment and make sure the label reflects the highest label.

Is there any information available on the effectiveness of re-bracing under duty switchgear?

It may be possible, if the equipment is of recent construction and design and a similar design is available from the manufacturer with the higher rating, that bracing can be upgraded in the field. However, if the equipment design is no longer manufactured and a similar tested design with the higher rating is not available, it may be difficult to reliably upgrade the equipment in the field. The need and possible corrective actions should be discussed with the original manufacturer of the equipment.

Do transformers have a fault current rating?

Transformers are typically designed to carry fault current based on time limits set forth in the applicable standards. When a short circuit and coordination study is performed, the protection-engineer should identify the proper damage curve for the transformer type involved. This provides a graphical representation of those limits used in protection analysis. Transformers will have mechanical and thermal damage limits. Depending on the type, size and design of the transformers, there are limits on how many times a transformer is rated to withstand large fault currents. The manufacturer or an experienced protection engineer should be able to provide guidance on this subject. Generally, if a circuit fed by a transformer has been faulted testing will be recommended to attempt to ensure it has not been damaged. The manufacturer should be consulted to provide recommended tests and actions. Also, the secondary connections should be checked post any high magnitude through faults to ensure they remain reliable.

What agency enforces NFPA 70E?

NFPA 70E is considered an industry consensus standard and, technically, not enforced by any specific agency. OSHA can use this standard for establishing the availability of abatement but not for citation. OSHA is the law "what needs to be done". 70E being an Industry consensus standard is one method of demonstrating intent of meeting OSHA requirements. Standards such as 70E are used to identify the risk and mitigation required for electrical safety in the workplace for employer to protect employees from electrical hazards.

What is the cheapest, and the most expensive arc mitigation solution?

It depends if cost considerations are based on initial cost or life cycle cost! Some solutions may cost less to implement but may not mitigate risks as well, or have higher life cycle cost. A risk analysis needs to be performed based on the task being performed. Mitigation cost and efficacy depends on the risk encountered while performing the task and employer determination of acceptable residual risk. Considering the life cycle cost, elimination, substitution and engineering controls are the most effective methods to reduce risks. These measures are less likely to be affected by human error. Administrative controls and PPE are less initial cost but are less effective methods to reduce risk as they are more likely to be affected by human error. There is no single best solution for the arc flash hazard other than to never work on energized equipment or circuits. NFPA 70E discusses arc flash as one of several electricity related hazards a worker may be exposed to. A hazard creates risk of injury or harm to the worker. Depending on various factors that should be considered as part of systematic risk analysis, a systems designer, installer or worker can select the hazard control measures that best address the risks involved in any contemplated task or situation. Appendix F in NFPA 70E includes an excellent discussion of risk analysis with respect to Electrical Hazards.

As a very brief discussion one can consider the risk assessment from the hazard perspective, or from the risk perspective for performing a specific task. From the hazard perspective the lowest cost solutions will tend to be those implemented early in the design phase of system, and may function to lower the risk associated with a hazard by:

- lowering the level of energy available (less volts, less current, less time);
- lowering the risk of exposure (keep workers away– or further away, providing remote controls, etc.) or;
- lowering the probability of an event (add insulation/isolation, increase distance between conductors, double insulation, High Resistance system grounding in LV systems, etc.).

Considered from the task perspective the same solutions may apply, as well as those that involve worker behavioral improvements, such as training, properly planned procedures and others.

Ideally, any solution considered should be analyzed from the perspective of the hazard controls hierarchy described in NFPA 70E and other safety management standards such as ANSI Z10, the ability to provide the best possible hazard control for the installation, as well as meeting the prescriptive requirements of the NEC. The NEC is a minimum requirement for safe installations and is not a design guide, nor, in all cases is the NEC infallible with respect to achieving its intent. In other words, meeting the "letter" of the NEC may not always meet the intent.

If the goal is to meet 240.87 there are a couple of approaches that could be considered. First, in stiff systems (particularly 480V) where 1200A molded case circuit breakers are used, it is possible that the fundamental protection provided by the instantaneous of the circuit breakers is enough to meet 240.87. Unless the devices are highly adjustable, the maximum

IOC tends to be approximately 10X. If the system uses insulated case circuit breakers, or Low Voltage Power circuit breakers selected to help maximize selectivity, there may be a desire to set instantaneous at high settings or turn it off. This increases the risk that the instantaneous may not meet 240.87. An easy, encompassing and cost-effective method to meet 240.87 is to implement an ERMS switch (aka maintenance switch, or RELT in GE products).

ZSI can also be added cost effectively and may, particularly with GE products, meet 240.87 and provide very good improvements in AF protection. However, this cannot be guaranteed without a coordination and arc flash study.

Depending on how an AHJ chooses to enforce that specific requirement, or an owner evaluates the expected arc flash related results, implementing ZSI as a blanket solution may have some risk. Other solutions such as bus differential protection and active energy mitigation systems tend to be niche solutions that may work very well but may require implementing additional solutions in some circuits and require skilled power systems engineering to implement correctly.

240.67 may be more difficult to meet without the addition of special measures. Fuses are not adjustable and if a fuse is determined to be too large to meet the requirements in the code during an AF study, there may be little that can be done to correct the installation after the fact. It may be good to use a device such as the GE HPC switch that can have an ERMS, or even an adjustable instantaneous, included when the switch is initially installed, or even added after it is installed if needed. For switches 1600A and larger it is recommended that the ERMS function or the instantaneous be used every time. Except in very stiff systems it may be difficult to get good protection from large fuses. IEEE 1584 indicates that fuses above 2000A do not offer good AF protection on systems with up to 100kA available at 600V.

See GE publication *DET-1002* for further discussion on NEC 240.87 and 240.67

See GE publication *DET-1001* for further discussion on ZSI

See GE publication *DET -1004* for further discussion on RELT (aka ERMS in the NEC)

Who should conduct an arc flash study?

Any task, electrical or non-electrical, that can result in possible injury and damage to the health of an employee should be performed by a qualified person. Conducting an arc flash study is no exception. When hiring anyone to perform an AF study it is strongly recommended to engage a qualified person knowledgeable of construction and operation of equipment involved and experienced in performing electrical system studies, the applicable arc flash and electrical safety documents. An arc flash study produces data that may be used to perform risk analysis that is crucial to worker safety. GE Services, as well as the service organizations of other major electrical equipment manufacturers and many qualified consultants provide this kind of service. Guidance on specifying an AF study maybe found in *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*(™). It should be understood that an AF study provides data that is to be used by responsible parties for hazard risk assessment and management. The AF study, by itself, does not replace that analysis or all the other facets of proper safety management within a facility.

Has a determination been made concerning calculations on horizontal versus vertical bus? EasyPower has introduced calculations based on a Littlefuse whitepaper, but there does not appear to be any other basis.

This specific issue, as well as others, has been taken up by the IEEE 1584 Working Group based on research performed by a joint cooperative research project of the NFPA and IEEE. The resulting revised IEEE guide is available in draft from the IEEE. It has gone through two public ballots and is in the process of addressing comments provided during the 2nd ballot. Generally, horizontal versus vertical arcing structures can produce significantly more incident energy on a nearby worker. However, that is not the only variable. Suggest that interested parties consult the draft IEEE guide available today or wait for the final guide that may be published sometime next year.

http://standards.ieee.org/develop/project/1584.html

What is your stance on Arc Resistant switchgear and MCCs versus using engineering controls to limit incident energy?

The occurrence of an arcing fault inside an equipment inside an enclosure produces a variety of physical phenomena very different from a bolted fault. For example, the arc energy resulting from an arc developed inside the enclosure causes a sudden increase of pressure and localized overheating. Equipment tested under bolted fault conditions is not tested to withstand an internal arcing fault, Arc Resistant Equipment (AR equipment), in North America, is tested per the testing guidelines in IEEE/ANSI C37.20.7- *IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults*. The latest version of this guide was issued in 2018 and now includes various types of electrical equipment.

AR equipment is one of the devices to help minimize exposure of high incident energy to employees while performing local operation if equipment is installed, maintained and operated according to manufacturer's instructions. AR equipment is one hazard control mechanism available in the industry. Like many others it performs well for its intended purpose if its limitations are understood and accounted for in the pertinent risk analysis. For example; AR equipment is sometimes considered a "substitution" as defined in the hierarchy of hazard control methods. However, AR equipment requires maintenance to be in good condition and doors and panels need to be closed as required. Equipment protection must be implemented, hence appropriately maintained, to limit faults to the time limits qualified for the AR rating. This later requirement is often not met in the incoming section. If there are tie compartments, the possibility of a double arc may need to be considered and the AR rating is rarely sufficient for that doubling of potential energy. Because of these various factors it is probably best to consider AR equipment as "engineered solution" within the hierarchy of hazard controls. Consideration should be any proposed task that requires opening panels or doors where the main power conductors may be exposed as well, to evaluate if AR equipment is a good solution for the application considered.

One should also consider that multiple hazard control mechanisms may be implemented simultaneously. For example, it is possible to implement AR equipment and a well-designed protection system to keep all protection operating at "instantaneous" at expected arcing current, while providing full selectivity simultaneously. One does not replace the other, they are different and may be considered to complement each other.

See GE Arc Watch: *http://apps.geindustrial.com/publibrary/ checkout/DET-760?TNR=Application%20and%20Technical|DET-760|generic* and *http://www.geindustrial.com/arcwatch*

See GE publication *DET-1002* for further discussion on NEC 240.87 and 240.67

See GE publication *DET-1001* for further discussion on ZSI

See GE publication *DET -1004* for further discussion on RELT (aka ERMS in the NEC)

Can you outline the steps in an arc-flash analysis?

The process for performing an AF study is described in IEEE 1584 and guidelines for specifying a study are provided in IEEE 1584.1. However, briefly, the steps may be considered as:

- Collect the system and installation data. Data that is required for short circuit study, coordination study and arc flash study (the latter of which will require some equipment details not typically collected)
- Determine the system modes of operation. This includes possible system topologies, sources, ties, open/closed, motor loads on, motor loads off, etc.
- Determine the bolted fault currents. This is usually done via short circuit study.
- Determine the system voltages and classes of equipment as required to decide on arcing gaps and other factors important to the AF calculations. Some of this may be obtained by direct inspection of the equipment or in consultation with the equipment manufacturer.
- Determine the equipment electrode configuration. This will be important for the next edition of IEEE 1584, but it is not a variable in the 2002-edition.
- Determine the working distances. This is task related and equipment related.
- Calculate arcing current. This is typically done by the analytical software after all the required data has been provided.

- Determine the arc duration. This is determined from coordination study data.
- Calculate the incident energy. If the duration of an arc (and consequently the incident energy) is higher than deemed acceptable, different settings or protection techniques may need to be implemented. The coordination study and AF study repeated.
- Determine the Arc-Flash Boundary for all Equipment. Often these are marked on the floor around the equipment.

Why is HRG (High Resistance Grounding) not addressed?

A great majority of electrical faults in solidly grounded systems start as phase to ground faults that escalate to phase to phase faults. High resistance grounding inserts an impedance in the ground fault return path to limit ground fault to 10 amperes or less for LV systems allowing insufficient fault energy to directly create an arc flash hazard. High resistance grounding will not significantly affect the arc flash energy due for line to line or 3 phase faults. However, it is a well-recognized technique to increase the reliability of a power distribution system and to reduce the probability of an arc flash event. A consideration is that HRG systems do need skilled maintenance to ensure that faults that occur are not left active too long.

Have you ever heard of overdutied equipment, and will an arc flash study catch this?

Yes, overdutied equipment in existing facilities is often found during a short circuit study and equipment evaluation analysis performed in preparation for the AF study. Overdutied equipment does not meet NEC installation guidelines and an arc flash study on that equipment or downstream equipment is not, generally, considered appropriate until the equipment is replaced or the overduty situation is corrected in some other manner. An upstream properly rated overcurrent device may be considered for calculation of incident energy however consideration should include that the overdutied equipment may fail in an unpredictable manner creating significant unquantifiable risk.

How can ZSI extend beyond a single switchboard enclosure to cover remote equipment?

ZSI systems can extend beyond a single lineup of equipment. The need to do this is uncommon but happens. The distance that normal ZSI signal wiring can extend may vary by manufacturer or type of system. 1000 feet or more should be possible for most hardwired systems. Systems that implement serial communications may be able to extend further.

Would arc flash occur in a facility that is 208V 3-phase service, 400-600A? If so, how would one go about creating a study?

Sustaining an arc at 208V is more difficult, but not impossible and will depend on available fault current and equipment construction. A study may be implemented using the procedures outlined in IEEE 1584 and IEEE 1584.1. In small 208V systems the main problem may be low arcing currents and the fact that the protective devices trip very slowly for such low fault currents. If the protective devices are small and the arcing currents are high enough, circuit breakers operating in their instantaneous range should result in very low incident energy values.

What effects do you see on the existing completed studies and labels in the field because of the changes in the IEEE 1584 equations?

The new model was developed based on over 1860 tests performed by the project at different voltage levels. The 2002 model was based on approximately 300 tests. The model performance was also evaluated against the existing IEEE 1584-2002 model test results. This model produces results that are more accurate than those of model included in the 2002 model for configurations common in both models. Furthermore, the new model provides a method to evaluate the incident energy for other electrode and enclosure configurations not previously considered, such as vertical conductors in a box with a barrier and horizontal conductors in a box, or without a box. Upon approval of this revision, IEEE 1584-2002 would be marked as superseded. A draft of the new standard is available from the IEEE.

Does 2017 NEC 240.87 limit engineering from disabling (turning off) the instantaneous trip setting on service disconnects (circuit breakers) with LSI trip units when performing selective coordination as part of a coordination study?

240.87 does not specifically state this cannot be done, but the practical effect of doing it is that one of the other methods to improve arc flash protection will need to be implemented. Note that in a well-designed system it often is not necessary to turn off instantaneous protection to achieve selectivity. Nor, should it be necessary to adjust the instantaneous above arcing current levels to achieve selectivity. See GE publications on this subject at these links: *http://apps.geindustrial.com/publibrary/checkout/DET-760?TNR=Application%20and%20Technical|DET-760|generic* and *http://www.geindustrial.com/arcwatch*

At what distance is the <8cal/cm^2 expected for ZSI?

This question cannot be answered. ZSI is a technique to enhance protection. Generally, it improves protection speed for in-zone protection in upper tiers for a multiple tier system while maintaining systems selectivity and reliability. By itself it may not significantly improve AF protection if it is not applied correctly. It needs to be applied correctly, which will probably require a coordination study and an AF study.

See GE publication *DET-1001* for further discussion on ZSI. *http://apps.geindustrial.com/publibrary/checkout/DET-760?TNR=Application%20and%20Technical|DET-760|generic* and *http://www.geindustrial.com/arcwatch* for additional information on instantaneous selectivity and arc flash protection

Can we expect, at some point, to see Insulated Bus included in the NEC as an acceptable form of protection?

It is improbable. Although adding insulated bus to equipment is a good way to lower the probability of arcing faults, it is probably not sufficient or sufficiently uniformly successful to be considered on a par with the other methods described in 240.87 and 240.67, all which target fault clearing time. Nevertheless, GE recommends that insulated bus be used as often as possible within electrical enclosures.

The way that the Informational Notes in NEC 110.16 are formatted, it appears that they specifically apply to 110.16(B). Obviously, it would be better to reference NFPA 70E for the label information for 110.16(A). Could an inspector consider a label as non-compliant if a label does not match ALL the guidance of NFPA 70E?

Informational note 2 would apply to any product safety label and is pertinent to both 110.16(A) and 110.16(B) compliant labels. The labelling requirements in 110.6 are consistent with generally accepted electrical safety practices, the hierarchy of hazard controls and risk assessment practices.

110.16(A) addresses the requirement for a basic hazard warning label to be applied to any electrical equipment that can be considered to pose an arc flash hazard and, during normal maintenance or use, may expose workers to that hazard. This is consistent with a minimal application of the 4th level of control (awareness) within the 6-level hierarchy of hazard controls described in NFPA 70E or ANSI Z10.

110.16(B) defines additional labelling requirements for service entrance equipment. 110.16(B) identifies that two labels are possible, one described within 110.16B that provides the required data for a worker to implement the category method for PPE selection outlined in NFPA 70E 130.5(C) ,130.7(C)(15)(a), 130.7(C)(15)(b) and 130.7(C)(15)(c), or alternatively, allows the installer to install a label as described in NFPA 70E, section 130.5(H), exhibit 130.6 which provides data determined from an arc flash study or from the standard PPE practices for the facility.

Would opening or removing a switchgear or panel cover qualify as arc flash danger, requiring the use of additional PPE?

NFPA 70E Table 130.5(C) provides guidance on whether specific tasks may or may not require PPE. However, deciding whether a task requires the use of PPE is a risk assessment that qualified, responsible individuals must make based on the best available information. The answer to the question posed is not so clear cut. The level of the potential hazard behind the panel should be considered (how much energy can be released); the condition of the equipment (maintenance, age, environment); the condition of the installation (NEC compliant, condition of the grounding system, etc.); the difficulty of removing the panels; where the person will be located and distance to the potential arc; many other factors that will affect the situation energy that could be released (severity); and probability of an event.

Does NFPA 70E always apply even if the state/locality has not adopted it?

NFPA 70E is not usually "adopted" like the NEC (NFPA 70) is. See answer to previous question.

If a client does not allow energized work of any nature, does the system require an Arc Flash Analysis and labeling?

The need may be reduced but may not be totally eliminated. NFPA 70E requires establishing an "Electrically safe Work condition" prior to performing an electrical task. However, establishing an electrically safe work condition requires possibly performing energized work such as operating an overcurrent device, testing to verify absence of voltage and performing lock out tag out operation and installing temporary protective grounding for personnel protection if necessary. Equipment is considered energized until these steps are performed. Appropriate PPE guidelines would probably need to be developed for that task. A hazard risk analysis is suggested to ensure that no hazard or risk has been overlooked.

I thought that arc flash was sustained for 480 Volt Systems, not self-sustained for 208 Volt?

Arcs at 208V volts have been sustained at certain available fault current and equipment configurations. IEEE 1584 provides guidance for arc flash calculations at 208V volts ac.

What is cal/cm(squ)?

Calories per square centimeter. Arc Flash incident energy is typically stated in calories per square centimeter or joules per square centimeter.

Would arc flash incident energy above 1.2 cal/cm^2 cause a third-degree burn?

According to available data, the onset of a second degree burn on an unprotected skin is likely to occur at 1. 2 cal/cm^2.

What are the arc flash calculations and PPE requirements for DC systems installation/maintenance?

This is addressed in NFPA 70E Table 130.7(C)(15)(b) for the category method. If incident energy calculations are made, one of the several identified methods may be used. None of these are codified in a standard or industry guide but are recognized from industry literature. One of these methods is known as the Doan method and is described in Annex D.5 of NFPA 70E and "*Arc Flash Calculations for Exposures to DC Systems," Doan, D.R., IEEE Transactions on Industry Applications*, Vol. 46, No.6.

NFPA 70E also identifies additional resources as: "*DC-Arc Models and Incident-Energy Calculations*," Ammerman, R.F.; et al.; *IEEE Transactions on Industry Applications*, Vol. 46, No.5. "*DC Arc Hazard Assessment Phase II*", Copyright Material, Kinectrics Inc., Report No. K-012623-RA-0002-R00.

Is arc resistant gear a code requirement? If so, when was this requirement established?

Arc resistant equipment is one method of reducing risk to employees by design and not generally required by any code or standard. Arc resistant equipment has been successfully tested under the guidelines of ANSI/IEEE C37.20.7 for effects on equipment due to an internal arcing fault.

The hazard category tables in 70E section 130 only consider what the available fault current is, not the clearing time of the breaker. As the NFPA 70E is revised based on more and more NEC requirements for reducing incident energy by reducing breaker clearing time, do these tables ever get revised to require lower levels of PPE? If so, is there a risk of someone using the tables in a newer version of NFPA 70E to determine hazard category and PPE levels for switchgear that was installed under a version of the NEC that didn't require enhanced circuit breaker clearing time?

NFPA 70E does identify clearing times at available fault currents. The PPE categories identified in NFPA table 130.7(C)(15)(a) are based on circuit breaker clearing time at a value of maximum fault current not the arcing current, maximum clearing time and minimum working distance. The clearing time of a protective device at bolted fault current has no relationship to the clearing time at an arcing current that may be half of that or less. Clearing time at the arcing current level could be much longer. However, the question is correct to raise the concern that the clearing time at arcing current could be quite different than that identified in the table. Performing incident energy calculations based on actual available fault current, clearing time and working distance for the task provides more representative results.

The example Arc Flash Hazard label in the 2017 NEC Article 110.16 is a generic warning label and does not show specific calculated incident energy or other values. Is this a disconnect between requirements of NFPA 70E?

The labels in 110.16 fulfill different roles within a hazard control management system. The question does identify that labels that fully comply with NFPA 70E provide more information and may be more useful in a well implemented hazard risk control management system.

Our interpretation of 110.16 is that the manufacturer general warning label is sufficient to meet the code and an Arc Flash study is not required by code. The code includes a picture of a Non-Arc flash study sticker. Please comment.

Implementation of the labels identified in 110.16(A) and 110.16(B) do not require an Arc Flash study. Labels provided by the manufacturer may fulfill the requirements of 110.16(A) but usually will not meet the requirements of 110.16(B). The label for service entrance equipment to fulfill the requirements of 110.16(B) is best installed in the field after the fault current at the equipment has been properly identified, and the clearing time of the main SE device at that fault current has been determined.

Are circuit breaker manufacturers adjusting their breaker design to comply with code changes?

Circuit breaker manufacturers are constantly improving their products to make it easier for users and installers to meet regulatory, safety and performance requirements. GE has created new circuit breakers, circuit breaker trip units, and selectivity analytical methods to provide our customers a wide range of tools to help meet the selectivity and safety requirements of the code and other electrical industry standards, including NEC 240.67, IEEE 1584, etc.

For further information see GE Arc Watch. *http://apps.geindustrial.com/publibrary/checkout/DET-760?TNR=Application%20and%20Technical|DET-760|generic* and *http://www.geindustrial.com/arcwatch*

See GE publication *DET-1002* for further discussion on NEC 240.87 and 240.67

See GE publication *DET-1001* for further discussion on ZSI

See GE publication *DET -1004* for further discussion on RELT (aka ERMS in the NEC)

Can an arc flash study be limited to just a branch of a 480V distribution system using an isolation transformer as a "source" point?

There are two methods of selecting arc flash PPE- Incident energy analysis method and PPE Category method. Either, but not both, methods are permitted for the same piece of equipment. The results of an incident energy analysis method to specify an arc flash PPE category in tables is not permitted. However, it is important to understand the variance in fault current that the portion of the system being analyzed may be subject to from changes in the rest of the system. It may be necessary to perform a short circuit study for a larger portion of the system to identify the lowest and highest possible fault current available within the portion of the system being analyzed.

Is there a time associated with the 1.2 cal/cm^2 value?

Time is already part of the unit. 1.2 calories are equivalent to 5 joules. A joule may be defined as; The energy dissipated as heat when an electric current of one ampere passes through a resistance of one ohm for one second.

Is the Arc Flash Reduction requirement by NEC required on downstream overcurrent devices, 1200Amp and up, if arc flash reduction has already been provided ahead?

The NEC makes no such distinction in the 2017 NEC. In fact, when NEC identifies that a protective device must operate at the arcing current it does not identify arcing current location. It should be the arcing current at any point in the protected circuit, however the argument may be made that the code does not explicitly state that. If you look at figure in the NFPA 70E Handbook, which is part of the definition for available fault current, you will see that the fault current at the far end of conductor, where it is connected to the load, is identified. An OCPD should operate instantaneously for an arcing fault at that point in the circuit at arcing current level if the goal is to achieve the best possible arc flash protection that device can provide.

What are the regulations/requirements for rated PPE when conducting trouble shooting tasks with meters on roof top units, cooling towers and chillers to verify voltage/amps?

Same as anywhere else. Hazard controls should be implemented based on a risk analysis of all possible hazards, electrical and non-electrical. This includes PPE for the level of incident energy the worker may be exposed to.

For 5KV gear, what is the most economical approach in sub-station – transformer and 480 distribution?

This is complex answer to provide. Designing a system to implement the best possible "Prevention-through-design" practices takes careful consideration of the potential hazards, risks and tools available to the engineer. IEEE will publish a guide to assist system designers in this task (IEEE 1814). The questioner is encouraged to search out this document when it becomes available and to also reach out to GE Equipment Application Engineers that may be able to help with this task. An IEEE guide with regard to motor controls centers, IEEE 1683, is already available.

When a system has the ZSI feature, how is the labeling done – based on worst case or based on ZSI?

When properly implemented and maintained, ZSI is part of the engineered protection system. It may be considered when calculating incident energy values. It should be noted that if the ZSI communication fails, LV ZSI systems are designed to fail protective, so the AF study should still apply even if ZSI fails to operate as intended.

If a 1000AT circuit breaker is called out on the plans, do we need to provide RELT?

Not per 240.87. However, if the voltage is low, the system weak, there is always a chance that arcing currents are too low to be sensed by the instantaneous protection in a 1000A circuit breaker. Hence, it is always good to perform some level of assessment of what the expected arcing current for the protected circuit is and evaluate if the instantaneous protection will provide the desired protection. If not, then RELT (maintenance switch) may be a way to provide improved protection.

The Code reads 'any breaker that can be "adjusted" to 1200A', so does a 1200A breaker with a 1000A rating require Arc Flash Reduction? It seems it would be required since the rating plug could be changed.

That will be up to the jurisdiction having the authority to make the determination. Generally, a rating plug requires special tools to change and it would be a very intentional change. If the circuit is cabled with 1000A worth of cable it would seem unusual that the RP would be changed to 1200A. On the other hand, if there are 1200A worth of conductors and a 1000A RP, the JHA would have a basis to consider the circuit to be a 1200A circuit that needs to meet the requirements of a 1200A OCPD!

How should 240V single-phase systems be addressed? IEEE 1584 calculations only apply to 3-phase systems, and NFPA 70E optional methods only apply to instantaneous clearing times. However, arcs are possible at 208V.

IEEE 1584 states that single phase incident energy calculations may be made by using the single-phase fault current and three phase arcing equations and incident energy equations. However, this will generate very conservative incident energy predictions. It may not be unreasonable to expect incident energy to be 1/3 of this calculated incident energy if there is a single arcing current instead of three.

What is the status of the IEEE 1584 updated standard? What are the major changes?

The new edition of IEEE 1584 will be a substantial change from the existing 1584 published in 2002. A draft of the upcoming guide is available from the IEEE.

http://standards.ieee.org/develop/project/1584.html

What section of NFPA 70E references the replacement of labels after 5 years, if no changes?

NFPA 70E-2018 has several requisites with respect to frequency of actions to implement safe work practices.

> **130.5(G) Incident Energy Analysis**
>
> The incident energy analysis shall be updated when changes occur in the electrical distribution system that could affect the results of the analysis. The incident energy analysis shall also be reviewed for accuracy at intervals not to exceed 5 years.
>
> **130.5((H) Equipment Labeling**
>
> The method of calculating and the data to support the information for the label shall be documented. The data shall be reviewed for accuracy at intervals not to exceed 5 years. Where the review of the data identifies a change that renders the label inaccurate, the label shall be updated.
>
> The owner of the electrical equipment shall be responsible for the documentation, installation, and maintenance of the marked label.

Audits of the Electrical Safety Program shall be performed every 3 years [110.1(K)(2)]. However, it would be recommended that the arc flash data records be updated to indicate that they have been reviewed, by what method, and determined to be accurate and the date when that transpired.

NFPA 70E 2018 Edition states "If rubber insulating gloves with leather protectors are used, additional leather or ARC RATED gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement." To what ATPV does that combination protect the worker (i.e., Class 00 rubber insulating gloves, with .7mm thick leather protector glove)? Is it 12 cal/cm^2, 30 cal/cm^2, 60 cal/cm^2?

The NFPA 70E handbook provides the following information:

Heavy-duty leather gloves or leather protectors worn over the rubber gloves are included as arc flash protection. Leather materials are typically not arc flash rated. However, heavy-duty leather gloves made entirely of leather with a minimum thickness of 0.03 in. (0.7 mm) that are unlined or lined with nonflammable, non-melting fabrics have been shown to have arc thermal performance values (ATPV) of 10 cal/cm^2 or more. Leather protectors worn over rubber insulating gloves provide additional arc flash protection for the hands. Before opting for leather gloves or protectors instead of arc-rated gloves, it is necessary to determine that the leather gloves will provide adequate protection from the anticipated incident energy.

When using the incident energy analysis method, the selection of PPE must also comply with the requirements of 130.7(C).

For more information on arc flash or GE solutions please visit geindustrial.com/arcflash