EATON

Cutler-Hammer

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FRED 691

THE 80% BREAKER DERATING RULE.....

All Cutler-Hammer Miniature and Molded Case Breakers are 80% derated unless marked and listed as 100%. Only electronic trip Cutler-Hammer breakers can be rated for 100%.

The thermal magnetic breakers are tested by U.L. in open air and are rated for 40C ambient. The associated published curves reflect the performance and calibration of this factory test at 100% current. This same breaker is then applied in the field by putting it into an enclosure or on a panel and is subject to the standard 80% derating. Attached are three documents for applying this derating (1) Cutler-Hammer Application Statement (2) NEC Code (3) Nema AB3.

To determine the minimum size breaker for an application take the FLA times 1.25 and select the next standard amperage. Or if you have a breaker you take the nameplate amperage and multiply it X .80. Example: 100Amp X .80 = 80Amp would be the maximum amperage you would apply to this breaker. This is similar to sizing wire. You round up to a maximum of 800A, above 800A you round down to the next standard amperage NEC 240-3c. A list of standard amperages is in the NEC 240-6.

All Cutler-Hammer Miniature and Molded Case breakers require the use of 75C wire for proper heat sinking and performance. You can only use 90C wire if you use the ampacity of the 75C wire.
Motor circuit protectors are sized at a minimum of 1.15 X FLA. Molded Case Switches are 100% rated as standard per U.L.
Electronic breakers are also derated 80% except those that are U.L. listed 100%. Be aware that these 100% rated breakers have certain air space or ventilation requirements and special wire requirements. Reference the breaker frame instruction leaflet for these specifications.

The above is a general approach to sizing breakers. The NEC Code gives more specific details for proper protection for various applications, such as transformers, capacitors, welders, etc.
Always make sure you are properly protecting the connected wire.

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6-26-01

Circuit Voltage

Molded case circuit breakers are rated by voltage class and should be applied only to system voltages within their rating. The voltage rating is determined by the maximum voltage that can be applied across its terminals, the type of distribution system and how the breaker is applied in the system.

Note: On all three-phase Delta, grounded B Phase applications, refer to Cutler-Hammer.

Circuit Frequency

The tripping characteristics of most molded case circuit breakers remain virtually constant when applied to frequencies of 50 and 60 hertz. On higher frequency applications, molded case circuit breakers must usually be specially calibrated and/or derated. The amount of derating depends upon the frame size and ampere rating as well as the current frequency. In general, the higher the ampere rating in a given frame size, the greater the derating required.

Thermal magnetic molded case circuit breakers applied at frequencies above 60 hertz could require that individual consideration be given to thermal performance, magnetic performance and interrupting capabilities.

Electronic trip units are usually calibrated for 50/60 hertz, although operation at higher frequencies is achievable with the use of special derating factors and specially sized cable or bus.

Avoid making circuit breaker performance assumptions on applications above 60 hertz. Consult Cutler-Hammer for any Cutler-Hammer molded case circuit breaker above 60 hertz.

Continuous Ampere Rating

Molded case circuit breakers are rated in rms amperes at a specific ambient. This ampere rating is the continuous current they will carry in the ambient temperature for which they are calibrated. Cutler-Hammer thermal magnetic breakers are calibrated for an ambient temperature 40°C (104°F) which is the average temperature within an enclosure; thus, they minimize the need for derating. If the enclosure ambient is known to exceed 40°C, the breaker used should either be especially calibrated for that ambient, or be derated accordingly. (Refer to item 9, Unusual Operating Conditions, for specific information.)

The selection of a specific ampere rating for a given application is dependent upon the type of load and duty cycle, and is governed by the National Electric Code. In general, the N.E.C. requires overcurrent protection at the supply and at points where wire sizes are reduced. It further states that the conductors be protected in accordance with their current carrying capacity, but lists exceptions for applications such as motor circuits where a larger rating is often required to override motor inrush currents.

Cable Selection

Note: UL listed circuit breakers rated 125A or less shall be marked as being suitable fo 60°C (140°F), 75°C (167°F) only or 60/75°C (140/167°F) wire. All Cutler-Hammer listed breakers rated 125A or less are marked 60/75°C. All UL listed circuit breakers rated over 125A are suitable for 75°C conductors. Conductors rated for higher temperatures may be used, but must not be loaded to carry more current than the 75°C ampacity of that size conductor for equipment marked or rated 75°C or the 65°C ampacity of that size conductor for equipment marked or rated 65°C. However, the full 90°C ampacity may be used when applying derated factors, so long as the actual load does not exceed the lower of the derated ampacity or the 75°C or 60°C ampacity that applies.

Circuit Breaker Sizing Considerations

The following paragraphs outline pertinent information from the NEC according to the type of load and duty cycle.

A. Service
A service includes the conductors and equipment for delivering electrical energy from the supply system to the wiring system of the premises served.

NEC Article 230 contains the many requirements for services of 600 volts or less including the sizing, location and overcurrent protection of conductors, disconnect means, permissible number of disconnects, grounding of conductors, and ground fault protection requirements of service equipment.

B. Feeder Circuits
A feeder is composed of the conductors of a wiring system between the service equipment or the generator switchboard of an isolated plant and the branch circuit overcurrent device.

NEC Article 220: Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the noncontinuous load plus 125 percent of the continuous load.

Exception: Where the assembly including the overcurrent devices protecting the feeder(s) are listed for operation at 100 percent of their rating, neither the ampere rating of the overcurrent device nor the ampacity of the feeder conductors shall be less than the sum of the continuous load plus the noncontinuous load.

Only breakers listed for 100% application, and so labeled, can be applied under the exception (for example, type CKD). Breakers without 100% application listing and label are applied under (B) above, or at 80% of rating.

NEC Article 430: Breakers for feeders having mixed loads; i.e., heating (lighting and heat appliances) and motors, should have ratings suitable for carrying the heating loads plus the capacity required by the motor loads.

NEC Article 430: Breakers for motor feeders shall have a rating not greater than the sum of the highest breaker rating of any of its branches and the full load currents of all other motors served by the feeder.

C. Branch Circuits
A branch circuit is the portion of a wiring system extending beyond the final overcurrent device protecting the circuit.

(1) Lighting Circuits (NEC Article 310): These are protected in accordance with the conductor ratings as given. High wattage incandescent lamp loads may result in abnormally high inrush currents that must be taken into account to avoid nuisance tripping. The lamp manufacturer should be consulted for data relative to the inrush currents.

(2) Motor Circuits (NEC Article 430): Breakers are primarily intended for the protection of conductors, motor control apparatus and motors against short circuits and ground fault conditions.

On motor overloads, the motor overcurrent device will open the circuit before the correctly applied breaker. Currents higher than the locked rotor value will be interrupted by the breakers, protecting the circuit from these heavy fault currents. The breaker must not trip on normal starting.

While breakers may be applied for motor running overcurrent protection when the requirements of Article 430 of the NEC are met, these applications are not recommended for Cutler-Hammer breakers and, therefore, this discussion is confined to the use of a breaker as a circuit protector.

For many applications, particularly those where starting behavior if the motor is unknown, the NEC maximum rules are followed. Usually, lower rated breakers can be used successfully. This is further discussed under motor circuit application and motor application tables.

Motor Circuit Application (NEC Article 430): The breaker must have a continuous rating of not less than 115% of the motor full load current. Before applying a breaker, one should check to determine the effect of any of the following conditions: High ambient temperature, heating within breaker enclosure due to grouping of current consuming devices, frequent motor starting, and lengthy motor acceleration period.

Breaker Rating or Setting (NEC Article 430): The motor branch circuit overcurrent device shall be capable of the motor. The required protection shall be considered as being obtained when the overcurrent device has a

(b) A fixture having tap conductors as provided in Section 410-67
(c) Individual outlets, other than receptacle outlets, with taps not over 18 in. (457 mm) long
(d) Infrared lamp industrial heating appliances
(e) Nonheating leads of deicing and snow-melting cables and mats

Exception No. 2: Fixture wires and flexible cords shall be permitted to be smaller than No. 14 as permitted by Section 240-4.

210-20. Overcurrent Protection. Branch-circuit conductors and equipment shall be protected by overcurrent protective devices that have a rating or setting that complies with (a) through (d).

(a) Continuous and Noncontinuous Loads. Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the noncontinuous load plus 125 percent of the continuous load.

Exception: Where the assembly, including the overcurrent devices protecting the branch circuit(s), is listed for operation at 100 percent of its rating, the ampere rating of the overcurrent device shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load

(b) Conductor Protection. Conductors shall be protected in accordance with Section 240-3.

Exception No. 1: Tap conductors as permitted in Section 210-19(d) shall be permitted to be protected by the branch-circuit overcurrent device.

Exception No. 2: Fixture wires and flexible cords shall be permitted to be protected in accordance with Section 240-4.

(c) Equipment. The rating or setting of the overcurrent protective device shall not exceed that specified in the applicable articles referenced in Section 240-2 for equipment.

(d) Outlet Devices. The rating or setting shall not exceed that specified in Section 210-21 for outlet devices.

210-21. Outlet Devices. Outlet devices shall have an ampere rating that is not less than the load to be served and shall comply with (a) and (b).

(a) Lampholders. Where connected to a branch circuit having a rating in excess of 20 amperes, lampholders shall be of the heavy-duty type. A heavy-duty lampholder shall have a rating of not less than 660 watts if of the admedium type and not less than 750 watts if of any other type.

(b) Receptacles.

(1) A single receptacle installed on an individual branch circuit shall have an ampere rating of not less than that of the branch circuit.

Exception No. 1: Where installed in accordance with Section 430-81(c).

Exception No. 2: A receptacle installed exclusively for the use of a cord- and plug-connected arc welder shall be permitted to have an ampere rating not less than the minimum branch-circuit conductor ampacity determined by Section 630-11(a) for arc welders.

FPN: See definition of *Receptacle* in Article 100.

(2) Where connected to a branch circuit supplying two or more receptacles or outlets, a receptacle shall not supply a total cord- and plug-connected load in excess of the maximum specified in Table 210-21(b)(2).

Table 210-21(b)(2). Maximum Cord- and Plug-Connected Load to Receptacle

Circuit Rating (Amperes)	Receptacle Rating (Amperes)	Maximum Load (Amperes)
15 or 20	15	12
20	20	16
30	30	24

(3) Where connected to a branch circuit supplying two or more receptacles or outlets, receptacle ratings shall conform to the values listed in Table 210-21(b)(3), or, where larger than 50 amperes, the receptacle rating shall not be less than the branch-circuit rating.

Exception: Receptacles for one or more cord- and plug-connected arc welders shall be permitted to have ampere ratings not less than the minimum branch-circuit conductor ampacity permitted by Sections 630-11(a) or (b) as applicable for arc welders.

Table 210-21(b)(3). Receptacle Ratings for Various Size Circuits

Circuit Rating (Amperes)	Receptacle Rating (Amperes)
15	Not over 15
20	15 or 20
30	30
40	40 or 50
50	50

Nema AB3

5.1.4 National Electrical Code

The selection of a specific ampere rating for a given application is dependent upon the type of load, duty cycle, and/or point of application. In general, the National Electrical Code requires overcurrent protection at the supply and at points where conductor sizes are reduced. Conductors shall be protected in accordance with their ampacities, but exceptions are allowed for applications such as motor circuits where a higher ampere rating is often required to carry motor inrush currents.

NEC Section 110-9 requires that equipment intended to break current at fault levels shall have an interrupting rating sufficient for the system voltage and the current which is available at the line terminals of the equipment.

Where equipment is intended to break current at other than fault levels, it should have an interrupting rating at system voltage sufficient for the current that must be interrupted.

NEC Section 110-10 defines how the protective equipment along with the other circuit components shall perform when clearing a fault.

Some other performance requirements to be considered include:

- Ground Fault Requirements, for Equipment Protection under NEC Sections 215-10, 230-95, and 240-13.
- Health Care Facility Feeder Selectivity Requirements for Equipment Ground Fault Protection under Section 517-17(b)
- Fire Pump Circuit Breakers under Section 230-90(a), Exception No. 4
- Circuit Breakers used as Switches in Fluorescent Lighting Circuits—Under NEC Section 240-83(d)(SWD)
- Circuit Breakers used for Group Motor Overcurrent Protection under NEC Section 430-53(c)(HACR)

5.2 GENERAL CONSIDERATIONS FOR MOLDED CASE CIRCUIT BREAKER APPLICATION

5.2.1 General Requirements

In keeping with the user's specifications and single-line wiring diagram, the circuit breaker should be selected with the type of mounting arrangement, physical configuration, terminations, operating characteristics, and accessories required for the installation.

The circuit breaker selected should be the best suited for the available environmental surroundings and operating conditions.

The circuit breaker selected should satisfy all national and local Code requirements while providing the maximum protection and greatest degree of reliability with minimum maintenance requirements.

5.2.2 The Main Circuit Breaker

The main circuit breaker in most installations generally means the main service circuit breaker. It is located near the point of entrance of the supply conductors to a building and is the main means of disconnecting the supply. A service includes conductors and equipment for delivering electrical power from the supply system to the distribution system of the premises served.

The ampere rating of the main service circuit breaker should be selected so that the rating will not be higher than the allowable ampacity of the service-entrance conductors in compliance with Section 230-90 of the National Electrical Code.

The interrupting rating should be selected so that it will be equal to or greater than the available fault current at the supply terminals in compliance with NEC Section 110-9. The voltage and frequency ratings should be as required for the distribution system.

If the system and main service circuit breaker requirements fall within the parameters defined in NEC Section 230-95, the circuit breaker selected should have suitable integral ground fault protection or should be one that can operate in conjunction with separately mounted ground fault protection devices.

The circuit breaker selected should be equipped with the appropriate short time rating or time/current tripping characteristics, or both, to provide the type of selective coordination required by the user's specifications.

5.2.3 The Feeder Circuit Breaker

A feeder consists of all circuit conductors between the service equipment, or the source of a separately derived system, and the final branch-circuit overcurrent device.

The ampere rating of the feeder circuit breaker should be selected in accordance with Part B of Article 220 of the National Electrical Code so that the rating will be no less than the noncontinuous load plus 125 percent of the continuous load served.

EXCEPTION: Where the assembly including the feeder circuit breaker is UL listed for operation at 100 percent of its ampere rating, the circuit breaker ampere rating may be selected on the basis of the sum of the noncontinuous load plus the continuous load served.

Only circuit breakers that are listed and marked for 100 percent application and mounted in suitable enclosures may be applied in accordance with this exception. All other overcurrent devices are applied at 80 percent or less of their ampere rating for continuous loads (three hour or greater duration).

For a specific fixed motor load, as per the National Electrical Code, the ampere rating of the feeder circuit breaker should be selected so that it is no greater than the ampere rating for the largest branch circuit protective device (based on NEC Table 430-152) plus the sum of the

full load currents of the other motors in the group (NEC Section 430-62).

On feeder circuits used for large capacity motor installations where future additions are expected, the ampere rating of the feeder circuit breaker should comply with the rated ampacity of the feeder conductors (NEC Section 430-62(b)).

Typical feeder circuits with lighting and single or multiple motor loads are shown in Figures 5-1 and 5-2.

The interrupting rating should be equal to or greater than the available fault current at the line side terminals in compliance with NEC Section 110-9. The voltage and frequency ratings should be as required for the distribution system.

Where applicable, the use of listed series tested molded case circuit breaker combinations may be considered. See 5.4.6.

If ground fault protection is required on the main breaker, as defined in NEC Section 230-95, consider the selection of a feeder circuit breaker with suitable integral ground fault protection or one that can operate in conjunction with separately mounted ground fault protective devices.

This additional level of ground fault protection is mentioned in the fine print note (FPN) of NEC Section 230-95, where maximum continuity of electrical service is necessary for general installations and is mandatory for health care facilities per NEC Section 517-17.

As may be required in the user's specifications, the circuit breaker selected should have the appropriate short time rating or time current tripping characteristics, or both, to provide the type of selective coordination required.

5.2.4 The Branch Circuit Breaker

A branch circuit is that portion of a distribution system extending beyond the final overcurrent device protecting the circuit. Branch circuits are intended to serve lighting, appliance, motor and/or other single loads.

In general, the continuous load supplied by a branch circuit should not exceed 80 percent of the branch-circuit rating, unless the assembled equipment, including overcurrent devices, is approved for continuous operation at 100 percent of its ampere rating.

The ampere rating of the circuit breaker should not exceed the specified values as shown in NEC Section 240-3 of the National Electrical Code for conductors; in NEC Section 240-2 for equipment; and in NEC Section 210-21 for outlet devices.

The interrupting rating of the branch circuit breaker should be equal to or greater than the available fault current at the line side terminals in compliance with Section 110-9. The voltage and frequency ratings should be as required for the distribution system.

Where applicable, the use of listed series tested molded case circuit breaker combinations should be considered. See 5.4.6.

If ground fault protection is required on the main breaker as defined in NEC Section 230-95 and is also included on the feeder breaker, the user should consider selecting a branch circuit breaker with suitable integral ground fault protection or one that can operate in conjunction with separately mounted ground fault protective devices.

This additional level of ground fault protection is mentioned in the fine print note (FPN) of NEC Section 230-95 where maximum continuity of electrical service is necessary.

For specific 15 and 20 ampere, 125 volt single phase receptacle circuits, as defined in NEC Section 210-8, the user should select ground fault circuit interrupters equipped to provide personnel protection.

5.3 LOAD REQUIREMENT CONSIDERATIONS

A paramount consideration in selecting a circuit breaker is the load. Attention should be given to the type of equipment comprising the load, the normal continuous/non-continuous current to be carried, the ON-OFF duty cycle, and so forth. There are load conditions that will call for the use of circuit breakers having time-current characteristics or other operating features, or both, fine-tuned for the particular application.

This list is not intended to cover all possible types of loads and combinations of loads, but the examples are cited to illustrate a few of the loading variations that should be considered. If there are any questions about the proper breaker for an application, contact the manufacturer of the circuit breaker or equipment, or both.

The following are examples of loads frequently encountered:

NOTE: Pulsating loads, such as welders and phase controlled devices, require special considerations to prevent nuisance tripping. Consult the manufacturer.

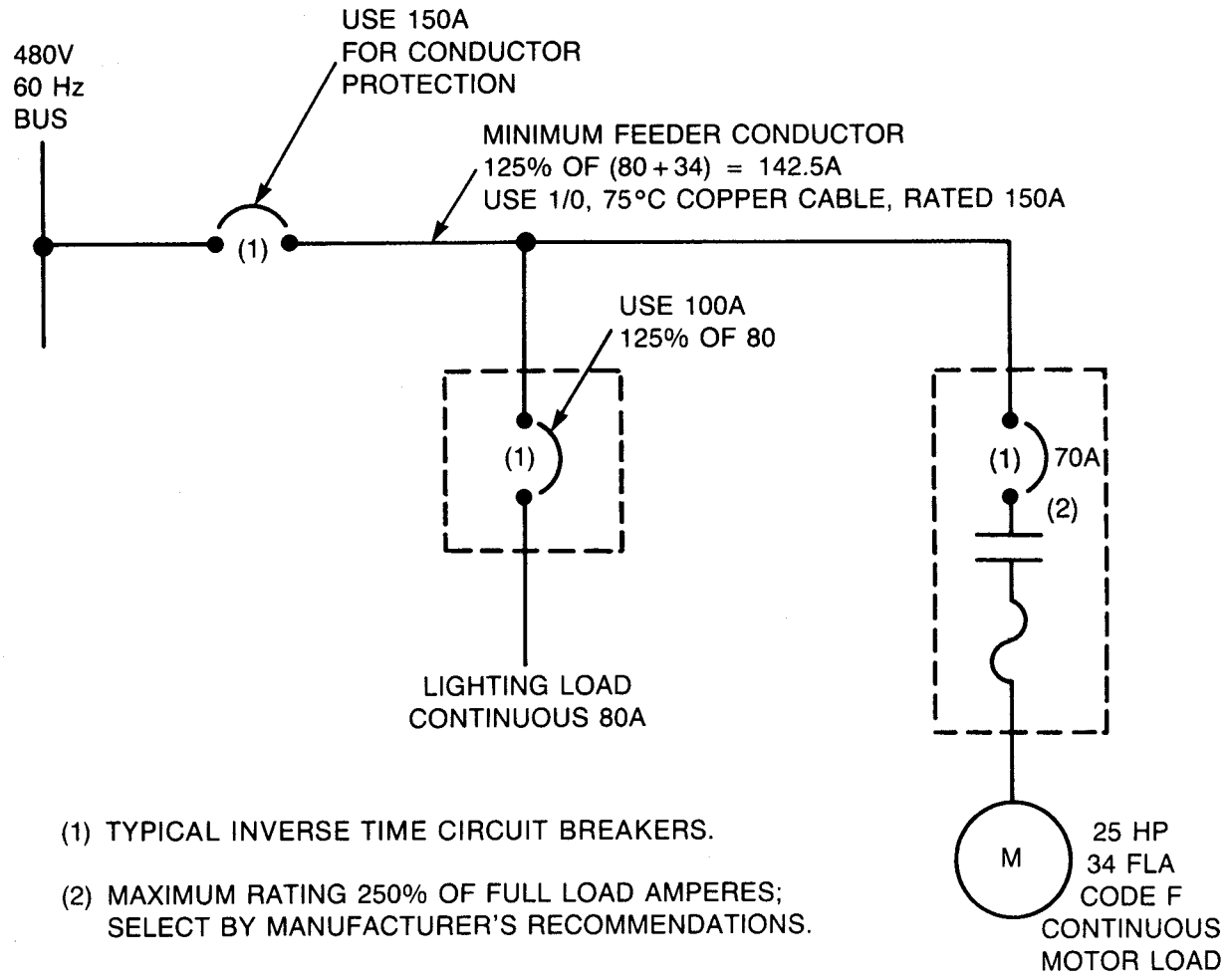

Figure 5-1
TYPICAL FEEDER CIRCUIT
(LIGHTING LOAD AND SINGLE FIXED MOTOR LOAD)

5.3.1 Continuous Duty, General Purpose Load

Selection of a standard inverse time circuit breaker, sized 125 percent of the continuous load current is usually recommended. There are cases where it might be desirable to use a circuit breaker rated to carry 100 percent of its rated current continuously. Breakers rated for this application are specifically marked.

5.3.2 Lighting Loads

For circuits involving the switching of fluorescent lighting loads, there are breakers especially designed and tested for that purpose. These breakers are marked "SWD."

For high intensity discharge lighting, high wattage security lighting and other special lighting applications, the circuit breaker manufacturers can recommend devices designed for the purpose.

5.3.3 Heating, Air Conditioning, and Refrigeration Loads

Select circuit breakers marked "HACR" which are designed, tested, and listed for the multi-motor and combination loads encountered in heating, air conditioning, and refrigeration equipment.

5.3.4 Motor Loads

Since motor loads are so important and prevalent in industrial and commercial applications, they are covered separately in 5.4.8.

5.4 SPECIFIC CONSIDERATIONS FOR MOLDED CASE CIRCUIT BREAKER APPLICATIONS

5.4.1 Conductor Selection

The prime requisite of a molded case circuit breaker is to protect the circuit conductors. In order for the circuit breaker to provide this protection, the user should ensure that the breaker and conductors are properly matched.

5.4.1.1 TEMPERATURE RATING OF CONDUCTOR

The manufacturer's specific recommendations for insulated conductors to be used with breakers are: breakers rated 125 amperes or less are calibrated to use 60°C rated wire, unless otherwise marked; breakers rated above 125 amperes are calibrated to use 75°C rated wire.

It should be noted that some circuit breakers rated 125 amperes or less are marked 60°/75°C and are suitable for use with conductors of either temperature rating.

Wire rated for higher temperatures, such as 90°C, may be used if the conductor size is determined by either the 60°C or 75°C size, as appropriate.

In certain cases involving circuit breakers suitable for operation at 100% of their rating, 90°C conductors, sized in accordance with 75°C ampacity, are required. Refer to marking on the circuit breaker.

5.4.1.2 CONDUCTOR AMPACITY.

Copper (Cu) and Aluminum (Al) are the most widely used conductor materials. The ampacities of most commonly used insulated conductors are listed separately in Tables 310-16 and 310-17 of the National Electrical Code. In order to apply the tables correctly, consideration should be given to the correction factors in the footnotes and the notes that follow the tables.

A Word of Caution! The standards that determine the size of conductors inside a factory-wired assembly may be different from the standards used for branch circuits. Therefore, the size of the factory wiring should not be used to determine the size of the branch circuit wiring.

5.4.2 Terminations

Terminations provide the means of connecting the molded case circuit breaker to both the power source and the load. Due to the importance of electrical connections which can affect the performance of the molded case circuit breaker, consideration should be given to the proper selection, application, and installation of the molded case circuit breaker terminations.

Various methods of connection include bolted, plug-in, and terminal wire connectors (lugs). In some cases, more than one method will be used on the same molded case circuit breaker. For example, a breaker could have plug-in connections on one end to connect to a panelboard bus and terminal wire connectors on the other to connect to cables. Plug-in connectors should be used only with equipment specifically designed to accept them.

When terminal wire connectors are used to connect the breaker, only those terminal wire connectors specified by the manufacturer for use with the molded case circuit breaker should be used. When alternate means of connection are desired, consult the manufacturer.

Cables should be terminated according to the instructions furnished by the manufacturer. Particular care should be taken not to exceed the recommended stripping length to avoid the possibility of reduced electrical clearances. Terminal connections should be torqued according to the marked requirement on the circuit breaker or to other specifications provided by the manufacturer.

Terminal wire connectors are available which are suitable for use with both copper and aluminum and are marked Al/Cu. Special care should be taken to follow the manufacturer's installation instructions.