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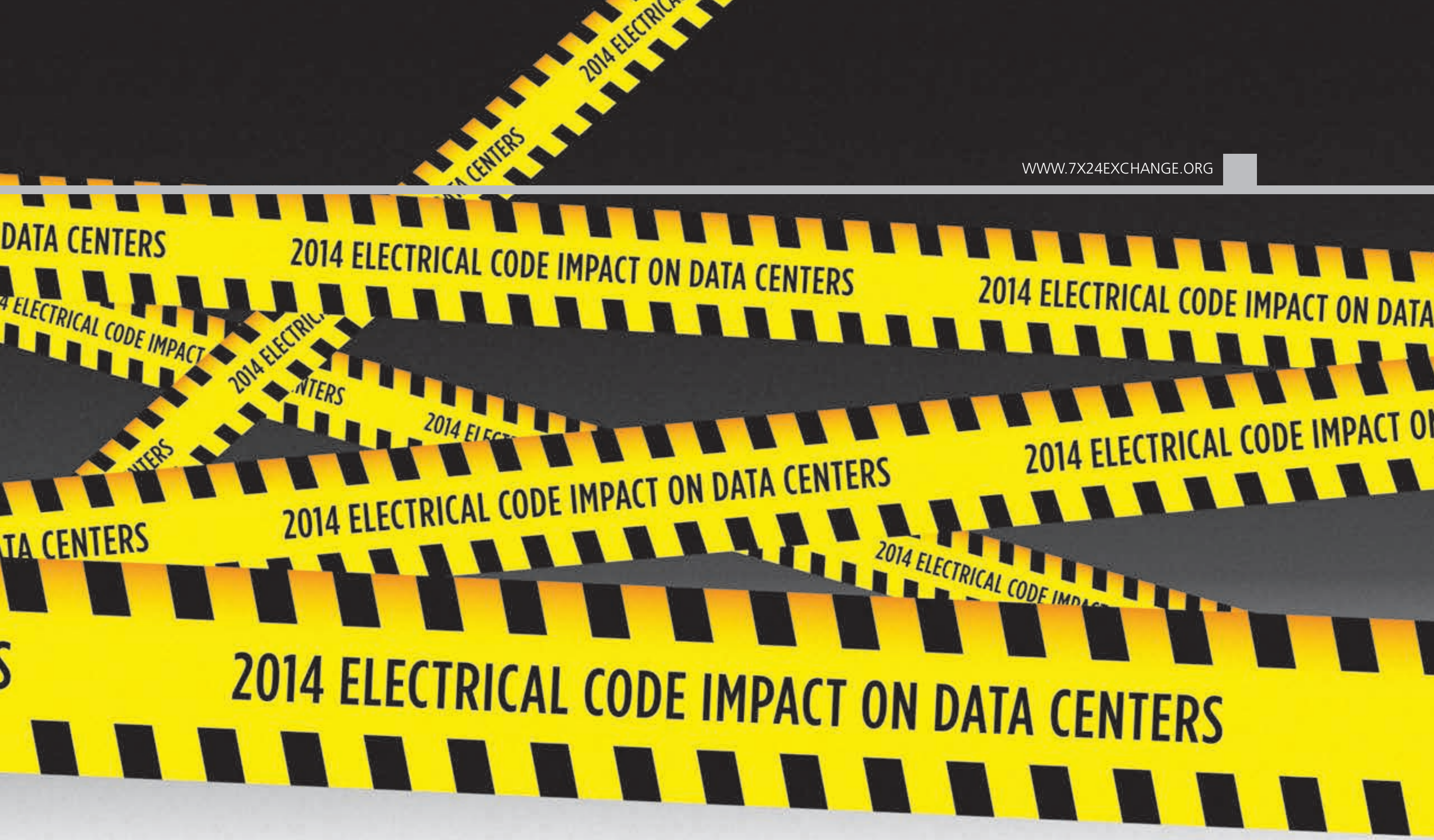


By Dennis R. Julian PE, ATD, DCEP

THE ELIMINATION OF THE NEC REQUIREMENT FOR SMOKE DETECTION UNDER THE RAISED FLOOR, WITH THE REQUIREMENT TO SHUT DOWN AIR CIRCULATION WHEN SMOKE IS DETECTED, IS A SIGNIFICANT AND LONG DESIRED CHANGE. THIS AND OTHER CHANGES ARE CONTAINED IN THE NEW NATIONAL FIRE PREVENTION ASSOCIATION (NFPA) ISSUED 2014 EDITION OF NFPA 70, NATIONAL ELECTRIC CODE (NEC).

High availability and energy efficiency make data centers unique facilities when, if not properly designed, these robust systems can result in undesirable complexity and increased safety hazard. Several articles in the NEC deal directly with mission critical data centers, including Article 645 Information Technology Equipment, Article 646 Modular Data Centers and Article 708 Critical Operations Power Systems. Some of the changes with the most impact:

1. Article 645 – Information Technology Equipment (ITE) has eliminated the electrical code requirement for smoke detection below the raised access floor. The NEC now permits the critical cooling to remain functional during an underfloor smoke event. This will minimize the opportunity for false shutdowns of the ITE cooling systems.

2. New Article 646 Modular Data Centers (MDC) regulates the increasing popular offsite constructed data center (modular or containerized). This, along with UL 2755 for Modular Data Centers, will provide structure and regulation to this form of data center deployment.

3. The revised more strict definition of Selective Coordination will pose new challenges for critical operations data centers and will require detailed engineering to specify equipment and more expensive overcurrent protective devices to meet the new requirements.

4. To increase safety by reducing arc flash energy exposure all circuit breakers rated 1200A and above are required to have an approved method for speeding up device operation. This change may increase equipment costs and complexity within the data center. Engineering will be needed to determine the appropriate features and sequence of operations.

CODE-WIDE CHANGES

The NEC definition of switchgear, previously referred to as metal-enclosed power switchgear, was revised in Article 100 to be more comprehensive. It is now a generic term that encompasses many different types of metal-enclosed switchgear, including 1000V and above. Switchgear was added to the title of Article 408 which governs installation and construction of distribution equipment and many other sections where the term switchboard was previously used.

The terms switchgear and switchboard are often interchanged without recognizing the fundamental differences. For example, low-voltage metal-enclosed switchgear is constructed to standard UL 1558 and is compartmentalized with physical barriers between circuit breakers and bussing. Enclosure depth is typically greater than switchboard construction and switchgear requires front and rear access. Switchgear can be designed with 30-cycle interrupting ratings and can also be designed to be arc-resistant.

Switchboards, on the other hand, are constructed to standard UL 891 are not typically compartmentalized, 30 cycle rated and are not available in an arc resistant construction. Switchboards can be designed front accessible only.

ARTICLE 110: REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

Service equipment is required to be field-marked with the maximum available fault current and the date that the calculation was performed. The available fault current is often calculated using the infinite bus method, which assumes there is zero impedance in the upstream utility system. This calculation method results in the highest value of fault current, and is a typical practice for verifying equipment withstand and interrupting ratings. However, this theoretical value can result in under calculating the available arc flash energy due to the apparent quick operation of overcurrent devices. These devices would, in reality, operate slower with the actual available short circuit current. The new informational note in Article 110.24 advises that these markings should not be used for determining arc flash incident energy levels, and guides users to NFPA 70E, *Standard for Electrical Safety in the Workplace* for determining potential exposures, planning safe work practices and selection of PPE.

Personnel doors from working spaces containing equipment rated 800A or above (reduced from 1200A) must have outward swinging door(s) equipped with listed panic hardware in accordance with 110.26(C)(3).

Many data centers have **outdoor equipment yards** that contain transformers, generators, switchgear, and mechanical equipment. This outdoor equipment is now subject to the same dedicated equipment space requirements as indoor equipment based on 110.26(E)(2)(b). Outdoor equipment yards and similar areas must be carefully coordinated between all trades to ensure dedicated equipment spaces are free of: mechanical, plumbing, fuel, piping and other foreign systems.

ARTICLE 240: OVERCURRENT PROTECTION

Article 240.87 Arc Energy Reduction, now requires all circuit breakers rated **1200A and above**, be provided with an approved **method for reducing clearing time during a fault**. The following methods are indicated for reducing clearing time: Zone-selective interlocking, differential relaying, energy-reducing maintenance switching with local status indicator, energy-reducing active arc flash mitigation system (e.g. high-speed shorting switches, optical sensors, etc), and approved equivalent means. High-speed shorting switches are most commonly applied to medium voltage systems. When an arcing fault is detected, these devices actively close a switch to create an intentional three-phase fault, which increases the fault current and trips the associated protective relays faster. Optical relaying may be alternative method for consideration, where deemed an "approved equivalent means" by the local Authority Having Jurisdiction (AHJ). These systems detect an arcing fault by looking for specific light and current characteristics and trip only when both are present. The changes to 240.87 have the potential to limit the number of equipment manufacturers who offer these systems and may increase equipment costs. Engineers must weigh the various pros and cons for each method and determine the most appropriate strategy on a case-by-case basis.

The two main factors that affect arc flash incident energy are current and time. The longer a fault exists, the higher the resultant arc flash severity. Unlike short circuit current where the device closest to the source has the highest value, a higher arc flash hazard may exist at locations further from the source due to the time it takes the lower fault current to activate the overcurrent device. Unfortunately, maximum selectivity and maximum service continuity can be in direct conflict with one another. Ideally, any overcurrent protective device that detects a fault should open instantaneously to reduce arc energy. However, at the same time, selectivity is often necessary to ensure that upstream devices are restrained long enough for the device nearest to the fault to open first to minimize the impact of the fault on the remainder of the system.

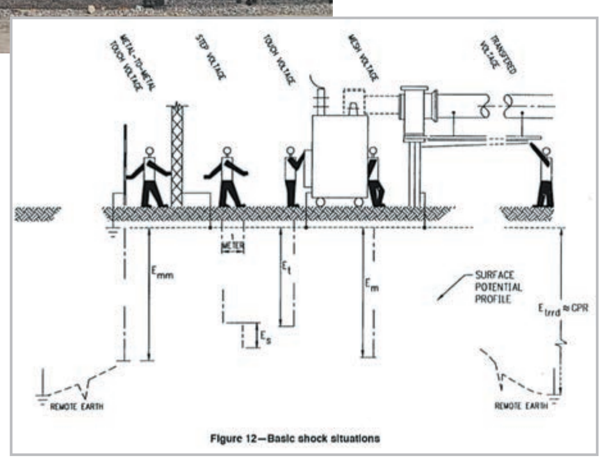
ARTICLE 250: GROUNDING AND BONDING

Many data centers are supplied by outdoor electrical substations that are often enclosed by metal fences to restrict access to qualified personnel. Based on the new provisions in 250.194, metal fences and other metallic structures **must be grounded and bonded** to limit the rise of hazardous step, touch and transfer voltages. *IEEE 80 Guide for Safety in AC Substation Grounding* is the industry standard for fence grounding.

ARTICLE 310: CONDUCTORS FOR GENERAL WIRING

Conductors and cables installed on rooftops exposed to direct sunlight are subjected to higher ambient temperatures than the surrounding environment. These conditions require the ampacity of the conductors to be temperature-adjusted, which typically results in larger size conductors. An exception added to 310.15(3)(c) allows Type XHHW-2 conductors to be used **without temperature-adjustment**. Type XHHW-2 conductors are comprised of a thermoset insulation suitable for high ambient temperatures, which may be simpler and more cost effective than increasing conductor and raceway sizes.

Example of a Metallic Fence Around a Substation



Basic Shock Hazards in Substations

(Copyright © IEEE 80-2000, Figure 12)

ARTICLE 480: STORAGE BATTERIES

Article 480 has been expanded adding to the code many industry best practices for installation which now makes them mandatory and enforceable by the local Authority Having Jurisdiction (AHJ).

Uninterruptible Power Supply (UPS) systems often use stationary storage battery systems to maintain power to critical IT equipment when other power sources are unavailable. There are different battery technologies on the market; the most commonly used in data centers are vented type (flooded wet cell) or sealed type (valve-regulated). Many batteries emit hydrogen gas during normal charging cycles, vented batteries more than sealed batteries. To **coordinate with building and fire safety codes** NEC article 480.9 requires provisions "appropriate to the battery technology" be employed to prevent the accumulation of explosive or otherwise harmful gasses. Therefore, the electrical AHJ will now also enforce this requirement.

Battery installations must comply with article 480.9(C), which references 110.27 for **guarding of live parts**. Minimum front and top clearances are indicated. Additional clearances should be considered to enable access for rigging equipment used during future battery replacements.

Battery rooms may also contain emergency showers, eye washes and spill containment, all of which should not encroach on the dedicated equipment and working spaces.

Example of a Vented Lead-Acid Battery Installation

ARTICLE 645: INFORMATION TECHNOLOGY EQUIPMENT (ITE)

Article 645 covers equipment and installations for ITE rooms. ITE rooms are power intensive and cooling sensitive environments; two aspects which present many unique safety challenges. Article 645 permits the use of alternate, less stringent wiring methods, provided that all six conditions listed in 645.4 are met.

Requirements and descriptions for HVAC systems in ITE rooms are clarified under 645.4 Special Requirements.

Non-plenum rated power cables, communications cables, cord-and-plug connections, and receptacles are permitted to be installed below a raised access floor used as an air plenum, provided the provisions of 645.5(E) are followed. Previous editions required smoke detection under the raised floor to cease the circulation of air upon the detection of smoke. The requirement for **under floor smoke detection and to stop air circulation under the floor was removed** from 645.5(E)(4). Smoke detection under the raised floor may be required by other building codes or standards but is no longer required by the NEC.

Article 645.14 System Grounding was added to specifically indicate that separately derived grounding systems shall meet the requirements of Article 250. In addition 645.15 states that grounding and bonding shall comply with article 250.

Declaring an ITE room as a Critical Operations Data System in order to **not install EPO switches** triggers a requirement to **selectively coordinate** overcurrent protective devices in accordance with 645.27. This requirement makes the design and installation more complicated and expensive.

Traditionally, selective coordination can be accomplished by overlaying the Time-Current Characteristic (TCC) curves for each overcurrent protective device and adjusting their trip settings to ensure the TCC curves did not overlap. Selective coordination in the instantaneous region (below 0.1 seconds) poses significant challenges when modeling similarly rated circuit breakers, while simultaneously trying to minimize arc flash incident energy. Previous editions of the NEC did not define specific time or current parameters where selective coordination must exist; this resulted in many systems that were coordinated only in the short and long time regions (beyond 0.1 seconds) or under "bolted-fault" conditions in an effort to avoid installing larger, more expensive equipment.

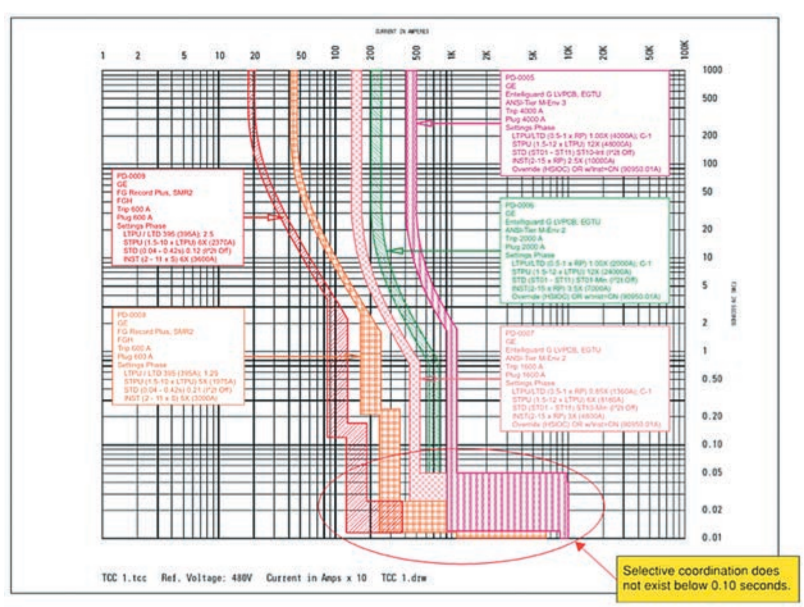
For example, the typical 20A circuit breaker is not selectively coordinated with the typical 225A main panel board circuit breaker. This is also true of many molded case circuit breakers with instantaneous trips. It will be necessary to specify and select different equipment and devices to comply with this requirement for selective coordination.

The **revised definition in Article 100 now states that selective coordination** must include: "the **full range of available overcurrents**, from overload to the maximum available short circuit current, and for the full range of overcurrent protective device opening times". Conventional TCC analysis may no longer be sufficient. Manufacturer selectivity tables, which specify the relative operating times of various circuit breaker combinations, and other techniques such as instantaneous Zone Selective Interlocking (ZSI), may be necessary to achieve selective coordination in the instantaneous region. According to the NEC, 'selective coordination' should not be confused or interchanged with the term 'coordination' referenced in other code articles, such as 517.30(G). Coordination refers only to "the period of time that a fault's duration extends beyond 0.1 second".

ARTICLE 646: MODULAR DATA CENTERS

Modular Data Centers (MDCs), or offsite constructed data centers, represent a growing trend in data center architecture. MDCs are prefabricated units rated 600 volts or less, which are preassembled at a factory and shipped to the construction site. An MDC may consist of one module that contains ITE and all supporting power and cooling equipment, or it may consist of multiple interconnected modules with the ITE separated from the supporting power and cooling equipment.

MDCs offer several advantages over traditional "stick-built" data centers: they are constructed off-site in controlled environments and can be shipped nearly anywhere in the world, enabling accelerated project deliveries and reducing project risk due to weather or other unforeseen site conditions. MDCs are inherently scalable and provide greater flexibility, with nearly unlimited load-on-demand opportunities.



Typical TCC Curve used for Selective Coordination

Centercore Modular Data Center in Omaha, NB

Centercore Modular Data Center in Omaha, NB

MDCs may be listed and labeled, in which case, all factory-installed equipment and wiring would be certified under the listing procedures. Listed MDCs are only required to comply with certain sections under Article 646; however, any field-installed components would be subject to full NEC compliance. The UL 2755 *Outline of Investigation for Modular Data Centers* is one way to identify specific listing requirements. MDCs that are not listed must comply fully with Article 646.

MDCs are permitted to use the alternate, less stringent wiring methods in Article 645 (646.3(L).

An approved disconnecting means (i.e. EPO) is **required to disconnect power** to all electronic equipment and dedicated HVAC systems (646.3(N)). A nameplate is also required on each MDC enclosure that identifies the information listed in 646.5 which includes the full load current and short circuit rating. The supply conductors shall be sized at not less than 125% of the full load current listed on the nameplate.

Flexible power cords and cables that are listed for extra-hard usage are permitted to be used for interconnecting separate MDC enclosures (646.9(A)). However, they may not be used for connecting an MDC to an external power source, such as a building electric service (646.9(B)).

Workspace requirements for MDCs must comply with 110.26, which is the same for all traditional data centers (646.18). MDCs containing equipment greater than six-feet-wide or deep require one entrance to, and egress from, the working space (e.g. two doors), regardless of the ampere rating of the equipment (646.19). Workspace requirements also apply to low-voltage circuits rated above 30 volts-rms, 42 volts-peak, or 60 volts-dc (646.20).

SUMMARY

There are many new changes in the 2014 NEC that will impact data center designs and costs. Standard designs will need to change and the effect on costs and equipment delivery times will need to be determined.

The NEC is a consensus standard that must be adopted at the state level, often with amendments, before it becomes enforceable. More than half of the states have adopted or are in the process of adopting the 2014 NEC. The following website tracks NEC adoption http://electricalcodecoalition.org/state-adoptions.aspx.

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