Arc Flash Considerations for Data Center IT Space

White Paper 194

Revision 0

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Executive summary

Do IT administrators violate arc flash requirements when they turn off or reset a branch circuit breaker? What about swapping out a rack power strip? Most data center operators are familiar with fire safety and shock hazard protection, but are less familiar with arc flash safety. Three IT trends have increased the severity of a potential arc flash in the IT space; higher data center capacities, higher rack densities, and higher efficiency designs.

This paper discusses these three trends in the context of arc flash safety within the IT space. Arc flash is explained, potential areas of concern in the IT space are identified, and compliance with associated regulations is discussed.

Introduction

Over the last several years there has been an increasing amount of learning and awareness around arc flash hazards due, in large part, to the number of injuries and deaths. Investigations into these accidents have led to updated standards and an increase in regulatory enforcement. In particular, the data center environment is under increasing scrutiny due to the frequent need for adding new and upgraded branch circuits without shutting down critical loads. In some cases this work on energized circuits, sometimes called "hot work", has sometimes led to the data center owner being fined. One example of such work is the use of busway systems where plug-in units are inserted or removed from a live bus, placing data center workers at potential risk. Incidentally, this growing scrutiny places greater value on concurrently maintainable power systems.

Three IT trends have increased the severity of a potential arc flash in the IT space: higher data center capacities, higher rack densities, and higher efficiency designs. This paper discusses these three trends in the context of how they impact arc flash within the data center IT space[1]. The paper provides guidance to data center professionals on what arc flash is, the potential areas for concern in the IT space, and compliance with regulations.

This paper will help answer questions like, what is the typical fault current in a 20 amp circuit? Is arc flash different than shock? Is my employer liable if a contractor performs hot work in a data center? Is it considered hot work to plug in a rack PDU? Does "Fingersafe^{TM}" mean that I can add a circuit to a live bus? Should I perform an arc flash assessment? For more information on the general topic of arc flash, Schneider Electric has several papers and podcasts[2] on various issues such as approaches to controlling arc flash.

Background on arc flash

The term "arc flash" describes what happens when electrical short circuit current flows through the air. A fault (the common term for short circuit) usually occurs between a live conductor (e.g. wire, bus) and another live conductor(s) or grounded metal. In many cases, a single-phase fault quickly evolves into a three-phase fault. In an arc flash, the current literally travels through the air from one point to the other, releasing a large amount of energy, known as incident energy[3], in less than a second. This energy is released in the form of heat, sound, light, and explosive pressure all of which can cause harm. Some specific injuries can include burns, blindness, electric shock, hearing loss, and fractures. It's important to note that an arc flash risk is different than a shock risk (see sidebar). There are several factors that determine the amount of incident energy (measured in calories/cm^2) but the two most important are controlled by the data center electrical design; available fault current and arc duration[4]:

- Available fault current, measured in kiloAmps (kA), is the maximum amount of current available (at the location of a fault) to "feed" a fault and is dependent on the electrical system design.

Shock hazard

According to NFPA 70E 2015, a shock hazard is different from an arc flash hazard. A shock hazard is associated with the "possible release of energy caused by or approach to energized electric conductors or circuit parts" resulting in electrocution or electric shock. An arc flash hazard is associated with the "possible release of energy caused by an electric arc". An electric arc doesn't necessarily result in electrocution or electric shock.

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[1] IT space in this paper includes computing operations areas of the data center regularly occupied by IT personnel including network operations center (NOC), wiring closets, meet me rooms, etc.

[2] Arc Flash Mitigation, Antony Parsons, July 2013 (last accessed 10/16/2014)

A comparison of arc-flash incident energy reduction techniques using low-voltage power circuit breakers, Oct 2011

Short-circuit, Coordination and Arc-flash Studies for Data Centers: Best Practices and Pitfalls, Oct 2011

http://www.schneider-electric.us/sites/us/en/customers/consulting-engineer/podcasts.page

[3] According to NFPA 70E (2015), incident energy is "The amount of thermal energy impressed on a surface, at a certain distance from the source, generated during an electrical arc event.

[4] Circuit breakers and fuses open faster as fault current increases. Reducing the fault current too much may actually increase incident energy because the breaker or fuse takes longer to open.

- Arc duration, measured in milliseconds (ms), is the amount of time it takes for a fuse or circuit breaker to open and clear a fault.

Within electrical gear, under normal conditions, insulators separate live parts from other conductive surfaces and the air gap between live parts is far enough to prevent arcing. Before an arc flash can occur, something must cause a breakdown of the insulation (air or otherwise) from phase to phase or to ground, such as:

- Improperly installed or specified equipment
- Corrosion around insulators and or conductors
- Cracked or brittle insulation
- Conductive contamination that builds up on conductors or insulators.
- Foreign bodies such as rodents and insects
- Contact through human error (e.g. dropping a screwdriver across conductors)

Once an arc is initiated, it sets off a chain reaction that feeds on itself. The heat energy from the arc causes the metal parts to vaporize which ionizes the air and forms a conductive plasma cloud. This plasma further lowers the resistance between conductive parts which allows more current to flow, leading to more heat energy, higher temperatures, and ultimately more damage to property and harm to any personnel nearby. Given enough energy, a pressure wave develops with significant force, referred to as an arc blast, which can throw personnel back leading to injury or death.

Arc flash risk in the IT space

Ten years ago there was less awareness about arc flash than today; this is especially true in data centers where there have been fines levied against employers for performing work on energized equipment (i.e. hot work). Not only does working on live electrical equipment increase the risk of arc flash, but the following IT trends are increasing the potential incident energy of an arc flash in the IT space:

- Higher data center capacities
- Higher rack densities
- Higher efficiency designs

Higher data center capacities

Over the last few years an increasing proportion of data centers have been built that can support over 1,000kW of IT load. This means that the utility connections for these high-capacity data centers can provide over 50kA of fault current on the low-voltage side of the medium voltage transformer. In comparison, a 500kW data center may have less than half of this fault current. Note that the available fault current alone does not dictate the amount of incident energy, but everything else being equal, incident energy will increase. Therefore, the trend toward data centers of larger power capacities, and the trend toward increasing the capacities of individual rooms in large data centers, both tend to increase the available fault current in the data center room.

Higher rack densities

Average rack densities have slowly increased over the years to beyond 4-5kW/rack. This means that the wire size and circuit current ratings have increased, both of which cause the fault current at the rack to be greater than in lower density data centers. The available fault currents at a high density rack today may be as much as 10X the fault current that was found in early data centers. Therefore, the trend to higher rack density is causing an increase of the fault current at the IT rack.

Higher efficiency designs

In a push to increase data center power usage effectiveness (PUE), electrical architectures are being designed to lower the losses from transformers and UPSs. Transformers, in addition to their voltage conversion and isolation functions, provide both resistive and inductive impedance in the power path that limits the fault current. However, transformers represent one of the highest losses in the electrical train, sometimes even greater than UPS systems. In an effort to reduce these losses, data center designs have deployed fewer, but larger, transformers which reduce the losses, but increase the available fault current at the IT racks. In some cases, the impedance (i.e. resistance in AC circuits) on these larger transformers are also lower than smaller transformers but can be specified with higher values to lower fault current. Therefore, the trend toward high efficiency designs does tend to increase the available fault current in the data center room.

Sources of arc flash risk

There are seven main sources of arc flash risk within a data center's IT space: switchboards, UPS, power distribution units (PDU), busway, remote power panel (RPP), panelboards, and rack power strips (i.e. rack PDU)[5]. While live conductors in the IT space are certainly a source of arc flash, they are seldom the point where an arc flash is initiated since these conductors are well insulated. Mechanical equipment such as cooling units are also a source of arc flash but generally pose a lower risk than electrical sources discussed below[6]. Note that these seven sources are listed in order of available fault current. In general, the further downstream toward the IT device you go in an electrical architecture, the lower the available fault current. As the electrical network splits up into more paths, the conductors tend to be smaller which increases their resistance, limiting the available fault current.

Switchboards
Switchboards contain circuit breakers that distribute power to PDUs, UPSs, or other large electrical equipment in the IT space. In general, switchboards found in the IT space have the highest available fault current, typically in the range of 35-45kA for data centers greater than 500kW. Circuit breakers found in the switchboard have some of the highest current ratings in the IT space. Opening, closing, or resetting a breaker in a switchboard should always be done by qualified workers and never by IT personnel.

UPS
UPS systems are sometimes located in the data center IT space especially in data centers less than 1,000kW but in larger data centers they are usually located in a separate electrical room. In case of a fault downstream of the UPS, the UPS generally switches to bypass which presents very little impedance to the flow of fault current. As a result, UPS systems have about the same fault current as the switchboards feeding them. Operating breakers or static switches on large three-phase UPSs should always be done by qualified workers and never by IT personnel.

Power distribution units (PDUs)
A power distribution unit sometimes contains an isolation transformer but always contains multiple panelboards that distribute branch circuits to each rack. In some cases the transformer may have the same input and output voltage, but in North America, it typically steps

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[5] For more information on these components see White Paper 61, *Electrical Distribution Equipment in Data Center Environments*

[6] Cooling units are almost always de-energized to perform work on electrical parts over 50 volts.

down the voltage from 480V to 120/208V or 240/415V. Isolation transformers provide an excellent source of impedance to fault current but, depending on the input and output voltage, the fault current could decrease or increase. **Table 1** provides four examples of the resulting fault current (kA) on the secondary side of a transformer based on 40kA of available input fault current.

Table 1

Estimated kA values at the secondary side of a transformer assuming 40kA fault current at the transformer input for two different impedance ratings

kVA	Primary volts	Secondary volts[7]	kA at % impedance	
			5%	6%
225	480	120/208	11	9
225	480	240/415	6	5
1,000	480	120/208	35	31
1,000	480	240/415	17	15

If a branch breaker in a PDU were to trip open due to an overload, it's generally accepted that an unqualified person, such as an IT administrator, can reset the breaker. However, if a breaker opens due to a fault or the cause is unknown, a qualified worker should first investigate why a breaker tripped before closing, resetting, or replacing it. If a fault exists, it's possible to cause damage or even an arc flash by closing a breaker on to the fault.

Busway

Busway, typically containing four to five busbars (three phases, ground, and sometimes neutral), may be run overhead above IT racks (and sometimes below raised floors), and can be used instead of panelboards to distribute power to the racks. Busways use plug-in power tap units with their own built-in circuit breakers to distribute power directly to each rack. Since busway replaces multiple runs of small branch wiring (each with relatively high impedance) with three large single bus bars, it has very little impedance to fault current. As a result, busway can have nearly the same fault current near the load as at the source power panels feeding them. This positions high available fault current in the immediate proximity of the rack, typically overhead. A common belief is that the power tap units for exposed busway systems are "hot swappable" but this is not the case according to some health and human safety regulations. In certain countries such as Canada and United States, **plugging a tap unit into an energized busway is considered work on "exposed live electrical parts".** For example, **in the United States it is a violation of OSHA[8] regulations for an employer to expose workers to this recognized hazard.** This is discussed in the "Arc flash safety" section. Just because an electrical system is "tool-less" doesn't mean that a user is protected from all electrical hazards (see side bar). The guidelines for IT personnel resetting a branch breaker on a plug-in unit are the same as those for a PDU.

Remote power panels (RPPs)

A remote power panel sometimes has the form factor of an IT rack and contains multiple circuit breakers that distribute branch circuits to each rack. Unlike a PDU, an RPP doesn't contain a transformer, therefore, only the wiring into and out of an RPP impedes the flow of fault current. Smaller RPPs (e.g. 100kW capacity) provide more impedance than larger ones (e.g. 400kW capacity) because the input wires are smaller.

Some RPPs offer circuit breaker modules that plug into open slots. Like busway, plugging these breaker modules into live RPP units, with exposed electrical parts, may not be allowed and may require that the RPP be de-energized prior to adding circuits.

"Fingersafe" vs. "exposed"

"Fingersafe" refers to one of many international protection (IP) codes described in the IEC 60529 Standard, "Degrees of protection provided by enclosures". When an electrical enclosure is "Fingersafe", it should conform to the IP2X degree of protection specified in the standard. This means that if an 80mm long, 12mm diameter finger were to penetrate the enclosure, it would have adequate clearance from hazardous parts. This also means that a 12.5mm diameter probe would not be able to fully penetrate the enclosure.

According to NFPA 70E 2015, "Exposed (as applied to energized electrical conductors or circuit parts)" is defined as "Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated."

Based on these definitions, it is clear that "Fingersafe" does provide some level of guarding, especially from shock hazards. However, there is currently no interpretation available from NFPA on whether "Fingersafe" qualifies as "suitably guarded" or provides protection from arc flash hazards. If "Fingersafe" is not considered "suitably guarded", from contact with tools, then it is, by definition, considered "exposed" to live parts.

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[7] See White Paper 128, Switching to 240V AC Distribution in North American Data Centers

[8] Occupational Safety and Health Administration

Even when a branch breaker trips (i.e. opens the circuit), IT personnel should seek a qualified worker to investigate why the branch breaker tripped to begin with, before opening the panel door and resetting it. It's possible that there is a fault somewhere in the rack or IT equipment which could result in undue risk if re-energized. There are a number of reasons that can cause a circuit breaker to trip including an overloaded circuit[9] which would require load shedding before resetting the breaker.

Panelboards

Panelboards are essentially "unpackaged" RPPs since they are typically mounted against a wall or on steel bracings and are accessible only from the front. Panelboards distribute branch circuits to each rack. The guidelines for IT personnel resetting a branch breaker on a panelboard are the same as those for a PDU

Rack PDUs

Rack PDUs, also referred to as power strips, are installed in IT racks and are powered from the mating connector of the upstream PDU, RPP, or panelboard. The fault current available at the outlet receptacles of rack PDUs tends to be the lowest of all power distribution components because they are the last component in the "power chain" and are fed by smaller gauge wires which reduce the fault current. The fault current at the input of rack PDUs should be limited to 10kA because this is the typical rating for most cord caps (i.e. input connector plug). Note that some rack PDU vendors tout high fault current ratings (i.e. 50kA). This is not logical because the cord cap is typically rated for 10kA and the system should never be allowed to provide more than this at the point of use, due to safety concerns. This topic of excessive kA ratings on point of use equipment is discussed later in the next section.

A recommended practice is to design a data center electrical system such that there is no more than 10kA available at the input of the rack PDU. Depending on the electrical architecture, increasing the branch circuit wiring length or decreasing the rack PDU kW rating, or both may be required to limit the fault current to 10kA at the rack PDU input. Just a few extra meters of smaller gauge (higher impedance) wire, significantly reduces fault current. **Note that this is more challenging with busway systems because they're designed to reduce branch circuit lengths.** **Table 2** illustrates the relationship between fault current at the rack PDU input, the rack PDU capacity, and the branch circuit length. The kA values are estimated based on a fixed fault current of 30kA at the RPP input. A higher or lower input fault current than 30kA has a corresponding effect on fault current available at the rack PDU input.

Table 2 suggests that 120V rack PDUs with capacities of 11kW or more should be rated for at least 10kA. While 230V or 240V rack PDUs with capacities greater than 17kW should be rated for at least 10kA. Note that the kA values for 230V are very similar to those in a 240V system used in North America. Even a relatively short length of a small-gauge branch circuit wire can significantly lower fault current. However, if a three-phase 60A circuit is required but the fault current is too high, it may be necessary to install a branch circuit approximately 8m (26ft) long or alternatively supply the rack with three 20A circuits to limit the fault current at the rack PDU to 10kA or less.

The available fault current for single-phase rack PDUs is much lower because phase to phase faults are eliminated. Therefore, a 5kA rating for single-phase rack PDUs is typically acceptable. An arc flash assessment provides the necessary information to validate the choice of rack PDUs in all cases. Anyone can plug or unplug a rack PDU input connector into its mating supply connector; however, all rack PDU loads should first be turned off. Turning off the loads prevents arcing between the mating connectors which can cause damage to the connectors or injury.

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[9] Circuits may be marginally overloaded, such that they reset successfully, but trip at an unpredictable time in the future. This is a key reason why a successful reset cannot be used to establish reliable operation and why an qualified worker should investigate.

Table 2

*Estimated fault current (kA) values at rack PDU input assuming **30kA** fault current at RPP input for two different branch circuit lengths*

(Each table represents a different voltage; 120V and 230V)

Wire gauge		Amps[10]	Max breaker	120V max 3-ph kW	kA at rack PDU input		
mm^2	AWG				2m (7ft)	4m (13ft)	8m (26ft)
2.08	14	16	20A	5.76	6	3	2
3.31	12	24	30A	8.64	8	5	3
5.26	10	32	40A	11.52	11	7	4
8.36	8	40	50A	14.40	14	10	6
13.3	6	48	60A	17.28	17	13	8

Wire gauge	Amps	Max breaker	230V max 3-ph kW	kA at rack PDU input		
mm^2				2m (7ft)	4m (13ft)	8m (26ft)
1.5	16	16	11.04	9	6	3
2.5	25	25	17.25	12	8	5
4.0	32	32	22.08	16	11	7
6.0	40	40	27.60	19	14	9
10.0	63	63	43.47	22	18	13

The problem with high fault current ratings

Short circuit current rating (SCCR) is the maximum permissible short-circuit current that the equipment can withstand, thermally and electrodynamically, without sustaining damage, for a given time period. SCCR is also referred to as short circuit withstand current and is measured in kiloAmps (kA). An SCCR rating is established through testing procedures developed by various standards bodies.

The reason this is important is that some vendors offer products with extremely high SCCR ratings, on the order of 50kA, for equipment that resides inside the IT space such as rack PDUs and computer room air handlers (CRAHs). If this amount of fault current was actually available at a rack PDU, that would mean that the available fault current at equipment upstream was about 60-70kA. This amount of fault current is unlikely and will rarely be present in an IT space that is designed with safety in mind. Therefore, there is no reason to specify such high kA values for any equipment inside the IT space.

Furthermore, vendors attain such high kA ratings, and selling prices, by installing relatively low-cost input fuses that open quickly upon a large fault current. This presents an additional single point of failure, additional cost, overhead for stocking spare fuses, and additional downtime in replacing them. Some cooling units can cost over $1000 more for a high SCCR option. The approaches discussed in this paper are far more effective than specifying extremely high SCCR ratings for equipment in the IT space.

Does all this imply that fault current should be minimized in all areas of the data center? The answer is “no”. If a circuit breaker were to trip open in 20ms regardless of the fault current, then it’s easy to conclude that reducing fault current will result in lower incident energy. However, circuit breakers and fuses open faster as fault current increases. They have time-current curves that specify their reaction time under varying fault currents. **Reducing the fault current too much may actually increase incident energy because the breaker or fuse takes a longer time to open and incident energy is a function of time**. Fuses are more prone to this since circuit breaker trip settings can be adjusted to open faster or slower for different fault currents and fuses cannot be adjusted.

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[10] The current (A) ratings in **Table 1** have been de-rated per National Electric Code for continuous load.

Compliance with regulations

There are four main groups of standards in Canada, US, and in the major regions around the world including China and Europe related to arc flash safety. Although there are regional differences even within the same country, all the standards, shown in **Table 3**, basically affirm or describe:

1. the employer is responsible for the protection of employees and contractors who perform work on electrical equipment in their facilities (e.g. OSHA 29)
2. how to install electrical systems according to code (e.g. IEC 60364)
3. the practices, trainings, and personal protective equipment (PPE)[11] required to protect workers from arc flash (e.g. CSA Z462)
4. how to quantify arc flash hazard levels (e.g. IEEE1584)

Note that in many parts of the world, arc flash standards are just now being written as new standards or as part of existing standards. Where there are no local standards, employers should get approval from the authorities having jurisdiction (AHJ) to use other established standards.

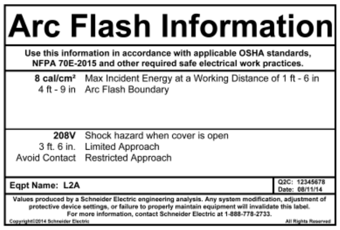
Table 3

Standards used throughout the world

Standard	Canada	China	Europe	United States
Health and human safety	Varies since health and safety is regulated by jurisdiction	GB16895 Electrical Installations of Buildings	Varies since health and safety is regulated by each European country	OSHA 29 Code of Federal Regulations (CFR) Part 1910 Subpart S and 1926
Electric code / installation	Canadian Electrical Code Part I (CEC)	GB 16895 Electrical Installations for Buildings	IEC 60364 Electrical Installations for Buildings	NFPA 70 National Electrical Code and some local codes
Electrical safety / arc flash	CSA Z462 Workplace Electrical Safety Standard	The Electrical Safety Program Guide, Second Edition	European Standard EN 50110-2013 Operation of electrical installations	NFPA 70E-2015 Standard for Electrical Safety in the Workplace
Arc flash calculations	IEEE Standard 1584-2002 IEEE Guide for Performing Arc-Flash Hazard Calculations			

A key tenet of some arc flash safety standards is that it is the owner's responsibility to provide or make available the necessary PPE to employees (and in some cases, third party contractors) who perform "work"[12] on electrical equipment in their facilities. It is the worker's responsibility to use the PPE. Failure to adhere to these regulations could result in fines and/or lawsuits. Responsibilities include, but are not limited to; knowing the levels of incident energy at the different locations in the electrical system, training, work permitting, safety programs, and documenting the dangers through the use of arc flash information labels placed on electrical equipment (see sidebar). The exact details of these requirements are not discussed in this paper and vary throughout the world. Ultimately, the safest practice is to place the electrical equipment in a de-energized state (i.e. absence of voltage, lock out sources, etc.) before performing work on it[13].

Example of arc flash information label



Arc Flash Information

Use this information in accordance with applicable OSHA standards, NFPA 70E-2015 and other required safe electrical work practices.

8 cal/cm²	Max Incident Energy at a Working Distance of 1 ft - 6 in
4 ft - 9 in	Arc Flash Boundary
208V	Shock hazard when cover is open
3 ft. 6 in.	Limited Approach
Avoid Contact	Restricted Approach

Eqpt Name: L2A

Q2C: 12345678
Date: 08/11/14

Values produced by a Schneider Electric engineering analysis. Any system modification, adjustment of protective device settings, or failure to properly maintain equipment will invalidate this label.
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[11] PPE is equipment such as gloves, safety glasses, suits, etc. worn by workers to minimize the risk of injuries as well as illnesses.

[12] Term "work" includes examination, inspection, adjustment, servicing, or maintenance of the equipment as described in U.S. National Electric Code (NEC) 2014, Article 110.16, Arc-Flash Hazard Warning

[13] A concurrently maintainable power system design allows for this practice while maintaining redundant power feeds to critical equipment.

In fact, health and human safety regulations generally prohibit or at least discourage work on exposed live electrical parts. For example, OSHA (United States) categorizes work under two standards; General Industry Standard (1910.333) and Construction Standard (1926.416). If the work you're doing in a data center is considered maintenance, it falls under the General Industry Standard which allows only three exceptions to work on live exposed live electrical parts. If the work is considered new work, such as adding a circuit, it falls under the Construction Standard which prohibits work on live exposed parts with no exceptions[14]. This means that **in the United States, it is a violation of OSHA regulations for employers to allow workers to add circuits to live exposed electrical parts such as switchboards, PDUs, busway, RPPs, etc.**

Furthermore, in most, if not all countries, only qualified people are allowed to "work" on electrical equipment. For example, in the United States, the NFPA 70E 2015 Edition (Article 100), defines a Qualified Person as "One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved." Rarely are IT personnel considered "qualified" to work on electrical equipment that exposes[15] them to potentially live electrical parts. For example, are you exposed to live parts when you insert a plug-in unit into a live busway? The answer, depending on local regulations, may be "yes", and if an employer is cited it will likely result in a fine per incident. Swapping out a rack power strip (with cord cap connector) is not considered working on live exposed electrical parts.

This paper recommends that all IT personnel request the help of a "qualified person" whenever there is a need to open the cover on switchboards, power distribution units, busway, remote power panels, or panelboards. In addition to this, a good practice for existing data centers is to commission an arc flash assessment. These assessments review current work practice policies, determine the arc flash risks present in the electrical system, suggest where risks should be appropriately labeled, and provide an overall plan to bring the data center into compliance with local codes and regulations. Oftentimes it's easier to depend on experts versus researching codes and regulations and interpreting what actions to take. An assessment should also be done after any major changes are made to the electrical system because this can significantly change the amount of fault current at a particular point. For example, if the utility company replaces a transformer that feeds the data center, the change in fault current could require changes to the main electrical gear.

Arc flash hazard PPE Categories

The best and surest method for protecting against injury from arc flash is to work on de-energized equipment after locking and tagging the source breaker(s) known as lock out tag out (LOTO). However, even in this case, de-energizing the equipment can be considered electrical work. Typically a circuit breaker must be opened to de-energize a piece of equipment. This may mean a worker must stand in front of the breaker and manually operate it[16], or it could mean opening the breaker remotely such as from a switch in the control room. In either case, after the breaker is open, a worker must wear appropriate PPE (e.g. gloves, hood, overalls, etc.) to measure the voltage *inside* the gear and confirm the absence of voltage and that an electrically safe working condition exists. Appropriate PPE is specified by assessing the shock and arc flash risks. This high-level process is essentially the same across the world but the lack of harmonized standards makes it difficult to carry out the specific steps without consulting with local authorities.

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[14] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=interpretations&p_id=21569

[15] The 2014 Edition of the NEC Handbook (Article 100), defines "Exposed" (as applied to live parts) as "Capable of being inadvertently touched or approached nearer than a safe distance by a person."

[16] Depending on local regulations, if the electrical gear meets certain conditions, PPE is not required to manually operate a circuit breaker.

NFPA 70E is currently the most mature arc flash standard that specifies PPE according to the amount of energy the equipment can sustain. There are various standards for testing this equipment, but they all have the common goal of protecting personnel from injury. Specific injuries that PPE is meant to protect against are burns, eye injuries, electric shock, hearing loss, and head injury. The NFPA 70E 2015 edition specifies four categories[17] (1, 2, 3, and 4) of arc flash hazard PPE for AC and DC system voltages. The PPE category is indicated for several scenarios in Table 130.7(C)(15)(A)(a). Each scenario is described in terms of maximum available fault current, maximum fault clearing time, and minimum working distance. Note that circuit parameters or equipment not covered in the tables require that someone perform an incident energy analysis. **Table 4** shows the minimum arc flash rating for each PPE category.

Table 4

Minimum arc flash rating for each PPE category

PPE category	Minimum arc flash rating
1	4 cal/cm2
2	8 cal/cm2
3	25 cal/cm2
4	40 cal/cm2

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[17] Category 0, specified under the NFPA 70E 2012 edition, has been dropped from the 2015 edition.

Conclusion

Practicing arc flash safety in the data center IT space means that IT personnel should request the help of a qualified person whenever there is a need to work on switchboards, power distribution units, busway, remote power panels, or panelboards. In some jurisdictions, the employer is responsible for the protection of employees and contractors who perform work on electrical equipment in their facilities. Many health and human safety regulations prohibit or at least discourage work on exposed live electrical parts including exposed busway. Failure to adhere to these regulations could result in fines and lawsuits. Responsibilities include, but are not limited to, knowing the levels of incident energy at the different locations in the electrical system, training, work permitting, safety programs, and documenting the dangers through the use of arc flash information labels placed on electrical equipment. Data center owners can help ensure adherence with local codes and regulations by commissioning an arc flash assessment service.

There are several approaches available to lower the incident energy in an electrical system by lowering the available fault current and reducing the arc duration. These approaches, discussed in other Schneider Electric papers, are far more effective at lowering the fault current in the IT space than specifying high SCCR ratings for equipment such as rack PDUs and CRAH units.

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