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Data Bulletin

Arc Flash Protection with Masterpact® NW and NT Circuit Breakers

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INTRODUCTION

Each year, workplace deaths and injuries are caused by arc flash incidents in faulted, industrial equipment. These injuries sometimes come despite awareness of and compliance with safety rules. Better control of arc flash would lead to fewer injuries and a safer workplace. This data bulletin introduces the new arc flash protection technology of the Masterpact® NW and NT circuit breakers, which can enhance workplace safety.

SQUARE D / SCHNEIDER ELECTRIC SAFETY PRACTICES

Square D / Schneider Electric has always stated in documentation that equipment must be de-energized and placed in an electrically safe condition before work can be done on it. Further, we work very hard in our own facilities to follow, and always recommend to our customers that they follow, safety guidelines such as National Fire Protection Association 70E (NFPA 70E), “Electrical Safety Requirements for Employee Workplaces.”

Although we design and manufacture equipment to and exceeding standards for safety, no design can provide complete protection without safe working practices. One unsettling statistic shows that many accidents happen when the electrician thought the equipment was de-energized.

Square D has led the industry with products that create safer conditions. Our company pioneered the safety switch, enclosed circuit breakers, current-limiting circuit breakers, ground-fault circuit interrupters, and arc-fault circuit interrupters. However, even with safe equipment, accidents can happen. A multi-faceted approach must be used: safe equipment and safe working practices.

WHAT IS ARC FLASH?

According to NFPA 70E, arc flash is a “dangerous condition associated with the release of energy caused by an electrical arc.” It is measured in terms of arc flash incident energy (AFIE), which is used to determine the level of Personnel Protection Equipment (PPE), and in terms of an arc flash protection boundary.

For Masterpact NW and NT incident energy calculations, see page 7.

An arc flash occurs when insulation or isolation between electrified conductors is breached or can no longer withstand the applied voltage. As employees work on or near energized conductors or circuits, movement near or contact with the equipment (or a failure of the equipment) may cause a phase-to-ground and/or a phase-to-phase fault. Temperatures of more than 5,000 degrees Farenheit and a powerful explosion can be produced in an arc flash incident.

The Occupational Safety and Hazard Administration (OSHA) has begun to enforce the NFPA 70E safety guidelines for arc flash safety. The guidelines:

- provide analysis detailing arc flash incident energy, boundary distances, and the PPE;
- state that Personal Protective Equipment (PPE) must be provided;
- mandate proper worker training;
- provide procedures for safe work practices;
- state that tools for a safe work environment must be provided; and
- state that equipment be installed in accordance with the safety requirements of the National Electrical Code.

TWO TYPES OF ARCING

Arcing Faults

Arcing faults occur when electrical clearances are reduced or compromised. These conditions come about when insulation deteriorates or when an accident happens, such as an electrician slipping with a screwdriver or dropping a wrench that comes in contact with opposite phases or phase-to-ground.

The arc burns in open air, creating a large amount of energy until an upstream overcurrent protection device opens to clear the fault.

The amount of energy released during an arcing fault is a function of the available fault current at the point in the system reduced by the dynamic impedance of the arc and the time the arc persists.

Bolted Faults

Bolted faults are typically caused by mistakes made during installation or maintenance. Here, opposite phases or phase-to-ground are connected together (bolted). The overcurrent protective device upstream of the fault opens to protect the system. Arcing occurs inside the protective device as the contacts open. When the device is a circuit breaker, arcing and gassing is vented through the arc chute to the outside of the circuit breaker.

HISTORY OF ARC FLASH PROTECTION

Through the years, Square D has worked to minimize the exposure of electricians to the effects of arc flash. Our products include dead fronts, covers, doors, interlocks, and other equipment that protect users and service personnel by preventing accidental contact and limiting exposure to arcing events. These safeguards, along with our insistence that equipment be de-energized before opening or disassembling, have played an important part in personnel protection.

Square D has also worked within the Institute of Electrical and Electronic Engineers (IEEE) to quantify arc flash hazards in different types of equipment so that the appropriate PPE can be recommended.

Fused switches and fused circuit breakers utilizing current-limiting fuses have been used to provide additional arc flash protection. The fuses provide quick clearing times during high-level short circuits and limit the amount of current available for the arc flash event. Thus, fuses can reduce the arc flash effects, but they create another set of problems for the user. These problems include:

- arcing fault currents that are not high enough to melt the fuse element, or fuses that provide little protection;
- hazards associated with changing fuses;
- the need for additional mechanical hardware and items that can wear out, including fuse holders, blown fuse indicators, anti-single-phasing devices, etc. that must be maintained or replaced and can become dislodged and cause arcing events;
- higher energy costs caused by additional resistances in the fuse holder and connections;
- larger equipment footprints;
- higher installation and service-life costs; and
- the need to stock and replace fuses after overloads or short circuits.

MASTERPACT® NW AND NT CIRCUIT BREAKER TECHNOLOGY

Breakthrough technology was used to design the new Masterpact NW and NT circuit breakers to interrupt large amounts of fault current without being protected by fuses.

The same technology and design that allows the Masterpact NW and NT circuit breakers to interrupt large fault currents without fuses also provides very good arc flash limitation.

The decision to design the Masterpact NW to eliminate the need for fuse protection is based on the following:

- requirements for smaller footprints and space-saving installations;
- avoidance of fuse installation, maintaining supplies, and the need to enter the equipment in order to check and change fuses;
- the need for adjustability to provide coordination with downstream products and better arc flash protection.

SYSTEM DESIGNS

Fused System Design

As discussed earlier, systems have been designed employing fused circuit breakers. The reason for the fuse is to protect the circuit breaker at fault current levels above the interrupting rating of the circuit breaker. The fuse is sized so that it does not interfere with the circuit breaker protection during normal system operation like energizing transformers or switching loads but operates to protect the circuit breaker at high fault currents. It is not desirable or necessary for the fuse to open at low level overcurrent conditions. Therefore, the fuse or fuse-limiter used with a circuit breaker is usually rated twice the ampere rating of the circuit breaker.

Since the fuses have relatively high thresholds of current limitation, they are not necessarily good protectors of personnel in arc flash circumstances. A 1600 A fuse-limiter (typically used to protect 800 A circuit breakers) will not operate within the threshold of current limitation until about 32,000 A. Below that level, the opening time will be considerably longer than the 1/2-cycle time in which fuses are thought to open under short circuit conditions. The additional time increases the potential hazard to personnel.

Further, during an arcing fault, the arc impedance will reduce the current level and the effectiveness of the fuse. (With 65,000 A available, typical arc current would be 38,000 A, which falls just into the current-limiting threshold of the fuse. With 40,000 A available, arc current would be 27,000 A, which falls below the current-limiting threshold of the fuse.)

MASTERPACT NW and NT System Design

The Masterpact NW and NT circuit breakers do not need to be protected by fuses. They clear faults very quickly and provide arc flash protection that is comparable to fuses at high currents and better protection than fuses at lower currents.

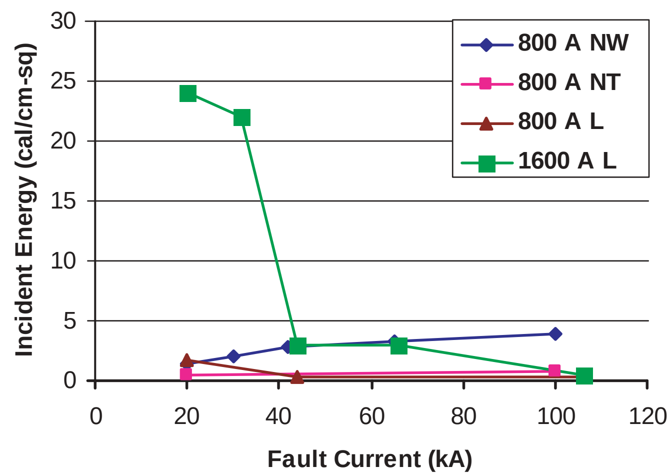
The following chart shows test data of fuses and Masterpact circuit breakers:

Example: A system in a large chemical plant uses an 800 A fused circuit breaker. The company chose the 800 A fused circuit breaker, which is protected by 1600 A class L fuses, to provide arc flash protection for its electricians at motor control centers. The available fault currents at the motor control centers are 20 kA–30 kA.

According to test data shown at right, the circuit protected by the 800 A fused circuit breaker with 1600 A fuse would require the electricians to wear Category 3 level PPE, which makes tasks like changing buckets more difficult to perform.

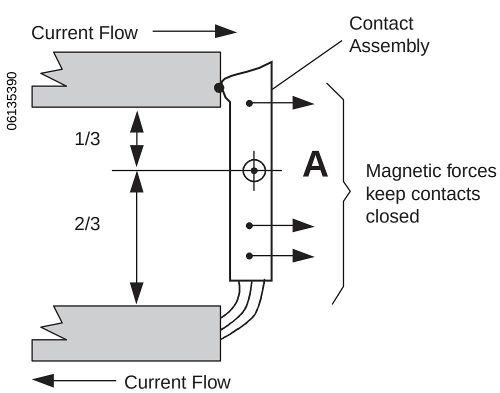
In the same circuit, Masterpact NT or NW arc flash-protecting circuit breakers would provide much better protection–well below 4 cal/cm^2, which requires only Category 1 PPE. The electricians would be better protected and more able to complete tehir tasks.

Figure 1: Incident Energy Values for Masterpact NW and NT and Circuit Breakers with Class L Fuses



The tests used to create this graph were conducted with the instantaneous adjustment on the Masterpact circuit breakers set on maximum. A lower instantaneous setting, if warranted by coordination studies, etc., would provide even better arc flash protection.

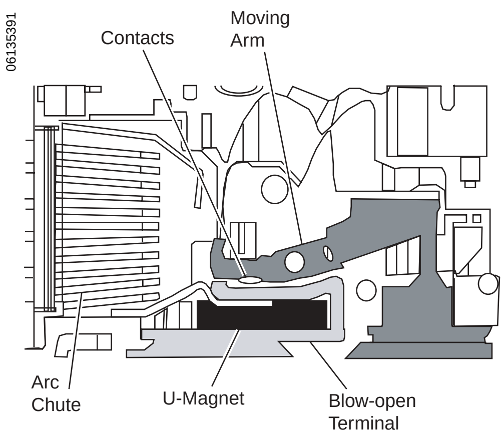
Traditional LVPCBs: 'Blow-closed' Design



Typical Low-Voltage Power Circuit Breakers (LVPCBs) use a current path designed to remain closed while carrying high currents to allow downstream overcurrent devices time to open to clear a fault. This was done for coordination purposes.

This design can be called "blow closed" because as the current flow increases, the force to keep the contact assembly closed increases. This is accomplished by moving the pivot point of the contact assembly toward the contact. This design is very effective and provides high withstand ratings and high close and latch ratings. This type of design is employed in the standard Masterpact NW circuit breakers that are available with Ampere Interrupting Ratings (AIR) of 100,000 A at 480 V and lower.

New Masterpact NW Technology: Reverse Current Flow

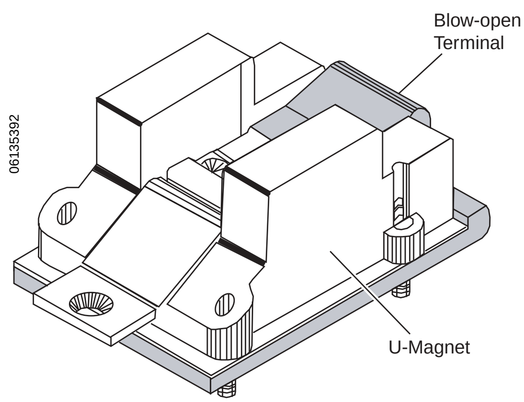


The design of the new Masterpact NW arc flash-protecting circuit breaker is unique to the industry.

The drawing at left shows a cross-section view of one pole of the circuit breaker. The shaded areas constitute the current path. The blow-open terminal is shaped so there is a reverse current loop at the moving arm. This reverse current flow creates a magnetic force that is proportionate to the amount of current. When the current is high enough, the force pushes open the contacts. The contacts open very quickly, without waiting for the mechanism to unlatch and the springs to pull the moving arm open. Between the folds of the blow-open terminal, where the reverse current loop is located, is the U-magnet, which intensifies the magnetic opening force.

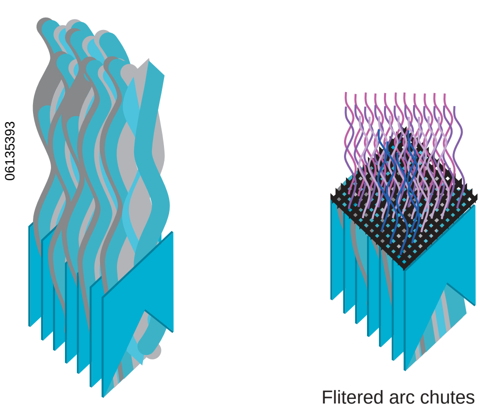
The Masterpact NW arc flash-protecting circuit breaker is designed to open quickly. This quick-opening action clears the fault and reduces the arc flash incident energy.

Here is another view. The blow-open terminal is shaded:



MASTERPACT NW AND NT ARC CHUTE

Figure 2: Two Arc Chute Designs



Standard arc chutes release a significant amount of gas during an interruption

Flitered arc chutes such as seen in the Masterpact NW, reduce the release of gas during interruption

One other unique feature found in the Masterpact NW is the design of the arc chute. The arc chute has an assembly of metallic grids and meshes that significantly reduce the gasses released during an interruption. The grids de-ionize and cool the emissions, which results in reductions in gas pressure and volume.

Standard arc chute designs absorb about 80% of the energy released during an interruption. With its additional filters, the Masterpact NW absorbs up to 90–95% of the energy and thus significantly reduces vented, ionized gas.

Bolted faults can generate the greatest amount of fault current because of their lower impedance. The arcing during a bolted fault is controlled inside the circuit breaker. The quick-opening design of the Masterpact NW circuit breaker—with the addition of the arc chute filter—keeps the release of arcing energy to a minimum, which greatly enhances the safety of electricians and end users.

MASTERPACT NW AND NT PERFORMANCE DATA

NOTE: The following data apply only to circuit breakers with trip units incorporating instantaneous tripping.

Interruption Let-through Characteristics

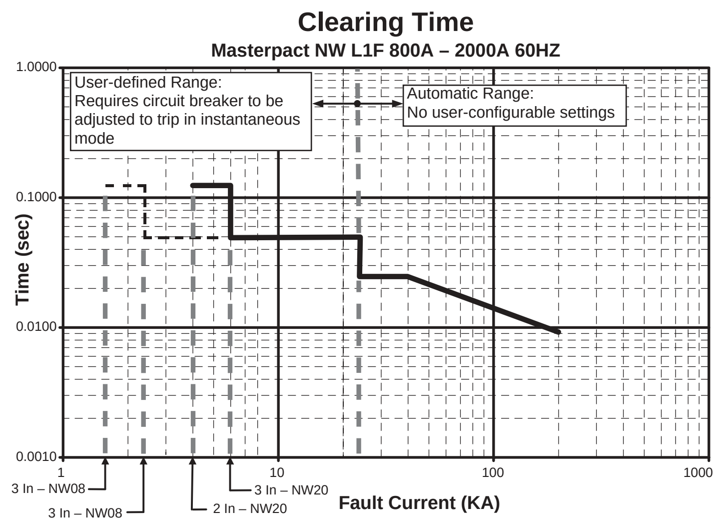
Masterpact NW-L 2000 A Frame

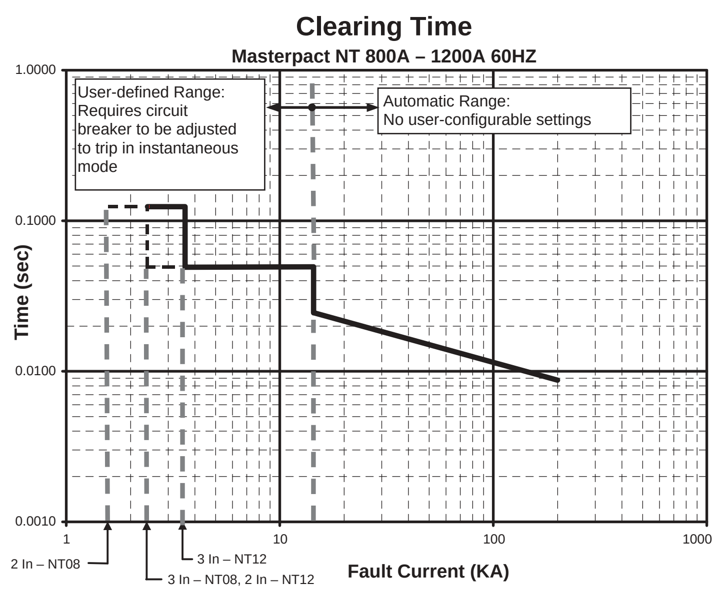
- At 480 Vac, 3-phase, and 50 kA available fault current, the maximum let-through peak current is 110 kA and the maximum I^2t is 65 x 10^6 A^2s for any pole.
- At 480 Vac, 3-phase, and 100 kA available fault current, the maximum let-through peak current is 150 kA and the maximum I^2t is 90 x 10^6 A^2s for any pole.

Masterpact NT-L 800 A Frame

- At 480 Vac, 3-phase, and 50 kA available fault current, the maximum let-through peak current is 75 kA and the maximum I^2t is 20 x 10^6 A^2s for any pole.
- At 480 Vac, 3-phase, and 100 kA available fault current, the maximum let-through peak current is 85 kA and the maximum I^2t is 25 x 10^6 A^2s for any pole.

Masterpact NW and NT Clearing Times





Arc Flash Calculations

To calculate incident energy, use the following equations:

800 A NW-L Masterpact Circuit Breaker

- $E = 0.067 + 0.064 \times I_b$ for $15 \leq I_b \leq 42$ kA
- $E = 2.16 + 0.017 \times I_b$ for $42 < I_b \leq 100$ kA

1600 / 2000 A NW-L Masterpact Circuit Breaker

- $E = 1.43 + 0.047 \times I_b$ for $20 \leq I_b \leq 50$ kA
- $E = 2.70 + 0.020 \times I_b$ for $50 < I_b \leq 65$ kA

800 A NT-L Masterpact Circuit Breaker

- $E = 0.47 + 0.0036 \times I_b$ 0for $10 \leq I_b \leq 100$ kA

Where:

- E is incident energy in calories/cm^2
- I_b is available bolted fault current in kiloamperes at the location of interest
- Working distance is 18 inches (457 mm) from the point of arcing
- Instantaneous trip setting is set at maximum (lower settings may result in lower incident energy values)

To calculate a flash protection boundary, use the following equations:

800 A NW-L Masterpact Circuit Breaker

- $D_b = 245 + 12.5 \times I_b$ for $15 \leq I_b \leq 42$ kA
- $D_b = 667 + 2.63 \times I_b$ for $42 < I_b \leq 100$ kA

1600 / 2000 A NW-L Masterpact Circuit Breaker

- $D_b = 541 + 7.6 \times I_b$ for $20 \leq I_b \leq 50$ kA
- $D_b = 775 + 2.92 \times I_b$ for $50 < I_b \leq 65$ kA

800 A NT Masterpact Circuit Breaker

- $D_b = 260 + 1.06 \times I_b$ for $10 \leq I_b \leq 100$ kA

Where:

- D_b is the flash protection boundary in millimeters
- I_b is available bolted fault current in kiloamperes at the location of interest
- Working distance is 18 inches (457 mm) from the point of arcing
- Instantaneous trip setting is set at maximum (lower settings may result in lower incident energy values)

CONCLUSION

The new technology employed in the Masterpact NW and NT circuit breakers make them unique in the industry. The technology provides the following benefits:

- Comparable arc flash incident energy and personnel protection to fuse-protected circuit breakers
- Reliable power
- A smaller footprint
- Reduced maintenance needs
- High interrupting ratings without fuses: Masterpact NW = 200,000 A at 508 Vac
- Circuit breakers designed for all applications:
  - — High withstand-rated circuit breakers for system coordination
  - — High close and latch ratings for systems with high inrushes, etc.
  - — Quick-opening designs for high available fault currents
  - — Quick-opening designs for arc flash protection without fuses

Masterpact NW and NT circuit breakers installed in PZ4 switch gear make possible smaller and safer installations. Since the Masterpact NW and NT circuit breakers do not need fuses, the following problems are eliminated:

- hazards associated with changing fuses;
- the need for additional mechanical hardware and items that can wear out, including fuse holders, blown fuse indicators, single-phasing devices, etc. that must be maintained or replaced and can become dislodged and cause arcing events;
- higher energy costs caused by additional resistances in the fuse holder and connections;
- larger equipment footprints;
- higher installation and service-life costs;
- the need to stock and replace fuses after overloads or short circuits

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