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Data center circuit protection

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Background

Over recent decades, data centers have become one of the most critical developments in the technology world. The explosion of communication, Smartphone applications, social media, cloud computing and the Internet of Things, has allowed individuals to weave the Internet into their daily routines. Also, businesses are storing and mining big data to become more productive as this technology allows them to solve these challenges long thought to be unsolvable.

The Internet has allowed everyone to work virtually, connect with each other globally, exchange information and data in real time, and has enabled everyone to harvest and analyze large data in order for people to become much more productive. This process has required data managers to store more data in their data centers. So much so that the number of data centers has doubled approximately every five years and will continue to grow exponentially. It's estimated that there will be a threefold increase in IP traffic growth moving forward, from 2015 to 2020. Add in the growing need of the Internet of Things, where devices are always connected and exchanging data at high volumes, managing data centers effectively has become, and always will be, mission critical.

Energy efficiency

Design engineers, operators and owners face many challenges when developing and managing today's data centers. One of the key considerations when designing within the whitespace is the electrical distribution system. To ensure maximum uptime for its users, a very complex electrical distribution system is required to support the system from incoming power down to the server racks. Each portion of the system presents its own challenges.

One of the first challenges that the designer is confronted with is the total cost of ownership. It's estimated that 50% of the annual operating cost is the electricity needed to power the entire system. With energy consumption being a large portion of annual operating costs, there are many ways to measure how efficiently electricity is being used. A popular metric to quantify this is Power Usage Effectiveness (PUE). PUE is a scale for how efficiently a data center uses power for its IT equipment versus the total power consumed, as shown below:

$$\text{Power Usage Effectiveness} = \frac{\text{Total power consumption}}{\text{IT Equipment power consumption}}$$

The goal is to get the PUE value as close to 1.0 as possible. In recent studies and surveys with data center owners and operators, it's been observed that the average PUE is around 2.0. This means that roughly half the power consumed by a data center isn't powering the IT equipment servers. Many designers tend to focus on the energy used for cooling and auxiliary power in a data center to lower this ratio as that is the non-value added power consumption. However, one must not forget that using the "effective" power more efficiently can indirectly affect the amount of non-value added power consumed within the whitespace. Doing this can result in a more positive affect on total power consumed. One of the ways to do this is to increase the system voltage. Removing transformers that step power down to 208V, or lower, can result in efficiency gains of 2% or more.

Due to advances in computing technology, today's servers are smaller, but still require the same amount of power. With more servers installed per rack, each rack is now consuming more power. In turn, higher system voltages provide efficiency gains down to the rack level which can result in reduced space for the same computing capacity, or greater computing capacity in the same space. Below is a table that calculates the power delivered to the server rack based on the volts and amps supplied to the rack Power Distribution Unit (PDU) from the busway or Remote Power Panel (RPP).

Circuit capacity (amps)	De-rated value (amps)	208Vac 3-Phase (kW)	415Vac 3-Phase (kW)	480Vac 3-Phase (kW)
20	16	5.8	11.5	13.3
30	24	8.6	17.3	19.9
50	40	14.4	28.8	33.2
60	48	17.3	35.6	39.9

From this table, it can be seen that higher voltages can greatly improve the power density at the rack level. By integrating this concept into the designs for medium to large data centers, designers and engineers can lower the up-front capital costs for the electrical distribution system. This also includes reducing the overall whitespace square footage, the number of installed transformers and conductor sizes, etc. All these advantages of higher voltages can decrease the total cost of ownership by reducing the initial capital to build a data center and the yearly operating expenses.

With the move to electrical systems with higher density and efficient power distribution, there can be a caveat, and that is the available fault current experienced throughout the whitespace. Since more power is delivered with lower impedance, fault currents can be much higher than in legacy designs. Per the NEC® and to ensure safety, designers must calculate available fault current levels at multiple points in the system. Circuit protection must then be incorporated into many points in the system to protect its components and, more importantly, the people servicing it. Determining adequate circuit protection when creating higher power density systems is an issue faced by many designers.



Figure 1: Typical data center busway, busway drop units and rack PDU with high fault current levels.

Design flexibility

With the growing needs of managing data, another challenge faced by data center engineers is to ensure their design is flexible and scalable. During the life cycle of a data center, IT refreshes are typically required to keep up with current user demands. Also, multi-tenant data centers are rapidly increasing with an expected 15% compound annual growth rate which actually outpaces the overall data center growth rate. As companies lease server space within a data center, the data center owner must accommodate changing power needs all the way down to the rack level. Ensuring that the power distribution is scalable throughout the system requires that the accompanying circuit protection is scalable as well.

For busway drops and RPPs with circuit breakers (that are fixed and not removable), having a scalable solution requires that an owner shut down the upstream Overcurrent Protective Device (OCPD) in order to service and replace the downstream devices, or replace the busway drop altogether. This causes downtime that's more widespread than necessary (which can be costly) or require extensive planning to execute. The issue faced by designers is how to future-proof the design of their electrical system to ensure it's scalable to meet the inevitable increasing power demands. Products that allow designers to accommodate such changes are increasingly in demand.

Benefits of fusible designs

Modern fuse solutions continue to evolve with better designs, materials, physical size and service features. Just as fuses provide critical protection for the demanding requirements of variable speed drives, UPSs, photovoltaic systems, electrical vehicle power and control systems, building emergency systems and critical operations power systems, they offer many features that benefit designers, maintainers and owners of today's and tomorrow's data centers.

These advantages are more pronounced when considering the challenges posed by data center trends to higher energy efficiency and greater power density. As a consequence, the OCPDs in the PDUs, RPPs, busway plug-in units, and rack PDUs must have higher interrupting ratings to meet the requirements posed by modern data centers. The electrical equipment, such as PDUs/RPPs and busway plug-in units, must typically have higher short-circuit current ratings. For data centers with higher fault currents, ensuring selective coordination becomes more critical for avoiding unnecessary outages. Similarly, higher voltages and fault currents generally demand higher performance OCPDs and greater attention paid to electrical safe work practices. For instance, when using non-current limiting OCPDs, higher fault currents result in higher arc flash incident energy. However, this is not necessarily the case when using current-limiting fuses that can reliably mitigate arc flash incident energy, even for high fault currents.

In this section, the benefits of fuses are divided into four general topics:

- Electrical installation safety requirements
- Reliability
- Safe work practices
- Flexibility

Taken in total, current-limiting fuses for data centers are a simple and easy means to ensure proper electrical ratings, selective coordination and safe work practices with the assurance of reliable protection upon the initial installation as well as when upgrades or changes occur during a data center's life cycle. In most cases, fusible solutions perform as well (or better) in systems with high fault currents. When changing equipment layouts, fusible solutions offer unique flexibility benefits.

Electrical installation safety requirements

There are mandatory NEC® and OSHA safety requirements for electrical equipment that must be met upon the initial installation and throughout the life cycle of the system. Most people recognize that the voltage ratings of electrical equipment must be equal or greater than the system voltage. However, two other critical equipment safety ratings include:

- Interrupting Rating (IR)
- Equipment Short-Circuit Current Rating (SCCR)

Interrupting Rating

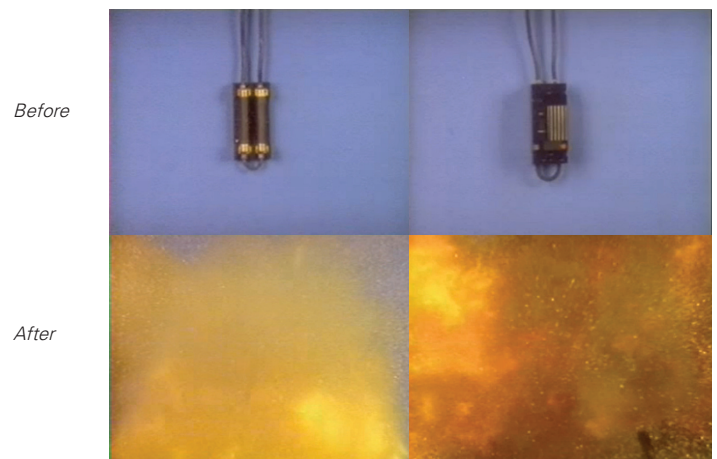
Interrupting Rating (IR) is the maximum short-circuit current at a specified rated voltage that a circuit breaker or fuse can safely interrupt under standard test conditions.

All OCPDs must have IRs equal to or greater than the available fault current at their lineside terminals per NEC® 110.9 and OSHA 1910.303(b)(4). It is a serious safety hazard to have an OCPD installed where the available fault current exceeds the device's IR. If a circuit breaker or fuse attempts to interrupt a fault current exceeding its IR, the device can catastrophically fail in a violent explosion. Scan the QR Codes below to view the slow motion videos of fuses and a circuit breaker being misapplied.

Test conditions: 50kA available fault current @ 480V

10kA IR Fuses

14kA IR Circuit Breaker



In addition to fault current levels trending up in new data centers, existing data centers can be expanded, increasing fault current levels beyond the IRs of existing OCPDs. Current-limiting fuses typically have IRs of 100kA, 200kA or 300kA for 600Vac or less. With higher voltage distribution to the cabinet (i.e., 415Vac or greater), it is not uncommon to have 20kA to 50kA or more available fault current at a RPP or busway plug-in unit. Even the rack PDUs can have high fault currents, as shown in Figure 1 on page 2.

Therefore, the 5kA IR or 10kA IR circuit breakers, often used in rack PDUs, may be inadequate for many installations.

Circuit breaker solutions for higher available fault currents are either:

- (a) Fully rated circuit breakers (each circuit breaker has an individual IR equal or greater than the available fault current at its lineside terminals).
- (b) Series combination rated circuit breakers (a circuit breaker is permitted to have an IR less than the available fault current at its lineside terminals if installed in a panelboard that is tested, listed, and marked with a specific line side circuit breaker or fuse).

Fully rated circuit breakers with higher IRs cost more and may have a larger footprint. In either case, with fully rated or series rated circuit breaker systems, achieving selective coordination is usually more difficult than when using standard molded case circuit breakers, and this is more pronounced as the fault currents and voltages increase.

Modern current-limiting fuses inherently provide high, fully rated IRs for systems with fault currents up to 100kA or 200kA without any price premium or footprint increase. All high IR current-limiting fuses are simple to selectively coordinate and easily provide excellent protection of circuit components. In addition, each current-limiting fuse class has unique physical dimensions so that replacement fuses will maintain the safety of high Interrupting Ratings.

Equipment Short-Circuit Current Rating (SCCR)

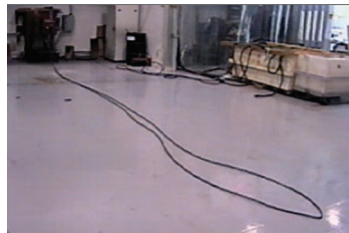
One of the principal advantages to fusing data center circuits is the current-limiting fuses' ability to greatly reduce the let-through energy during faults. Per UL 248 fuse product standard, current-limiting fuses are not permitted to exceed maximum allowable energy let-through values under fault conditions. This provides excellent protection for components and is a safety benefit. The most current-limiting Bussmann® series fuses provide superior short-circuit current protection. All equipment and components in the data center's electrical system are required per NEC® 110.10 and OSHA 1910.303(b)(5) to have an SCCR equal to or greater than the available fault current. This includes the transfer switches, UPSs, PDUs, RPPs, busways, bus plug-in units, CRAC units, row coolers, etc.

Most fusible panelboards, busway systems and enclosed disconnects can be tested, listed and marked with a 200kA SCCR. A practical example: when not protected by current-limiting fuses, a common 250A data center busway system has a standard SCCR of 22kA. This same busway (when protected upstream by 400A or less Bussmann series LPJ fuses) has been tested and listed with a 200kA SCCR at 600V or less.

The trend is that systems are capable of delivering more fault current as a result of higher efficiencies and higher power

density designs. One benefit of a current-limiting device when a fault occurs is to quickly drive the fault current down to zero and keep the let-through energy below equipment damage levels.

Scan the QR Codes below to view the normal speed videos illustrating the quick cutoff action of a 200A current-limiting (clears in less than 1/2 cycle) fuse versus a non-current-limiting OCPD that takes approximately one cycle to open.



Test condition: 90 feet of 2/0 conductor, 26kA fault current for 1 cycle.



200A non-current limiting OCPD



200A current-limiting fuse

Reliability

Selective coordination

Preventing an unnecessary power outage has been a design consideration in data centers and mission critical facilities long before it was an NEC® requirement. Mission critical system designers understand the added reliability that selective coordination of OCPDs provides. 2014 NEC® 645.27 requires the OCPDs in critical operations data systems to be selectively coordinated.

The use of properly selected and applied fuses in data centers alleviates the design hassle of trying to achieve selectively coordinated OCPDs at the cabinet and busway (or PDU) levels as well as further upstream. Fuses simply need to maintain a 2:1* amp rating ratio for Bussmann series Low-Peak fuses from the lineside fuse to the loadside fuse in order to achieve selective coordination. This eliminates the possibility of cascading multiple levels of OCPDs under fault conditions.

When OCPDs are not selectively coordinated, multiple, upstream levels of OCPDs can cascade open on a fault condition. For example: a fault in a power supply or rack PDUs results not only in one of the rack PDU OCPDs opening (as it should), but the RPP or busway plug-in OCPDs also unnecessarily open, resulting in the unnecessary power outage to the entire rack PDU. Even worse is if the much larger amp rated feeder OCPD (200A to 400A) supplying the busway or PDU/RPP would open for a fault in the rack PDU, resulting in an unnecessary power outage to an entire PDU/RPP or busway run.

Inherent fuse reliability

Fuse operation is based on a simple thermal principle; the fuse element will rapidly melt or vaporize and open at a very specific energy level. Users can be assured the precise thermal attributes of a fuse's element will always operate when called upon to remove a fault and protect valuable equipment. It is important to periodically inspect electrical equipment for signs of overheating, poor connection or insufficient conductor ampacity.

* Fuses in the same case size may not conform to the 2:1 ratio, consult Bussmann.

The internal parts of modern current-limiting fuses do not require maintenance. As a result, the ongoing maintenance cost of a fusible system is typically less.

Safe work practices

The safe work practices for electrical systems are important for worker safety and power system reliability in delivering power to the loads. OSHA has regulations that must be followed and NFPA 70E Standard for Electrical Safety in the Workplace is the leading consensus standard on how to comply with the OSHA safe work practice regulations.

Servicing fuses

Modern fuse solutions, like the Bussmann series CCPB/ CUBEFuse™ series branch circuit fusible disconnect switch, make servicing fuses much simpler than typical safety switches or older, fusible panelboard designs.

As shown in Figure 2, the CUBEFuse can be serviced without removing the deadfront to a PDU/RPP or accessing the interior of a busway plug-in enclosure. The CCPB/CUBEFuse combination is IP20 finger-safe when installed in a panelboard/ RPP with deadfront construction as shown in Figure 9 (see pages 6 and 7 for details on the CUBEFuse and the CCPB disconnect switch) or when installed in a busway plug-in unit as shown in Figure 13. In the event of a fuse opening, simply open the door of the panelboard to view the CCPB/CUBEFuses or merely look at the busway plug-in exterior to view the CCP/ CUBEFuses. The open fuse(s) will be identified by either the open fuse indicating light on the CCPB or the optional permanent indicator on the time-delay CUBEFuse. Both the CCPB and CCP disconnect switches are interlocked with the CUBEFuse. When extracting or inserting a CUBEFuse, the disconnect switch handle must be in the “OFF” position.

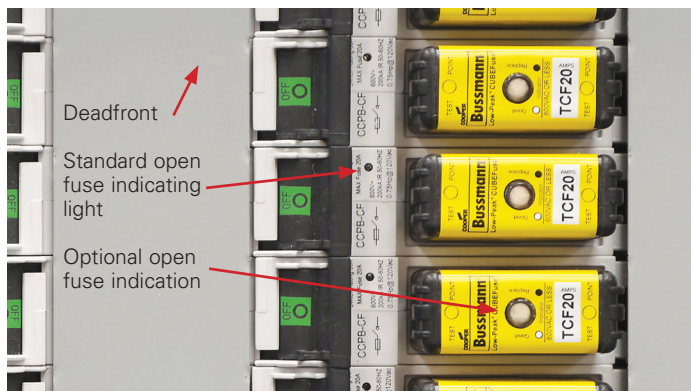


Figure 2. Servicing equipment with the finger-safe CCPB/ CUBEFuse is easy.

As shown in Figure 3 and 4, the new low profile CCP (CCPLP) is the smallest fusible UL 98 disconnect switch offering many features for data centers. When the 20 amp Class G CCPLP disconnect is used in the rack PDU, only an SC-20 fuse can physically be inserted (see page 10 for details). This ensures retaining the originally-designed and installed amp, voltage and interrupting ratings along with the established selective coordination ratio. The CCPLP disconnect is interlocked with the fuse access door so fuses are not accessible when the CCPLP is in the ON position. When extracting or inserting an SC-20 fuse, place the CCPLP disconnect handle in the “OFF” position.



Figure 3. The new low profile CCP is the smallest UL 98 Listed fused disconnect measuring 2-1/2 x 2-1/8 x 3/4 inches (63 x 54 x 19mm)

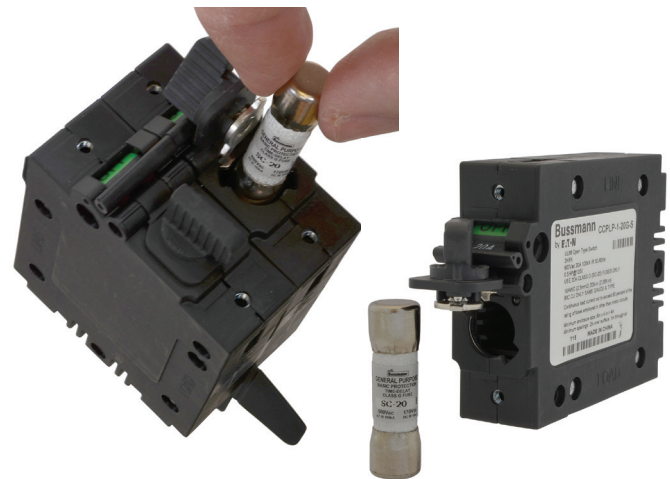


Figure 4. 2-pole CCPLP disconnect with SC-20 fuses. When the switch handle is in the OFF position, the fuse access door interlock allows access to the fuse compartment for extracting or inserting fuses.

Renewability

OSHA 1910.334(b)(2) is the law when concerning an OCPD that opens due to an overcurrent. If an overload caused the opening, then fuses can be replaced or circuit breakers reset. However, if a faulted circuit caused the opening, then fuses cannot be replaced nor circuit breakers reset “...until it has been determined that the equipment and circuit can be safely energized.” To avoid possible catastrophic damage to equipment or unsafe conditions for workers, it is important to identify the source of the fault and repair the faulted circuit before restoring power. Additionally, the conductors and electrical components on the faulted circuit path should be verified suitable to be placed back into service. When a fuse opens an overcurrent, it is replaced with a new, factory-calibrated fuse, ensuring the same level of protection, which is an advantage of using fuses. Per NFPA 70E 225.3, if a circuit breaker opens a fault approaching its interrupting rating, the circuit breaker must be inspected and tested in accordance with manufacturer’s instructions.

Arc flash reduction

Arc flash is a frequent concern in today's data centers. With minimizing downtime a priority, it is important to have current-limiting OCPDs to mitigate arc flash hazards where possible. By limiting the energy let-through and quickly bringing the current down to zero, fuses can reduce the arc flash incident energy experienced during most arc flash events. This especially pertains to the fuse types and amp ratings used in rack PDUs (typically 20A current-limiting fuses) and busway plug-in units (typically 100A or less current-limiting fuses). This also pertains to the busway when protected by fuses in the end-feeds.

In addition, arc flash hazard mitigation is dependent on the "design and condition of maintenance" of the OCPD per 2015 NFPA 70E 130.5(3). If OCPDs that require maintenance are not maintained, an actual arc flash event can be more severe than that determined by the arc flash risk assessment. 2015 NFPA 70E 205.4 requires OCPDs to be maintained and the "maintenance, tests, and inspections to be documented." Fuses are inherently reliable for fault conditions. There is no need to maintain the fuses' internal parts. All that is necessary is to maintain the external connections and proper environmental conditions.

Current-limiting fuse safety system

By design, a current-limiting fuse of a given UL class cannot be inserted into mountings designed for another fuse class. For instance, a Class CF CUBEFuse is the only fuse type that can be installed in mountings for a CUBEFuse. As a result, fuses with lower voltage and interrupting ratings, (or lower current limitation performance) cannot be accidentally put into service. This is a significant safety benefit when utilizing current-limiting fusible equipment.

Rejection features for fuse amp ratings can vary based on the fuse class and the type selected made by the designer and installer. For instance, an SC-20 fuse (commonly used in rack PDUs) has a unique dimension — only SC-20 fuses can be inserted in a 20 amp Class G fuse mounting.

Each approach provides different benefits, depending on the UL fuse classes used in the system design.

Flexibility

There are data center operation flexibility and inventory advantages for some applications with the CUBEFuse and the CCP disconnect switches it fits. Each flexibility attribute is described in the product sections that follow.

Data center products

Current-limiting fuses provide excellent overcurrent protection for the challenging needs of modern data centers. The following section will discuss the solutions current-limiting fuses provide for broad PDU and busway architectures.

Compact Circuit Protector and CUBEFuse

For data center applications, the CUBEFuse in conjunction with the Compact Circuit Protector Base (CCPB - bolt-on version) and CCP (DIN-Rail version), that are some of the smallest UL 98 fused disconnects, offer great advantages for PDU and busway architectures. The innovative finger-safe CUBEFuse with a 300kA IR is available in ratings from 1A to 100A. These fuses have been on the market for nearly two decades and offer many advantages including the smallest footprint of any UL fuse above 30A with more than 100kA IR. The CUBEFuse is available in two versions: 600Vac/300Vdc time-delay (TCF) and 600Vac/dc fast-acting (FCF). See Figure 5. Both CUBEFuse versions are very current-limiting, resulting in excellent equipment short-circuit current protection and arc flash incident energy mitigation. The time-delay TCF is available in both indicating and non-indicating versions, while the fast-acting FCF is available only as a non-indicating fuse.



Figure 5. Time-delay (TCF) and fast-acting (FCF) CUBEFuse.

The Compact Circuit Protector (CCPB or CCP) is available in ratings up to 100A. This combination of Compact Circuit Protector disconnect and CUBEFuse provides an excellent overcurrent protection/disconnect solution for many applications. The Quik-Spec™ Coordination Panelboard (QSCP) utilizes the bolt-on CCPB and CUBEFuse to provide the means for fusible PDUs/RPPs. The QSCP chassis (without enclosure) is sold to manufacturers for integration into their PDUs/RPPs with additional features such as monitoring.

For the data center busway architecture, the CCP with CUBEFuse is incorporated into busway plug-in units. The available CCP versions offer excellent switch/fuse combinations for data center applications.

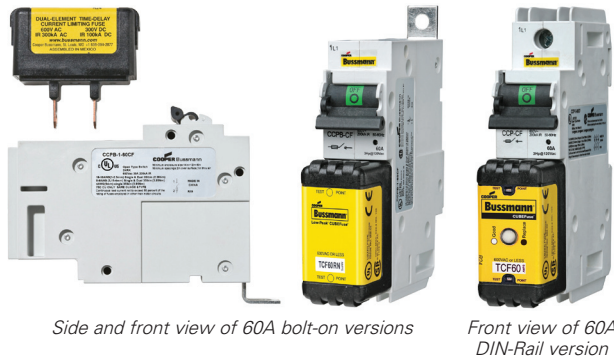


Figure 6. Bolt-on Compact Circuit Protector Base (CCPB) with non-indicating CUBEFuse, and DIN-Rail mount Compact Circuit Protector (CCP) with indicating CUBEFuse.



Figure 7. DIN-Rail CCP (shown) and bolt-on CCPB are available in 1-, 2- and 3-pole versions.

There are two versions of the Compact Circuit Protector using the CUBEFuse (see Figure 6):

1. CCP: DIN-Rail mount version, which allows small fusible switch applications such as the plug-in busway unit up to 100A.
2. CCPB: bolt-on version used in the QSCP panelboard, which allows fusible panelboards having up to 100 amp rated branch circuits with panel width and depth the same as traditional circuit breaker panelboards.

A CCP or CCPB has a disconnect amp rating and horsepower rating. A CCP or CCPB of a specific amp rating can accept any CUBEFuse amp rating equal or less than the CCP or CCPB amp rating.

There is a notable difference in the bolt-on CCPB and the DIN-Rail mount CCP. The DIN-Rail mount CCP is available in 30A, 60A and 100A ratings and accepts the CUBEFuse as follows:

CCP rating	CUBEFuse amp range
30A	1 to 30A
60A	1 to 60A
100A	1 to 100A

The bolt-on CCPB is available in the NEC® standard branch circuit ratings of 15, 20, 30, 40, 50, 60, 70, 90 and 100 amps. Each CCPB will accept any CUBEFuse amp rating equal or less than its amp rating.

This “rejection” feature of a given Compact Circuit Protector accepting CUBEFuse amp ratings equal or less than its amp rating provides some important options and flexibility for data center management. For instance, if a busway plug-in unit uses a CCP 60A and the cable whip is rated 60A, then any CUBEFuse from 1A to 60A can be installed.

For example, assume the initial installation has a 60A CCP with a 30A CUBEFuse installed in the busway plug-in unit. Then modifications are required to the cabinet changing the load so that a 50A CUBEFuse is needed. All that is necessary is to switch the 60A CCP disconnect to “OFF,” remove the 30A CUBEFuses and insert the required 50A CUBEFuse, then switch the CCP to “ON.” This can save time and reduce inventory of busway plug-in units since the entire busway plug-in unit does not have to be removed and replaced with a higher amp rated unit.

QSCP and PDU/RPP



Figure 8. RPP utilizing QSCP with CUBEFuse feeding Eaton ePDUs utilizing CCPLs with SC fuses.

The QSCP is rated 600Vac and can be utilized for either 208Vac or 415Vac data center applications (or up to 600Vac). The images in Figure 9 show the QSCP as a complete NEMA 1 panelboard (left) and as a chassis (right) that manufacturers integrate into their PDU/RPP equipment, and adding additional features such as monitoring.

Examples of the QSCP chassis in other RPPs are shown in Figures 10, 11 and 12.

The QSCP panelboard, in ratings up to 400A and SCCRs up to 200kA, eases achieving selective coordination and provides excellent arc flash hazard mitigation. It is also an excellent panelboard for electrical distribution systems supplying non-IT equipment loads in a data center such as the computer room air conditioners/air handlers (CRAC/CRAH).

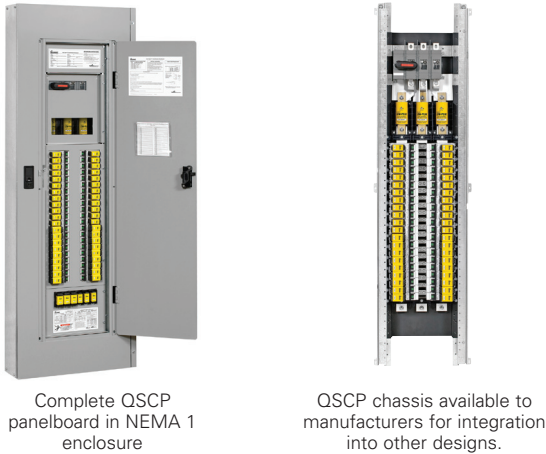


Figure 9. Quik-Spec Coordination Panelboard (QSCP).



Figure 12. RPP with QSCP chassis and spare CUBEFuses in holder. Courtesy Liebert® FDC™ power distribution cabinet from Emerson Network Power™.



Figure 10. Eaton RPP with QSCP chassis.

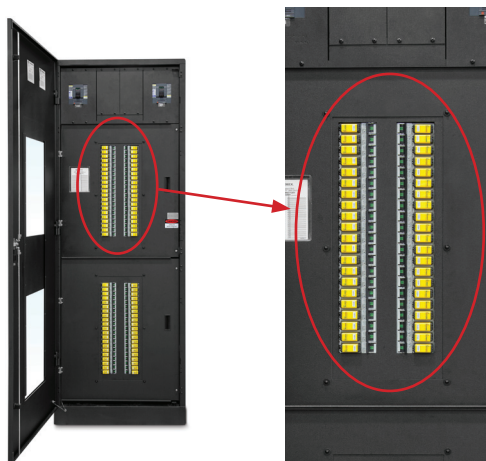


Figure 11. RPP with QSCP chassis. Courtesy Cyberex, Thomas & Betts Power Solutions.

There are two alternatives for specifying CCPBs into PDUs/RPPs:

1. The CCPB amp rating can be specified at any of the available branch circuit ampacities of 15A, 20A, 30A, 40A, 50A, 60A, 70A, 90A, or 100A. Each CCPB will accept CUBEFuse amp ratings equal to or less than its amp rating.
2. The CCPB amp rating can be specified, limiting the ampacities to 30A, 60A or 100A, or a mixture of these ampacities. This narrowing the number of specified CCPB ampacities provides the benefit of more flexibility and less CCPB inventory needed when changes are made to circuits or PDUs/RPPs. For instance, if all the CCPBs disconnects in an RPP are 60A, then it will accept all the CUBEFuse amp ratings from 1A to 60A. By installing 60A CCPBs, if the branch circuit conductors are changed to a different ampacity, the CCPBs do not need replacing; only the CUBEFuses will need changing to the appropriate amp rating. Similarly, if the RPP is moved, only the CUBEFuse will need to be changed so it meets the protection needs of the circuits at its new location.

With the QSCP, all branch circuit CUBEFuses are accessible without removing covers or exposure to any live parts. The QSCP also has a spare fuse holder so a replacement can always be at hand. Due to the CUBEFuse's current limitation, the energy during many fault conditions is greatly reduced which, in turn, can reduce the amount of damage during a fault, allowing for faster repairs. Together, these features can reduce Mean-Time-To-Repair (MTTR).

Busway plug-in fusible disconnect

A busway plug-in utilizing the DIN-Rail mount CCP is suitable for any voltage up to 600Vac. The cable whip connects the busway unit to the rack PDU. See Figure 13.

Like the QSCP, the CCP used in a busway plug-in unit also allows access to the CUBEFuse without removing covers or any exposure to live parts, as shown in Figures 14 and 15. Due to the CUBEFuse’s current limitation, the energy during many fault conditions is greatly reduced which, in turn, can reduce the amount of damage during a fault, allowing for faster repairs. Selective coordination with rack PDU fusing is easily achieved (see next page for details). Together, these features can reduce MTTR.



Figure 13. StarLine® Track Busway fusible disconnects utilizing CCP with CUBEFuse feeding ServerTech rack PDU utilizing the CCPLP with SC fuses.



Figure 14. StarLine® Track Busway fusible disconnects using the DIN-Rail mount CCP with CUBEFuse.

Courtesy of Universal Electric Corporation (UEC).



Figure 15. Eaton Busway fusible disconnects using the DIN-Rail mount CCP with CUBEFuse.

Low Profile Compact Circuit Protector (CCPLP) and SC fuses

Eaton's new Bussmann series Low Profile Compact Circuit Protector (CCPLP) is a unique addition to its CCP product line. This new fused disconnect adapts the same CCP technology into a smaller package. The CCPLP is the smallest UL 98 disconnect switch in the electrical industry. This small footprint makes the CCPLP's Class G version (with SC-20 fuses) ideal for rack PDUs. Available in 1-, 2- and 3-pole versions, the Class G CCPLP has a 100kA SCCR at 600V so it can be installed in virtually any data center without worrying about the available fault current.

By using the Class G CCPLP disconnect in the rack PDU, the rack PDU, IT equipment and circuits can be properly protected in systems with higher voltages, like 415/240V, and higher available fault currents, up to 100kA. As with the entire CCP product line, the disconnect's switch is interlocked with the fuse access door. To extract or insert an SC-20 fuse, the CCPLP switch must first be in the "OFF" position before the fuse access door can be opened.

In addition, the Class G CCPLP can isolate a faulted subsection of the rack PDU to keep the power supplies fed by the remainder of the energized rack PDU (when rack PDU fuses are selectively coordinated with upstream RPP fuses or busway plug-in fuses; see Note on Selective Coordination for rack PDU below). See Figure 13. If a fault or overload were to occur on rack PDU Branch 1, the Branch 1 fuse would open and remove the overcurrent from the circuit. The rest of the rack PDU would remain in normal operation. Rack PDU manufacturers provide options for local and remote notification of fuse openings. Remote notification includes both Simple Network Management Protocol traps (SNMP traps) and email alerts.

In addition to the Class G CCPLP, there are also Class CC and UL Midget / IEC 10x38 versions. All versions are below:

Catalog symbol	Fuse Class	Volts AC	Amps	SCCR (kA)	Poles
CCPLP_-G	G	600	20	100	1, 2, 3
CCPLP_-CC	CC	600	30	200	1, 2, 3
CCPLP_-M	UL Midget	240	30	10	1, 2, 3
CCPLP_-M	IEC 10x38	400	32	120	1, 2, 3

Available Bussmann series fuses include:

Fuse class	Time-delay	Fast-acting
G	SC-20	—
CC	LP-CC, FNQ-R	KTK-R
UL Midget	FNM, FNQ	BAF, KLM, KTK
IEC 10x38	C10G C10M	—



Figure 15. Partial views of fused rack PDU utilizing CCPLP with SC fuses. This rack PDU uses SC fuses to protect the receptacles and circuit to the power supplies. Courtesy of Server Technology, Inc.

Rack PDU fuse selective coordination with upstream fuses

The easiest way to achieve selective coordination with fuses is to adhere to the published Fuse Selectivity Ratio Guide (see the section Selective Coordination in the Selecting Protective Devices (SPD) handbook, No. 3002).

20 amp SC fuses are commonly used with CUBEFuses, either time-delay (TCF) or fast-acting (FCF). The published selectivity amp ratio for an upstream CUBEFuse supplying a downstream SC fuse is 4:1. To ensure selective coordination, a rack PDU using a 20 amp SC-20 fuse would need, at a minimum, an 80 amp CUBEFuse upstream.

However, a series of tests at specific system voltages have demonstrated that SC-20 fuses selectively coordinate with TCF fuses up to the available fault current (in kA) shown in the following table:

Loadside	SC-20	System voltage	Lineside	
			TCF30	TCF40 or greater
		208/120V	33.8kA	100kA
		415/240V	14.5kA*	100kA

* Available fault current measured at the point where the rack PDU (with a minimum 5 foot cable whip) is connected to the source.

As mentioned before, other fuse classes could be used in rack PDUs. For the amp ratios, please consult the published Fuse Selectivity Ratio Guide in the Selecting Protective Devices (SPD) handbook.

Overview of owner needs

Need	Solution
Reliability	Modern fuses are simple thermal devices with no moving parts. If a fuse does open, it is replaced with a new, factory-calibrated fuse.
Low maintenance	Fuses themselves do not require maintenance. Periodic inspection of all electrical equipment should be made for signs of overheating, poor connections or insufficient conductor ampacities.
High power density	Fuses allow utilizing higher voltages like 415/240V and/or higher ampacities easier without worrying about high short-circuit currents or difficulty in achieving selective coordination.
High energy efficiency	Fusible solutions can handle high short-current currents. There is no need to use higher impedance transformers or reactors to reduce fault currents. These high impedance devices can add cost/space and lower the overall efficiency of the data center.
Increased uptime	Fuses allow for easy selective coordination up to 100kA or 200kA at voltages up to 600V.
Equipment protection and arc flash mitigation	Current limitation can significantly reduce the magnitude and duration of a fault. The lower energy let-through can reduce arc flash incident energy and helps limit damage to the equipment.
Flexibility	Easier circuit changes: Install CCP disconnect for future growth and size fuse to amp rating needs. If changes to the electrical system cause the available fault current to increase, it will not affect the selective coordination of the fuses and is unlikely to exceed the fuse interrupting rating.
Low MTTR	CUBEFuse and SC-20 fuses used in Compact Circuit Protectors are easy to replace without exposure to equipment interior.
Easy compliance with NEC® requirements	No worry solution with high IR to handle short-circuit currents up to 200kA and ease in achieving selective coordination.

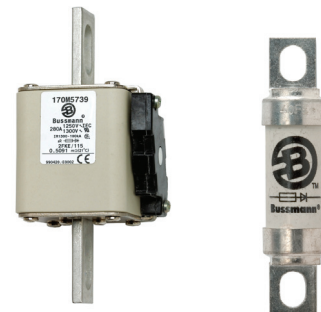
Other Eaton products used in data centers



Low voltage fuses (600V or less)

For protecting feeders and busway end feeds

- LPJ Class J
- JJS Class T



High speed fuses

For protecting UPSs and static transfer switches

- Square body
- Cylindrical bolt-on



High SCCR Surge Protective Devices

For protection against overvoltage surges

- Type 1 UL Listed
- Type 2 UL Recognized DIN-Rail



High SCCR power distribution blocks

For achieving high equipment SCCR in PDUs and RPPs

- Open versions or finger-safe versions for added safety