Westinghouse

Westinghouse Electric Company
Nuclear Services
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555-0001

Direct tel: (412) 374-4643
Direct fax: (412) 374-4011
e-mail: greshaja@westinghouse.com

Our ref: LTR-NRC-06-47

August 8, 2006

Subject: Westinghouse Motor Control Center (MCC) Breakers

Recently Mr. Christopher Even of the U.S. NRC requested technical information about Westinghouse Motor Control Center (MCC) breakers to provide information explaining the basic principle of how the breakers operate and what problems are associated with the breakers. The attached documents are non-proprietary and are provided per NRC request.

Attachment 1 contains basic breaker information including the history of the product line, along with a breaker's basic function.

Attachment 2 contains technical data for the AB DE-ION® classic breakers. Along with general information, catalog cut sheets for EB, EHB, FB and HFB breakers are included. Finally a sample time current curve and sample dimension sheets are provided.

The issue of grease degradation appears to be a common problem that was identified as early as 1993 (reference NRC Information Notice 93-26). Over time, the lubrication properties of the grease within a molded case circuit breaker degrades. This phenomena is not isolated to the Classic Series breaker. However, since it was brought to our attention, Westinghouse has published three technical bulletins, the last being TB-06-2. The plants' maintenance surveillance programs should detect this degradation before the function of the breaker becomes a safety issue.

If there are any questions, please contact J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing at 412-374-4643.

Very truly yours,

B. F. Maurer, Acting Manager
Regulatory Compliance and Plant Licensing

cc: Christopher Even, USNRC

Attachments:
1. A Working Manual on Molded Case Circuit Breakers
2. Technical Data for AB DE-ION® Circuit Breakers

T010

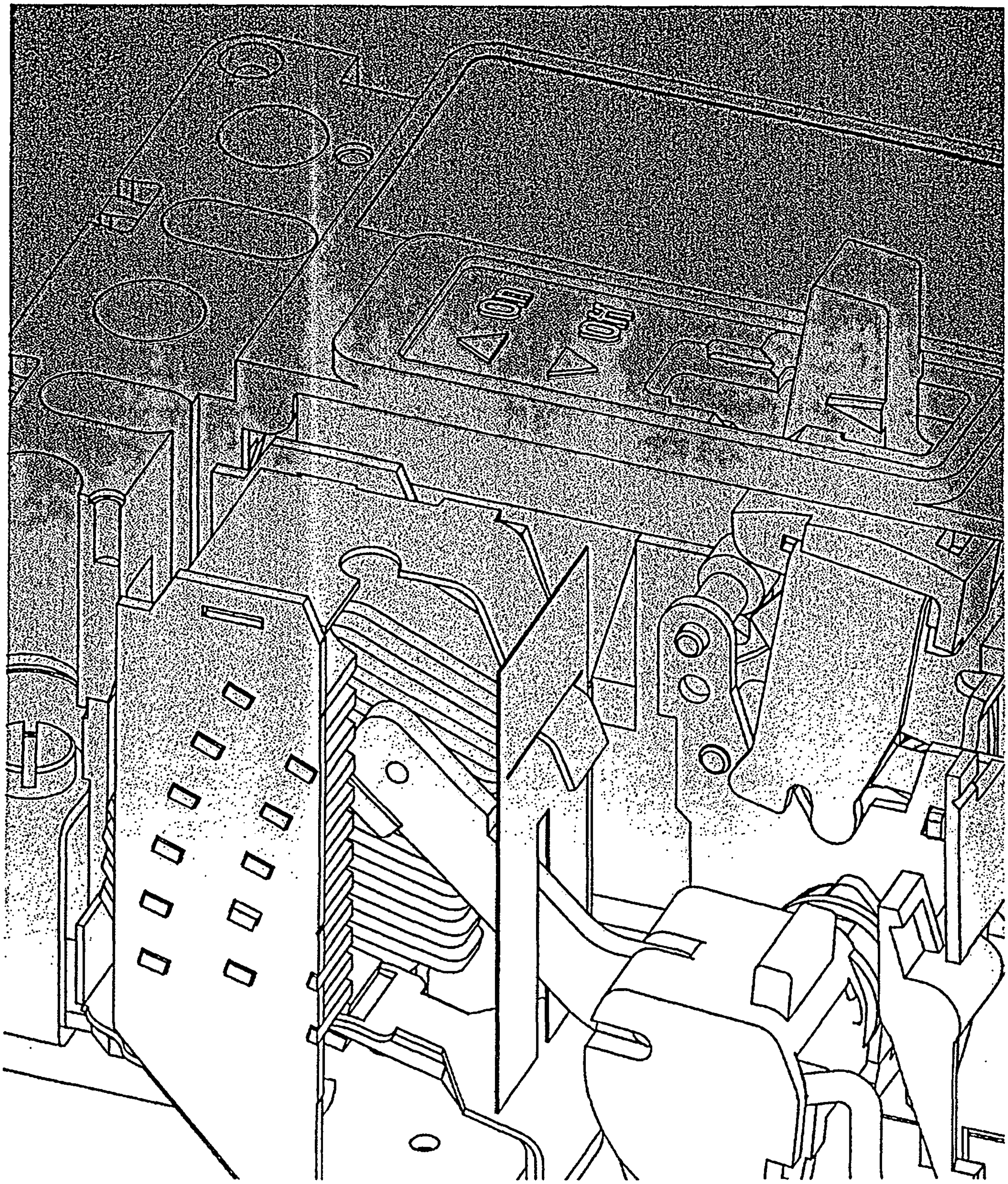
LTR-NRC-06-47
Attachment 1

A Working Manual on Molded Case Circuit Breakers

Page numbers included in Attachment 1 are as follows:
Cover Page
Pages 6, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21, 22, 160, 161, 162, 163, 164 and 165

Westinghouse Electric Company LLC
P.O. Box 355
Pittsburgh, PA 15230-0355

A Working Manual on Molded Case Circuit Breakers



[redacted]

FOURTH EDITION

Westinghouse has been the world leader in molded case circuit breaker technology since inventing the DE-ION® arc extinguisher over 60 years ago. A history of innovative concepts converted to practical applications has permitted Westinghouse to maintain its circuit protection leadership role since that time.

History

The need for molded case circuit breakers was created in 1918 when numerous applications for electrical motors resulted in a demand for a device that would ensure safe operation and, at the same time, protect electrical circuits. During this period, individual motors were used for the first time in industrial plants to operate machine tools, and in private homes to operate appliances. Plant electricians were constantly changing fuses blown during motor start-ups because of the lack of properly designed fuses for motor circuit protection. Homes experienced similar problems when electrical circuits were overloaded. Inspectors were concerned about fire hazards, because of plug fuses being bridged with pennies and the installation of fuses with too high of an ampere rating. Inspection authorities became involved and attempted to find a solution to the problem. Meetings with switch manufacturers were initiated in an effort to find a solution. Switch manufacturers were asked to develop a switching device that would interrupt a circuit under prolonged overload conditions. The device would have to be safe, reliable and tamperproof. It should also be resettable so as to be reusable after an interruption without replacing any parts. This search for better circuit protection resulted in many different but unacceptable approaches to the problem. These early meetings and subsequent efforts prepared the groundwork for the eventual development of the molded case circuit breaker.

During this period of research and development, Westinghouse produced the DE-ION arc extinguisher for use in large oil circuit breakers. Although too large in its initial form to be practical for small circuit breakers, the arc extinguisher was eventually modified into a usable size. The first compact, workable circuit breaker was developed in 1923 when the modified arc extinguisher was coupled with a thermal tripping mechanism. It was not until four years later, however, that Westinghouse research engineers found the ideal combination of materials and design that permitted circuit breakers to interrupt fault currents of 5000A at 120 volts AC or DC. One year later, Westinghouse placed the first circuit breaker on the market. Its acceptance was instantaneous.

Since that initial introduction in 1927, Westinghouse has been at the forefront of circuit breaker technology with an unprecedented series of circuit protective enhancements and introductions.

The Westinghouse Motor Circuit Protector (MCP) was introduced in the late 1960s and was the first device of its kind to be specifically designed for use on motor circuits.

Standard thermal magnetic circuit breakers remained state-of-the-art until 1973 when Westinghouse introduced the Seltronic™ Circuit Breaker. Seltronic was the first molded case circuit breaker with an electronic trip unit.

This innovative spirit continued and in 1976, the Systems Pow-R Breaker was unveiled, the most powerful encased circuit breaker available.

In 1979, Current Limit-R®, a true current-limiting circuit breaker, was introduced to the market. The design was based on the Westinghouse exclusive patented slot motor concept.

Recognizing the need for a world class device that would meet the higher and growing interrupting requirements of today without sacrificing size, Westinghouse established a new world class standard with the Series C̄®. The Series C̄ family of molded case circuit breakers met the challenge of the 80s and the future.

Westinghouse's history as the world leader in circuit protection is well documented. In this leadership position, Westinghouse has always and continues to identify the need and introduce innovative solutions, all supported by sound, state-of-the-art technology.

Definitions

What Is a Circuit Breaker?

A circuit breaker is defined in NEMA standards as a device designed to open and close a circuit by nonautomatic means, and to open the circuit automatically on a predetermined overcurrent, without injury to itself when properly applied within its rating.

A circuit breaker is also defined in ANSI standards as a mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also, making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short-circuit.

It can be seen that although the basic premise is the same for both circuit breaker definitions and both are accurate, the wording is quite different. Trying to present concise definitions for the many types of circuit breakers applied today is even more involved. Categorizing circuit breakers is complicated by the fact that only the molded case circuit breaker is precisely defined. For the sake of this discussion, if it is not a molded case circuit breaker by definition, it is considered a power breaker.

There are two classifications and three types of circuit breakers used for low voltage circuit protection. The two basic classes of circuit breakers are:

1. Low Voltage Power Circuit Breaker Class
2. Molded Case Circuit Breaker Class

The classifications themselves lend their names to the first two of the three types of circuit breakers and the third type of circuit breaker is derived from the molded case class and is known as an insulated case circuit breaker. The three types of circuit breaker are as follows:

1. Low Voltage Power Circuit Breakers (LVPCB)
2. Molded Case Circuit Breakers (MCCB)
3. Insulated Case (encased) Circuit Breakers (ICCB)

Briefly, some of the salient features of these types of breakers are the following.

Molded case circuit breakers, shown in Figure **4.1**, as a class, are tested and rated according to the UL 489 Standard. Their current carrying parts, mechanisms, and trip devices are completely contained within a molded case of insulating material. MCCBs are available in small and medium frame sizes with various interrupting ratings for each frame size. Current-limiting molded case circuit breakers are also available. They are characterized by fast interruption short-circuit trip elements but do not have short time ratings.

Insulated case circuit breakers are also rated and tested according to the UL 489 Standard. However, they utilize characteristics of design from both classes. They are of large frame size, have short time capabilities and utilize stored energy operating mechanisms.

Low voltage power circuit breakers are used primarily in drawout switchgear, they have replaceable contacts, and are designed to be maintained in the field. Figure **4.2**

The term power circuit breaker also applies to medium voltage (1000-72.5 kV) or high voltage (over 72.5 kV) breakers. Figure **4.3**

Insulated case power circuit breakers, designed and tested to the UL 489 Standard, are used primarily in fixed mounted switchboards but are also available in drawout configuration. They are generally considered not field maintainable but there are several maintenance operations that can be performed in the field. Figure **4.4**

Molded case circuit breakers are designed and tested to the UL 489 Standard. Some of the larger molded case circuit breakers are available in drawout design. They are used primarily in panelboards and switchboards where they are mostly fixed mounted.

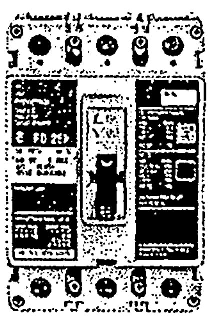


Figure **4.1** Series C̄ FD molded case circuit breaker.

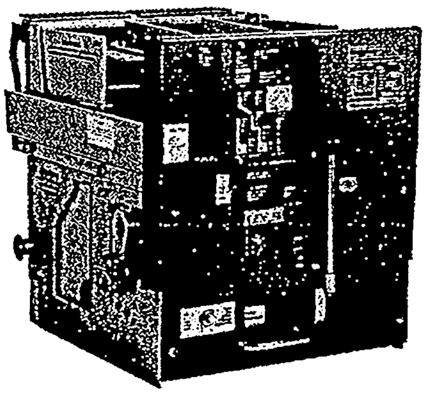


Figure **4.2** Type DS low voltage power circuit breaker.

Although molded case and insulated case circuit breakers are not field maintainable, they have relatively high endurance capabilities which should be evaluated in any application analysis.

Preferred ratings of low voltage power circuit breakers are as indicated in ANSI/IEEE C37.16. Standards for low voltage AC power circuit breakers used in enclosures are as indicated in ANSI/IEEE C37.13. Test procedures for low voltage power circuit breakers used in enclosures are as indicated in ANSI/IEEE C37.50-1973. Application recommendations are discussed in ANSI/IEEE C37.16-1980 and application factors are discussed in ANSI/IEEE C37.20. Low voltage power circuit breakers are generally UL listed and can be UL labeled.

Generally, the best guide for the choice of a type of breaker to use is to follow the practices which have a history of long term successful performance. But, the best engineering solution in any specific case may require thorough consideration of alternative approaches.

Function

The subject of molded case circuit breakers will only be covered beyond this point. Breaker Basics Volume I is dedicated to molded case circuit breakers and their applications. The subject of power breakers and encased breakers, will be detailed in a similar fashion in Breaker Basics Volume II.

Molded case circuit breakers are designed to provide circuit protection for low voltage distribution systems. They protect connected apparatus against overloads and/or short-circuits.

Standards

Molded case breakers are designed, built and tested in accordance with NEMA and/or Underwriters' Laboratories, Inc. standards. In addition, molded case breakers are designed to be applied in accordance with the requirements of the National Electrical Code, which is mandatory.

In addition to the above domestic standards, other international standards must be complied with to sell products to various world markets. There are many individual foreign standards on molded case breakers and not all molded case breaker designs comply with all the same standards. Some of the major foreign standards are:

- Australian Standards
- British Standards Institution (BSI)
- Canadian Standards Association (CSA)
- International Electrotechnical Commission (IEC)
- Japanese Industrial Specification
- South African Bureau of Standards
- Swiss Electro-Technical Association
- Union Technique de l'Electricite
- Verband Deutscher Elektrotechniker (VDE)

Compliance with these standards and the domestic standards previously mentioned satisfies most local and international codes, assuring user acceptability and application simplicity. The Westinghouse Series C family of molded case breakers, because it is a global design, complies with most major standards worldwide.

Figure 4.3 Type DHP air circuit breaker and type VCP-W vacuum circuit breaker.

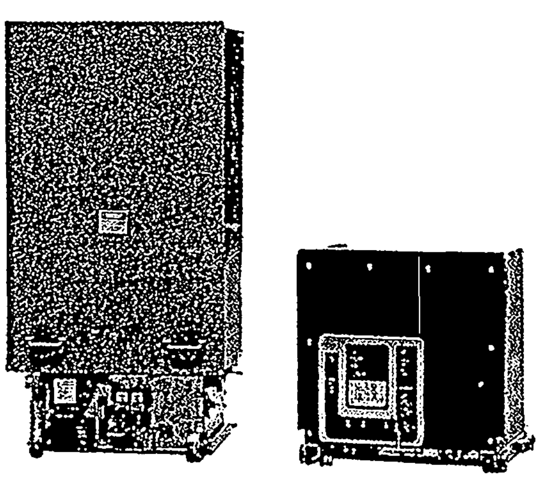
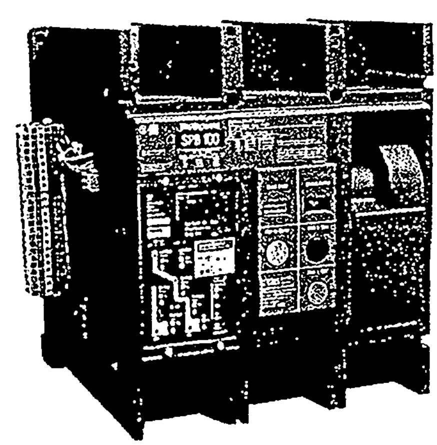


Figure 4.4 Type SPB insulated case (encased) circuit breaker.



Because of the tremendous impact UL standards and IEC standards have on the design and application of molded case circuit breakers worldwide, UL 489 and IEC 947-2 are specifically recognized in this section. In addition, refer to Section 11 of this publication for an overview of UL and IEC molded case circuit breaker testing procedures. Any discussion of these standards is meant only as a general overview and should not be considered as a substitute for either of the standards. For a full explanation of either UL 489 or IEC 947-2, consult the complete standards for details and proper conformance instructions.

National

In general, Westinghouse molded case circuit breakers are UL listed in accordance with UL 489. UL listed circuit breakers are identified by the UL listing mark, frequently referred to as the UL label as shown in Figure **4.5**. This listing is generally limited to circuit breakers equipped with inverse time and instantaneous (or short time) time-current characteristics.

Circuit breakers (interrupters) equipped with instantaneous only time-current characteristics are also covered under UL 489. These type devices, however, are classified as **recognized components** and bear the reversed UR marking. Figure **4.6**

Molded case switches (or circuit interrupters) are designed, built and tested in accordance with UL 1087. Much of the test performance criteria is the same as established for molded case circuit breakers under UL 489. Products tested under UL 1087 are listed as molded case switches and bear a suitably identified listing mark.

Although the Canadian Standards Association (CSA) falls into the category of a major international standard, design, submittal and follow-up test requirements for CSA are essentially the same as required by UL. In fact, harmonization programs between UL and CSA are underway to close the gap on any differences.

Most Westinghouse molded case circuit breakers are listed by the Canadian Standards Association and bear the CSA monogram as shown in Figure **4.7**. Circuit breakers so marked are listed under CSA Standards C22.2, No. 5-M1986.

UL 489

UL listed molded case circuit breakers must conform to the Underwriters Laboratories, Inc. Standard for Safety, No. UL 489. The following brief explanation of UL 489 illustrates why the UL listing mark exemplifies dependability and quality.

Underwriters Laboratories, Inc., is an independent not for profit organization which performs or witnesses testing on electrical devices, materials and systems to insure their safety for people and property. Only upon successful completion of all prescribed tests is the UL listing mark granted.

Molded case circuit breakers must undergo three distinct phases of tests as defined per UL 489:

1. Initial Submittal
2. Initial Production Inspections
3. Follow-up Testing

Before any circuit breaker could be considered for initial submittal testing, it must first be designed in accordance with the construction requirements defined in UL 489. These requirements define specific acceptance criteria including:

1. General Details
2. Corrosion Protection
3. Insulating Materials
4. Current Carrying Parts
5. Wiring Terminals
6. Operating Mechanisms
7. Spacings
   (creepage and clearance distances)

Figure **4.5** UL label.

Figure **4.6** UR marking for recognized component.

Figure **4.7** Canadian Standards Association monogram.

International Electrotechnical Commission (IEC)

Standard IEC 947-2, which replaced IEC 157-1, applies and covers test requirements for circuit breakers up to ratings not exceeding 1000 volts AC. This standard covers molded case circuit breakers normally covered by UL 489, as well as low voltage AC power circuit breakers normally covered by UL 1066 and ANSI C37.50. The performance and witnessing of IEC tests can take place in a number of independent international laboratories, such as KEMA in the Netherlands and CESI in Italy.

Every device tested to IEC 947-2 must be subjected to several test sequences in order to be officially approved. The test sequences are intended to check different parts of the device's characteristics over a number of different samples. Since IEC 947-2, unlike UL 489, covers both standard low voltage molded case circuit breakers, as well as low voltage power circuit breakers, the exact test sequences performed depends upon the category of the device. A "Category A" device would, in general, be a device without a withstand rating, while a "Category B" device would have a withstand rating. Therefore, most standard molded case circuit breakers would fall into "Category A," and power circuit breakers into "Category B."

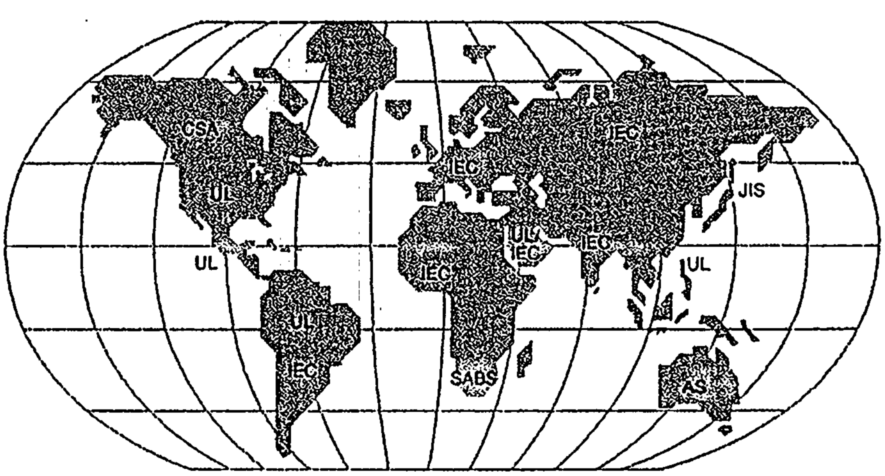
IEC 947-2 was developed with assistance rendered by members of the US National Committee. Still, a number of differences exist between IEC 947-2 and the above mentioned domestic standards. Therefore, any product comparisons made between products tested to each of these standards (domestic and international) should only be made with a thorough understanding of the differences that exist.

SUMMATION

There is no room for compromise when performance, quality and safety are involved. Exacting standards are established relative to the design, testing and manufacture of molded case circuit breakers, and compliance with these major standards insures the best selection. Understanding the sometimes subtle differences between sets of standards can make a significant difference in the final selection.

Molded case circuit breakers designed, built and tested in accordance with established UL, CSA and IEC standards offer a high level of quality performance. This performance, as is the case with UL and CSA approved devices, is even regularly verified by established follow-up and audit test programs. It is not prudent nor recommended to make device selections based on a superficial understanding of the standards a particular device complies with, because of the differences that exist from one set of standards to another. The selection process has been simplified, however, by the availability of molded case circuit breakers that are designed, tested and meet a wide range of both national and international standards. Figure **4.8**

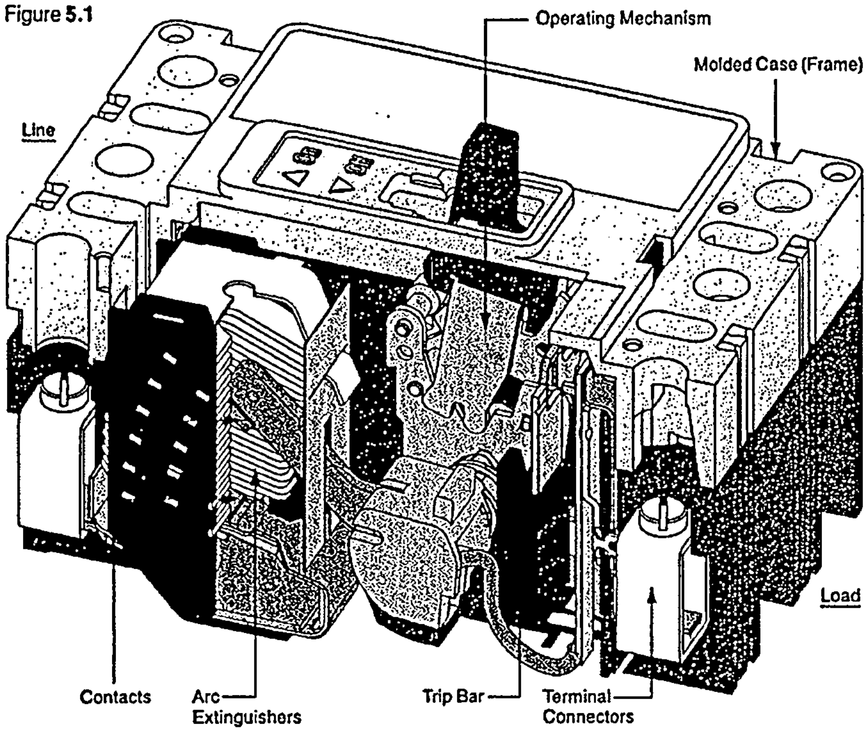
Figure **4.8** General standards influences around the world.



Although many types of molded case circuit breakers are manufactured, all are comprised of five main components as shown in Figure **5.1**:

- Molded Case (frame)
- Operating Mechanism
- Arc Extinguishers
- Contacts
- Trip Units

Figure **5.1**



Molded Case (Frame)

The function of the molded case is to provide an insulated housing to mount all of the circuit breaker components. The cases are molded from moldarta and/or glass-polyester material that combines ruggedness and high dielectric strength in a compact design.

Each different type and size of molded case is assigned a frame designation. Frames are identified by letters such as FD, JDC, KW, etc. This frame identification describes a number of important characteristics of the breaker, i.e., maximum voltage and current ratings, interrupting ratings, standards met and physical dimensions of the molded case. Unfortunately, all manufacturers have a different identification system because the breaker's characteristics are different. For example, a Westinghouse Series C̄ Breaker has three different interrupting ratings in the same physical frame size, while another manufacturer might have to use three physically different packages. Figure **5.2**

Figure **5.2**

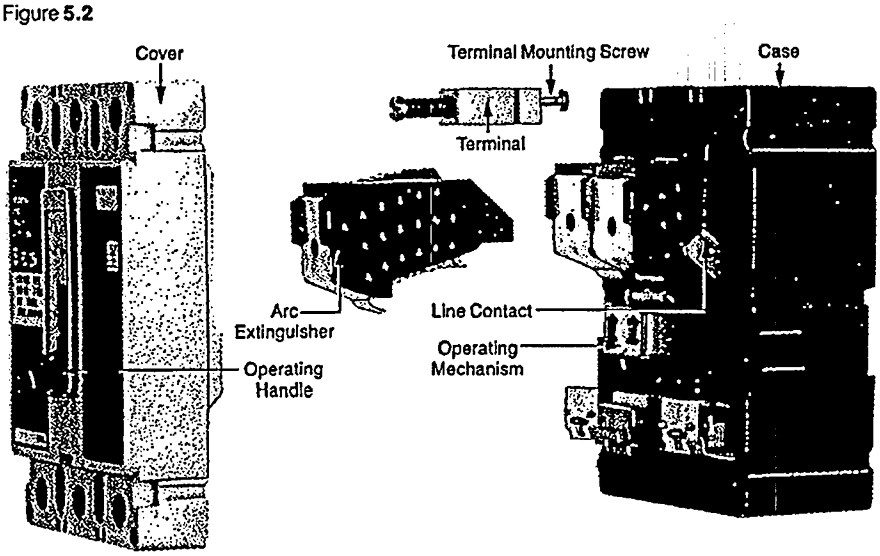
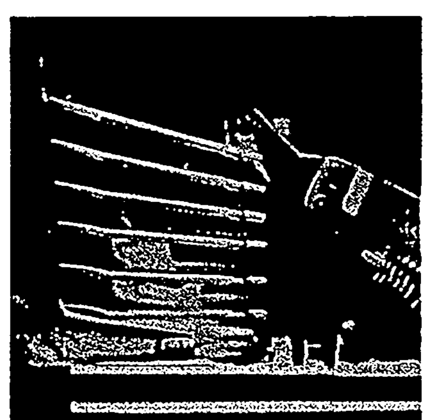


Figure **5.3** DE-ION arc quenchers extinguishing arc.



Operating Mechanism

The function of the operating mechanism is to provide a means of opening and closing the breaker. This toggle mechanism is the quick-make, quick-break type, meaning that the speed with which the contacts open or close is independent of how fast the handle is moved. The breaker is also trip-free, which means it cannot be prevented from tripping by holding the breaker handle in the "ON" position. The handle position indicates the contact status: closed, open or tripped (a midway position). To restore service after the breaker trips, the handle must first be moved from the center position (tripped) to "OFF," to reset the mechanism, and then to "ON." This distinct trip point is particularly advantageous where breakers are group mounted, such as in panelboard applications, because the handle position clearly indicates the faulty circuit. The Westinghouse Series C̅ design also incorporates a push to trip mechanism which provides a manual means of exercising the mechanism by manually tripping the breaker. This is accomplished by depressing the button located in the trip unit, the rating plug or circuit breaker cover, depending on the specific frame.

Arc Extinguishers and Contacts

The function of the arc extinguisher is to confine, divide and extinguish an arc each time a breaker interrupts a current. An arc extinguisher, therefore, dissipates arcs that result when the circuit breaker interrupts current flow, see Figure **5.3**. Each arc extinguisher consists of a stack of U-shaped steel plates held together by two insulating side plates as diagramed in Figure **5.4**. When an interruption occurs and the contacts separate, the current flow through the ionized region between the contacts induces a magnetic field around the arc and arc extinguisher. As the lines of magnetic flux show, the force drives the arc into the steel plates, deionizing the gas while dividing and cooling the arc as shown in Figure **5.5**. **See the Glossary Section for a discussion of magnetic flux.**

Standard molded case circuit breakers utilize a linear current flow contact arrangement. A small blow-apart force between the contacts is generated under short-circuit conditions, which helps to open the contacts. The majority of the opening action, however, is caused by the mechanical energy stored in the trip mechanism itself. This has been the conventional approach since Westinghouse developed the DE-ION arc extinguisher during the early 1900s.

Refinements have been made to the arc extinguisher since those early years, but not until the use of the reverse loop contact design have significant strides been taken in the direction of improved arc extinguishing. The reverse loop design takes advantage of a physics' principle that describes what happens when current flows in essentially opposite paths. A much greater blow-apart force between the contacts is generated with the reverse loop design. This blow-apart force is directly proportional to the size of the fault current; the greater the fault, the greater the force. This force assists with rapid arc extinguishing by causing faster contact opening speeds.

The reverse loop design opened the door for new breaker designs, such as the Current Limit-R and the entire Series C̅ family. Figure **5.6**

Detailed information on contact designs and their operation can be found in Section 12 of this publication.

Figure **5.4** Arc extinguisher.

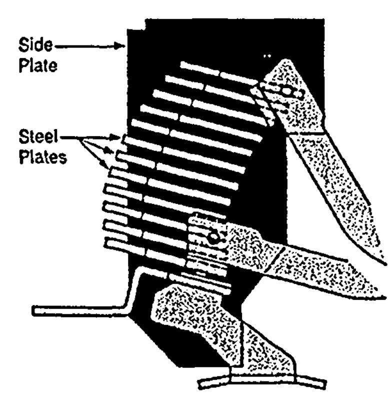


Figure **5.5** Arc extinguisher operation.

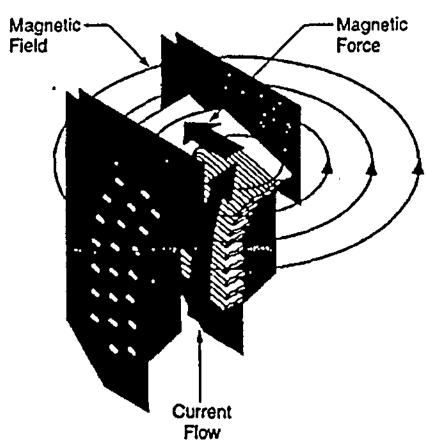
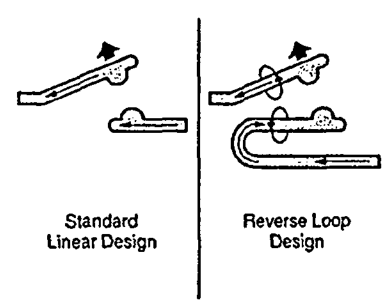


Figure **5.6**



Trip Units

The function of the trip unit is to trip the operating mechanism in the event of a prolonged overload or short-circuit current. To accomplish this, electromechanical (thermal magnetic) or electronic trip units are provided. Today's sophisticated electronic trips also incorporate protection against damaging arcing ground faults. The more sophisticated the electronic trip unit, the more versatile it becomes, offering electrical testing in the field, precise trip curve shaping, as well as monitoring and recording capabilities. Electronic trip units are covered in more detail later in this section and in Section 7 of this publication.

The traditional molded case circuit breaker has used electromechanical (thermal magnetic) trip units since Westinghouse invented the molded case circuit breaker. Protection is provided by combining a temperature sensitive device with a current sensitive electromagnetic device, both of which act mechanically on the trip mechanism.

Molded case circuit breakers utilize one or a combination of different trip elements to provide the required circuit protection for a particular application. These trip elements protect against three conditions: thermal overloads, short-circuits and arcing ground faults. Each of the three conditions is discussed first, followed by the different molded case breaker methods used to protect against any or all of these undesirable conditions.

Thermal Conditions

Insulation deterioration in electrical conductors is usually the result of overload conditions. When an overload condition exists, a temperature buildup occurs between the insulation and the conductor. Uncontrolled, this excessive heat will reduce the life of the conductor and eventually result in a short-circuit as the insulation fails.

The heat in a conductor depends on the square of the rms current (I^2), the conductor resistance (R) and the time (t) the current flows. If the current flowing into a conductor and the time for which it flows is monitored, overload conditions are predictable and can be detected.

A time-current curve shows the boundary between the normal and the overload condition. A typical time-current curve for the thermal (overload) element of a circuit breaker protective device indicates that a trip will occur in 1800 seconds at 135% of rating (Point A) or ten seconds at 500% of rating (Point B). Figure **5.7**

A circuit protective device uses time-current curves to indicate when it will operate to protect a conductor against overload conditions. Just how a molded case circuit breaker performs this function is covered in detail later in this section.

Short-Circuit Conditions

Short-circuit currents (fault currents) usually occur when abnormally high currents flow due to the failure of the insulation. When the insulation between phases or between phases and ground breaks down, short-circuit currents, limited only by the capabilities of the distribution system, can be expected to flow into the fault. The short-circuit must be eliminated quickly to protect against damage from the resulting thermal and dynamic stresses.

A typical time-current curve for a short-circuit (instantaneous) element of a circuit breaker indicates that a trip will not occur until the fault current reaches or exceeds Point A as shown in Figure **5.8**. The methods used by a molded case circuit breaker to protect against a short-circuit are also addressed in detail later in this section.

For a more detailed discussion of short-circuit conditions, see Section 10.

Figure **5.7** Typical time-current curve for 100A thermal element of a breaker.

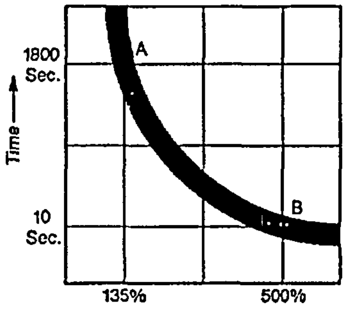
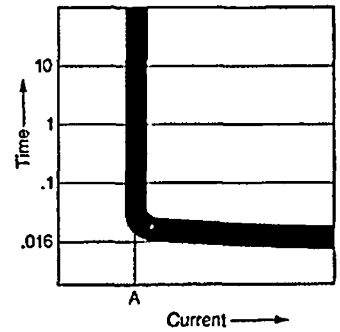


Figure **5.8** Typical time-current curve for fixed magnetic action.



Ground Fault Conditions

A ground fault is one particular type of short-circuit. It is a short-circuit between one phase and ground, and is probably the most common type of fault experienced on low voltage systems. Arcing ground fault currents are often not of a large enough magnitude to be detected by the standard protective device. Undetected, the ground fault current can develop into a current value high enough to trip the standard protective device. By this time, it is often too late and the damage has been done. This is especially true with motors where an internal insulation failure can result in serious damage.

Traditionally, when an electrical system required the detection of ground fault currents, separate ground fault protection devices were used to provide the additional level of protection. With the advent of electronic trip circuit breakers, ground fault protection has become an integral part of the trip unit. Ground fault protection as part of an electronic trip unit is discussed in Section 7 of this publication.

The National Electrical Code requires ground fault protection on specific applications, such as service entrance. NEC rules are dependent upon such factors as the service's current rating, the voltage level and the type of system.

Types of Trip Unit

Fixed or Interchangeable Trip Unit

Conventional molded case circuit breakers are available with either a fixed or interchangeable electromechanical trip unit, depending on the type and frame size. With a fixed trip breaker, the entire breaker must be replaced if a new trip rating is required. With an interchangeable trip breaker, only the trip unit has to be changed, up to the maximum current rating of the breaker frame.

Series C̄ molded case circuit breakers offer one additional interchangeable dimension, an interchangeability between electromechanical and electronic trip units within the same frame. Figure **5.9** shows a Series C̄ HLD breaker with an interchangeable electronic trip unit installed and a separate interchangeable electromechanical trip unit. The trip units can be interchanged with no modifications.

All interchangeable electromechanical trip breakers have adjustable magnetic elements which provide short-circuit protection. Certain smaller breaker frame sizes are sealed units, as required by UL, and are not interchangeable trip unit breakers. The magnetic element on these sealed breakers is not adjustable. Figure **5.10** shows a Series C̄ FD 150A frame breaker with factory seal affixed to the side of the case, indicating this particular breaker is a sealed unit.

Fixed Thermal and Adjustable Thermal Settings

Electromechanical trip circuit breakers contain thermal trip elements which provide overload protection. This thermal element can be either fixed or adjustable. Except for adjustable electronic trips, UL regulated circuit breakers can only utilize a fixed thermal element. IEC regulated circuit breakers can utilize either a fixed or adjustable thermal element.

Figure **5.9** Series C̄ HLD circuit breaker with interchangeable Seltronic (electronic) trip unit.

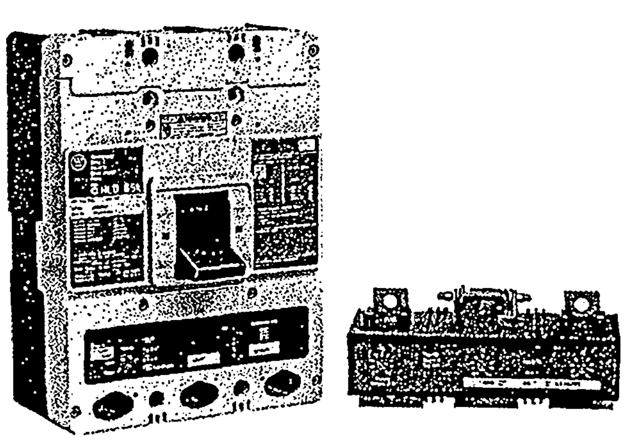
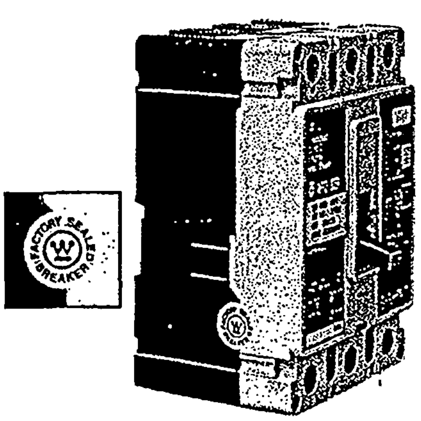


Figure **5.10**



Electromechanical

Conventional breakers utilize bimetals and electromagnets to provide overload and short-circuit protection. This type of protective action is referred to as thermal magnetic and has been the industry standard. Today, however, electronic devices play a much greater role, with continued use growth expected. To better understand this tripping action, the thermal and magnetic portions are explained separately and then combined.

Thermal (Inverse Time) Overload Protection

Thermal trip action is achieved through the use of a bimetal heated by the load current. On a sustained overload, the bimetal will deflect, causing the operating mechanism to trip. The time needed for the bimetal to bend and trip the circuit breaker varies inversely with the current. Figure **5.11**

A bimetal consists of two strips of metal bonded together. Each strip has a different thermal rate of heat expansion. Heat due to excessive current will cause the bimetal to bend or deflect. The metal having the greater rate of expansion will be on the outside (longer boundary) of the bend curve. To trip the breaker, the bimetal must deflect far enough to physically push the trip bar and unlatch the contacts. Figure **5.12**

Figure **5.11**

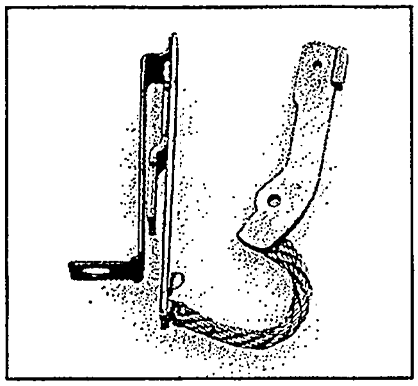
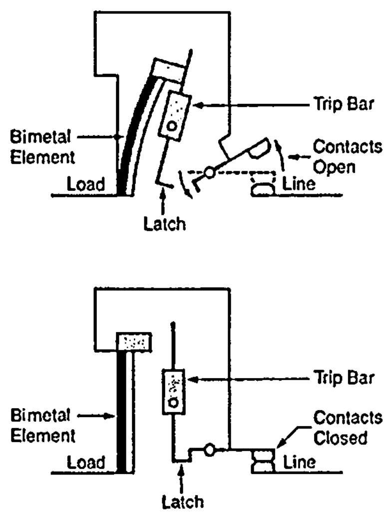


Figure **5.12** Thermal action.



Deflection is predictable as a function of current and time, as explained earlier in this section as shown in Figure **5.13**. This means, for example, that a typical 100A breaker might trip in 1800 seconds at 135% of rating (Point A) or ten seconds at 500% of rating (Point B). Consequently, bimetals provide a long time delay on light overloads, yet have a fast response on heavier overloads.

Thermal elements are calibrated at the factory and are not field adjustable for UL regulated applications. A specific thermal element must be supplied for each current rating. For example, a Series C̅ FD breaker is available from the factory with various thermal elements ranging from 15 to 150A. The thermal element cannot exceed 150A because an FD breaker is built on a 150A frame.

Where IEC standards apply to the application, the thermal element can be adjustable. IEC regulated versions of Series C̅ thermal magnetic circuit breakers with adjustable thermal settings have an adjustment button in the breaker cover. Turning the adjustment button changes the gap distance between the bimetal and trip bar. By varying the bimetal travel distance, the thermal rating is changed. Figure **5.14**

Figure **5.13** Typical time-current curve for 100A thermal element of a breaker.

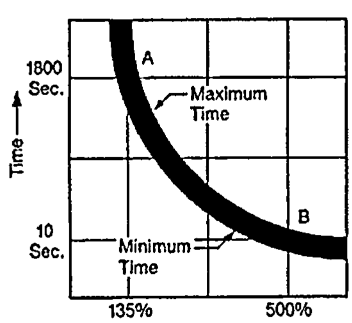


Figure **5.14** FW breaker with adjustable thermal settings.

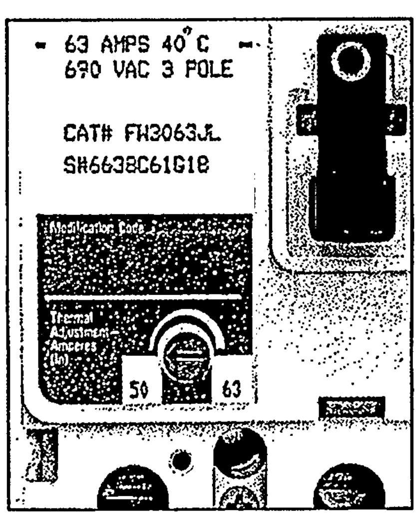
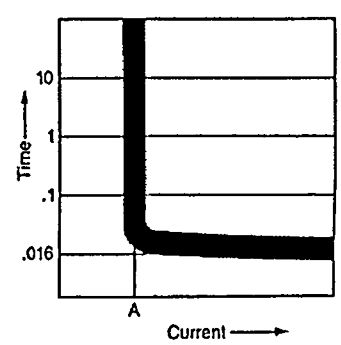


Figure **5.16** Typical time-current curve for fixed magnetic action.



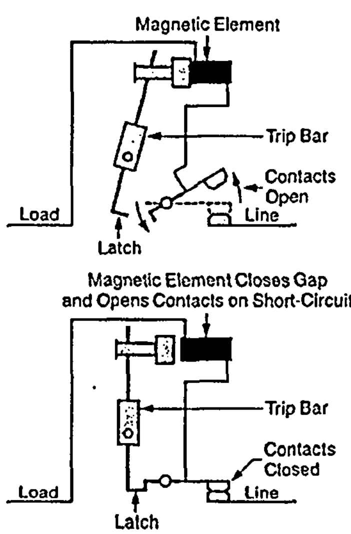
Magnetic (Instantaneous) Short-Circuit Protection

Magnetic trip action is achieved through the use of an electromagnet whose winding is in series with the load current. When a short-circuit occurs, the current passing through the circuit conductor causes the magnetic field strength of the electromagnet in the breaker to rapidly increase and attract the armature. As the armature is attracted to the electromagnet, the armature rotates the trip bar causing the circuit breaker to trip as diagramed in Figure **5.15**. The only delay factor is the time it takes the contacts to physically open and extinguish the arc. The action generally takes place in less than one cycle and trips the breaker instantaneously, without any intentional delay.
A typical magnetic time-current curve is illustrated in Figure **5.16** and indicates that the breaker will not trip until the current reaches or exceeds Point A. The opening speed of the contacts is dependent on the actual contact design, not just the operating mechanism itself. Certain Series $\overline{C}$ contact designs provide additional assistance to the opening cycle, resulting in improved arc extinguishing.

Magnetic elements can be either fixed or adjustable, depending upon the type of breaker and frame size. For example, most thermal magnetic breakers above the 150A frame size have adjustable magnetic trips.

With adjustable Series $\overline{C}$ models, the magnetic element of each pole of the trip unit can be adjusted by rotating adjustment buttons in the breaker cover, see Figure **5.17**. The buttons have several settings with values in multiples of the trip unit ampere rating. Spring tension on the magnet armature is changed when adjustments are made, resulting in different magnetic settings.

Figure **5.15** Magnetic action.



A similar curve for an adjustable magnetic element demonstrates how the adjustment buttons move the curve from left to right as the magnetic trip is increased, see Figure **5.18**. On the lowest setting, the breaker will not trip magnetically until the current reaches or exceeds Point A. As the magnetic setting is increased, the current trip point changes, as shown on the adjustable magnetic curve. The mechanism is continuously adjustable over the entire range, from the lowest setting to the highest setting.

Figure **5.17** Series $\overline{C}$ HJD breaker with adjustable magnetic settings.

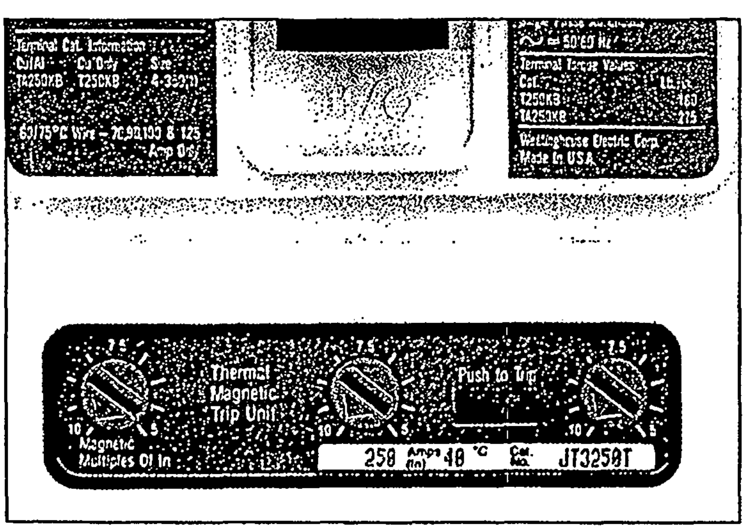
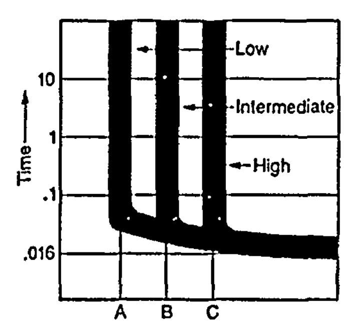


Figure **5.18** Typical time-current curve for adjustable magnetic action.



Electronic

Thermal Magnetic
(Overload and Short-Circuit Protection)

Thermal magnetic trip units combine the features of both the thermal and magnetic actions as illustrated in Figure **5.19**. For example, Points A and B on the illustrated trip curve show both the thermal and magnetic action for a typical 100A FD breaker as shown in Figure **5.20**. A 250% overload would take approximately 60 seconds before the bimetal would deflect far enough to trip the breaker. However, if instead of an overload there was a short-circuit that was 4000% (40 times) of the breaker rating, the electromagnet in the breaker would attract the armature and trip the breaker in less than one cycle.

A thermal magnetic trip unit is best suited to most general purpose applications because it is temperature sensitive and automatically tends to follow safe cable and equipment loadings which vary with ambient temperatures. Thermal magnetic trip units always act to protect the conductors, safeguarding equipment under high ambient conditions and permitting higher safe loadings under low ambient conditions. They do not trip if the overload is not dangerous, but will trip instantly due to heavy short-circuit currents.

Westinghouse introduced the first molded case circuit breaker with an internally mounted electronic trip unit in 1973, see Figure **5.21**. Since the introduction of the Seltronic line of molded case circuit breakers with electronic trips, circuit protection has experienced tremendous changes in this area. Today, precise curve shaping, integral ground fault protection, system monitoring, data gathering and information dissemination are rapidly becoming circuit breaker standards.

Molded case circuit breakers with conventional thermal magnetic trip units are increasingly being replaced by electronic trip units. This is especially true for the larger frame sizes. The result is increased accuracy, repeatability and discrimination. Another major advantage is the option of built-in ground fault protection. Previously, with thermal magnetic breakers, a separate ground fault relay was used to trip the breaker with a shunt trip.

In general, electronic trip systems are composed of three component items as shown in Figure **5.22**. First, a current transformer (sensor) in each phase to monitor and reduce the current to the proper level for input into a printed circuit board. Second, the printed circuit board can be viewed as the brains of the system, since it interprets input and makes a decision based on predetermined parameters. A decision to trip results in the circuit board initiating an output to the third component, a low power flux-transfer shunt trip which trips the breaker. An external source of tripping power is not required.

Electronic circuitry has been changing and improving rapidly. Earlier electronic trip units used analog circuitry, which is considered the conventional approach. An analog device looks at all the points on a particular curve and responds to peak values. The analog device remains a strong contributor to circuit protection. Figure **5.23**

As the demand for more sophisticated systems grew, so did the popularity of the microprocessor-based trip unit. The use of a microprocessor not only provides additional capabilities, it allows the trip system to perform a number of standard functions even better. A microprocessor (digital device) looks at selected discrete points on a particular curve and makes a summation of those discrete points which results in a root mean square (rms) value, in lieu of a peak value. The rms value is sometimes referred to as the effective value. The result is a more realistic overall view of a given set of circumstances. Figure **5.24**

Figure **5.19** Thermal magnetic action.

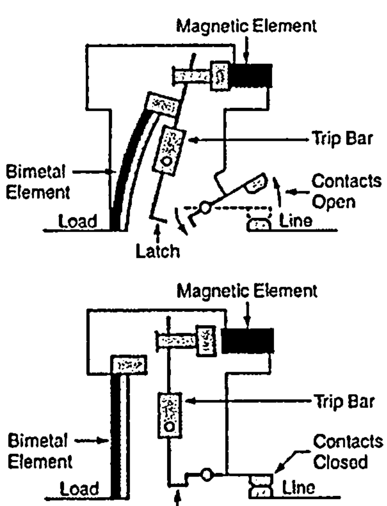


Figure **5.20** Typical trip curve for 100A thermal magnetic breaker.

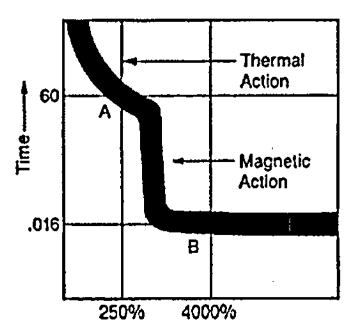
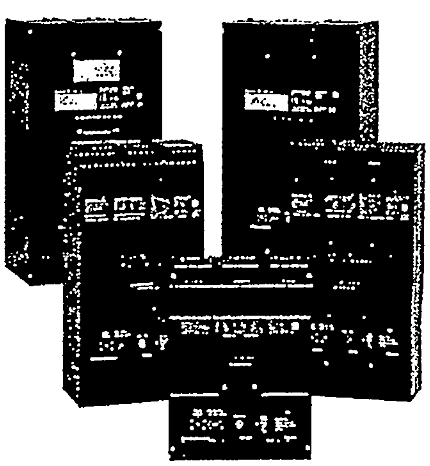


Figure **5.21**



Circuit breakers, because of tremendous advancements in trip technology, are no longer viewed as individual devices. A circuit breaker is expected to be a self-contained system performing many functions over and above its basic equipment protection duties.

Previously used for alternating current (AC) applications only, electronic trip devices now can be used for direct current (DC) applications also. Westinghouse developed a unique device to replace current transformers, because current transformers cannot be used with direct current. This development has opened the door for electronic trip unit applications in industries where DC power is of critical importance. The Uninterruptible Power Supply (UPS) industry is just one example. See Section 14 for additional UPS Industry and DC circuit breaker application information.

Detailed information concerning electronic trip units, how they function, their applications and future developments can be found in Section 7.

Figure 5.22

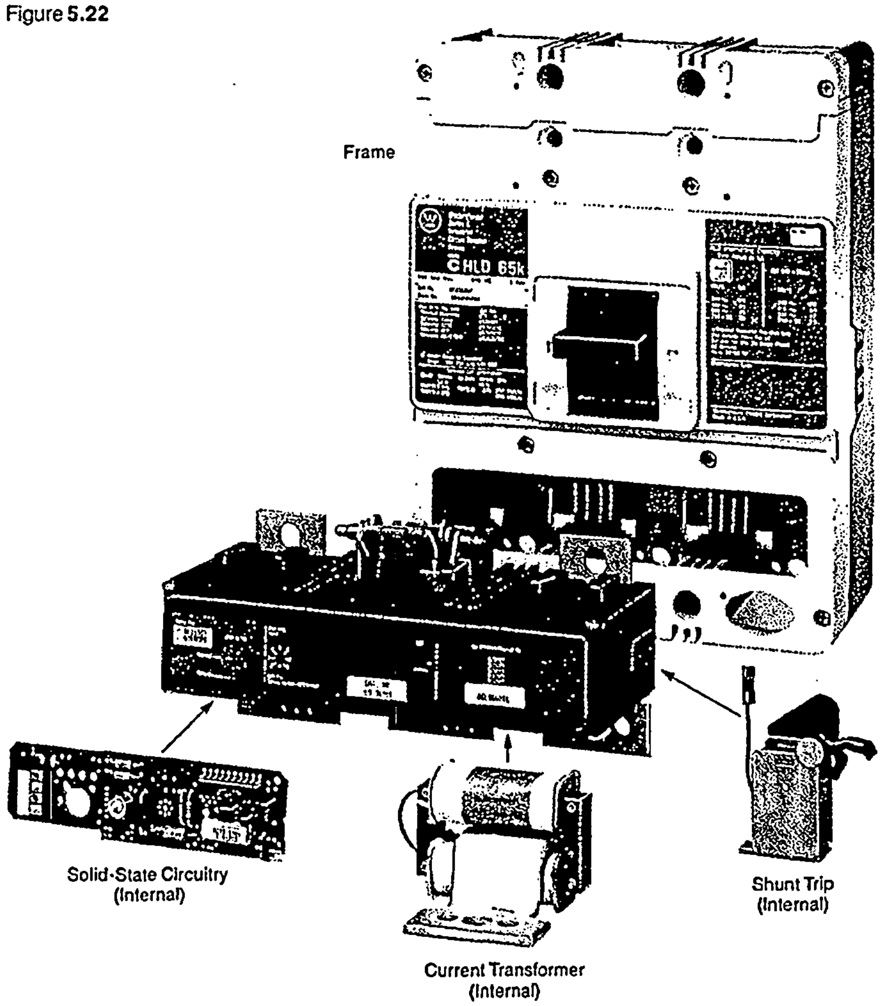


Figure 5.23

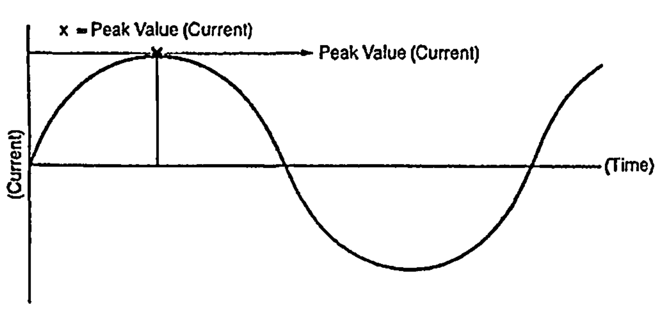
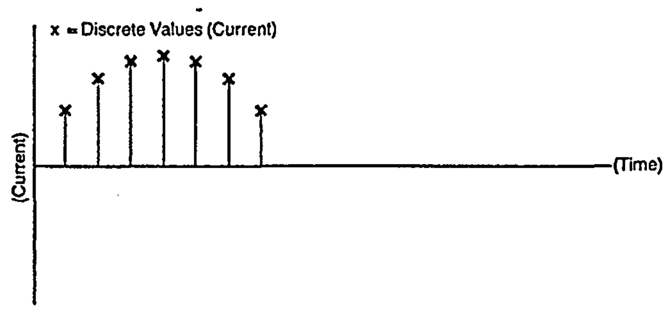


Figure 5.24



Trip Unit Options and Modifications

On standard thermal magnetic molded case circuit breakers, the selected trip unit determines in a somewhat narrow range, just how and when the breaker would act relative to a particular system condition. As discussed earlier in this section, the thermal element safely reacts to overload conditions and the magnetic element reacts to short-circuit conditions. If there was a need for ground fault protection, external devices were added. Any change in the specific parameters required changing of the trip unit or even the entire circuit breaker.

Electronic trip units greatly increase the flexibility of circuit breakers. This flexibility has also introduced the frequent use of terms and/or phrases normally associated with metal frame power circuit breakers. Although most are familiar and commonly used, they are briefly covered here as a reference aid for later sections of this publication.

Selectivity

The responses to a set of circuit or system conditions (usually in terms of current) within a specific time frame. In short, it is the ability to discriminate. The degree of selectivity is normally limited by the sophistication of the trip unit and the physical ability of the circuit breaker to withstand the thermal and mechanical stresses of a fault current.

Instantaneous Pickup

A preselected value of current where a trip action will take place immediately with no intentional time delay. This function is similar to the magnetic function of a thermal magnetic breaker.

Long Time Pickup and Delay

A preselected value of current that a breaker will carry continuously for a predetermined period of time. Once the pickup point is reached and the timing cycle begins, a trip action will not take place until the time delay has been achieved. This function is similar to the bimetal effect in a thermal magnetic breaker as it reacts to overload conditions.

Short Time Pickup and Delay

This function is similar in operation to long time pickup and delay, except current values are higher and time frames shorter. This function protects against low level short-circuits.

Ground Fault Pickup and Delay

The pickup function determines at what point a ground fault will be identified and the delay determines how long the trip action will be delayed after the fault has been identified.

Note: In the case of all pickups, the pickup value, which initiates the timing cycle, must be maintained throughout the timing cycle for tripping to occur. If conditions change and the pickup value is not maintained, the tripping system resets in anticipation of another timing cycle.

Special Calibrations and Applications

Certain operating conditions and ambient temperatures will affect the operation of trip units. In some situations, a derating factor is applied and in other instances it is necessary to recalibrate. Refer to Section 9 (Application and Selection) of this publication for details concerning special operating conditions.

Electronic trip units are temperature insensitive over a wide range of temperatures. Because of this advantage, electronic trip units have replaced the need for special breakers to operate in unusual ambient conditions.

An ambient compensated breaker is specially calibrated to properly function in a specific, other than standard, ambient temperature. These specially calibrated circuit breakers are still available from Westinghouse.

The terms and phrases contained in this Glossary are defined as used in the context of this publication, and are not intended to be all inclusive definitions. In many instances, you will be asked to refer to a specific page and section for a definition and/or discussion. Some terms and/or phrases are used, but not covered in detail in any specific section. In those cases, a definition or discussion is presented in the Glossary.

AC (Alternating Current)

Alternating current, normally represented as a sine wave, is the most commonly used type of electrical power. As its name suggests, alternating current flows in one direction and then changes, or alternates, and flows in the opposite direction (usually generator produced).

Alternating current flows from the negative terminal of the power source to the positive terminal. However, the polarity of the power source terminals change periodically, causing the direction of current flow to also change periodically.

The characteristics of alternating current make it less expensive to transmit over long distances than DC (direct current), without excessive power losses. This is the primary reason utility companies produce alternating current.

ANSI
American National Standards Institute

ANSI is an independent standards authorizing organization associated with a wide range of industries, equipment and processes, of which the electrical industry is part. For example, power circuit breakers and their enclosures are regulated by recognized standards published by ANSI. ANSI, as a standards authorizing organization, does not establish specific standards. It goes through a consensus process within a particular industry, and ultimately publishes recognized consensus standards established by all participants within the particular industry. See Section 4, page 8.

Accuracy

See Section 7, page 38.

Alarm Switch

See Section 6, page 26.

Altitude

See Section 9, page 79.

Ambient Compensated

Ambient compensated is normally used to describe an electromechanical circuit breaker whose trip element is calibrated and/or adjusted to perform as required in a specific ambient temperature condition.

Ambient Temperature

See Section 9, page 78.

Analog Device

See Section 5, page 20 and Section 7, page 45.

Arcing

Arcing is the discharge of electric current across a gap between two points. Arcing occurs between breaker contacts each time a breaker interrupts a current.

Arcing Contribution

See Section 10, page 85.

Asymmetrical Current

An asymmetrical current wave is not symmetrical about the zero axis. The axis of symmetry is offset from the zero axis, with the magnitude above and below the zero axis unequal. See Section 10, page 83.

Atmosphere

See Section 9, page 79.

Auxiliary Switch

See Section 6, page 25.

Bimetal

See Section 5, page 18.

Blow-Apart Force

See the Electromagnetics discussion in the Glossary and Section 12, page 108.

Bolted Fault (Bolted Short-Circuit)

The bolted fault is a short-circuit almost always of a very high magnitude. The principal effects of a high value short-circuit are heating and magnetic stresses, with both effects varying as the square of the current. See Section 5, page 16.

Branch Circuit

A branch circuit is comprised of the circuit conductors and components between the final overcurrent device protecting the circuit and the equipment, such as a motor. See Main and Feeders.

Bus

Bus is the conductor or conductors, usually made of copper or aluminum, which carries the current and serves as a common connection for two or more circuits.

CSA
Canadian Standards Association

See Section 4, page 10.

Calibrated

When a device, such as a circuit breaker trip unit, is adjusted or has its adjustments systematically standardized for a specific operating range, it is referred to as calibrated.

Characteristic Curve

See Time-Current Curve.

Charge

The process of storing energy in the closing springs of a breaker by either mechanical or electrical means.

Chip

A minute piece of a thin semiconducting material, such as silicon or germanium, processed to have specified electrical characteristics. See Section 7, page 44.

Circuit Breaker

See Section 4, page 8.

Circuit Protection

See Section 10, page 86.

Clearing Time

Fuse – The total elapsed time between the beginning of the specified overcurrent and the final interruption of the circuit at rated voltage. It is the sum of the melting time and the arcing time.

Mechanical Switching Device (Circuit Breaker) – The total elapsed time between the time the specified overcurrent causes a release device to be actuated and the instant of final arc extinction on all poles of the primary arcing contacts.

Conductor Protection

See Section 10, page 86.

Connecting Straps

See Section 6, page 28.

Contact

See Section 6, page 25 for those listed below:

- "a" Contact
- "b" Contact
- Normally Open Contact
- Normally Closed Contact

Continuity of Service

Continuity of service is the state, quality or ability to maintain continuous service. Examples are, maintaining electrical service without an outage or maintaining the operating condition of equipment without downtime.

Continuous Current

The continuous current rating of a circuit breaker is a maximum rating and specifies the maximum current the device is designed to carry on a continuous basis and remain within the applicable guidelines for that circuit breaker.

Continuous Rated

Continuous rated is the ability to perform a given function on a continuous basis, as opposed to intermittent rated. Switch contacts, for example, frequently have continuous and/or intermittent ratings.

Control Voltage

The voltage, frequently secondary with respect to a circuit breaker's operating rating, used to operate secondary devices and in secondary circuits. The voltage used to run a spring charging in a circuit breaker's tripping system or to operate space heaters in an enclosure are examples.

Current Limiter

See Section 6, page 31.

Current-Limiting

See Section 14, page 145.

Current Transformer

A current transformer steps current down to levels that can be used for a specific purpose. See Section 5, page 20 and Section 7, page 40.

Curve Shaping

See Section 7, pages 40 through 43.

DC (Direct Current)

Direct current is current that flows continuously in one direction through a closed circuit from a negative terminal to a positive (usually battery produced).

DE-ION Arc Extinguisher

See Section 5, page 15.

Deionize

The process of removing conducting ions, thus permitting arc extinction is deionization. See DE-ION Arc Extinguisher.

Digital Device

See Section 5, page 20 and Section 7, page 45.

Din Rail

See Section 14, page 135.

Distribution System

See Section 9, pages 74 and 75.

Downstream Device

In the context of a circuit, a device beyond a particular point in the circuit and farther away from the source is said to be downstream from that point. If the device is closer to the source, it is said to be upstream.

Dual Voltage Rating
See Section 9, page 77.

Dynamic Impedance
See Section 10, page 88.

Earth Leakage
See Section 6, page 32.

Electrical Operator
See Section 6, page 29.

Electromagnetics
See Electromagnetics discussion at the end of the Glossary.

Electromechanical Trip
See Section 5, pages 17 through 20 and Section 9, page 79.

Electronic Trip
See Section 5, pages 20 and 21, all of Section 7 and Section 9, page 79.

Encased Circuit Breaker
See Section 4, page 8.

Fault
See Section 10, page 83.

Fault Incidence Zones
See Section 10, page 84.

Fault Sources
See Section 10, page 84.

Feeders
Feeders are comprised of the circuit conductors and components between the main and branch overcurrent protective device. See Main and Branch Circuit.

Fixed Mounted Circuit Breaker
A fixed mounted circuit breaker is bolted into a fixed position with bus or cable mechanically bolted to breaker terminations.

Fixed Trip Unit
See Section 5, page 17.

Flux-Transfer Shunt Trip
See Section 5, page 20 and Section 7, page 46.

Frame
See Section 5, page 14.

Frame Rating
The frame rating of a circuit breaker is the maximum continuous current rating for a given frame size. See Frame.

Frequency
See Section 9, page 77.

Front Removable Circuit Breaker
A front removable circuit breaker is capable of being easily removed from a stationary frame, with the bus connection to the breaker termination by a manual compression fitting. See Section 6, page 27.

Fully Rated System
See Section 8, page 65.

Grounded
When an electrical circuit is provided with a connection that gives that circuit a direct, positive path to ground, the circuit is said to be grounded.

Ground Fault
See Section 5, page 17.

Ground Fault Pickup and Delay
See Section 5, page 22 and Section 7, page 42.

Handle Mechanism
See Section Section 6, page 29.

High Efficiency Motor
See Section 13, page 130.

High Shock
See Section 9, page 79.

IEC
International Electrotechnical Commission
See Section 4, page 11 and Section 11, page 98.

I^2t Response
I^2t is a measure of the heating effect or thermal energy of a fault current. See Section 5, page 16 and Section 7, pages 41 through 43.

Inductance
Inductance is a property of an electrical circuit that tends to oppose any change in the magnitude of current through the circuit due to the effect of CEMF. CEMF stands for counter electromotive force (back electromotive force) and is the result of the expanding and collapsing magnetic field around a conductor. In other words, the CEMF works counter to the normal voltage.

Instantaneous
See Section 5, page 19 and Instantaneous Pickup.

Instantaneous Pickup
See Section 5, page 22, Section 7, page 41 and Instantaneous.

Integrated Rating
See Series-Combination.

Intentional Delay
An intentional delay with respect to a circuit breaker's tripping action is a delay purposefully added or introduced to the tripping circuit, so as to delay the tripping function for a set time, once the circuit breaker is called upon to trip.

Interchangeable Trip Unit
See Section 5, page 17.

Interlock Device
See Section 6, page 30.

Intermittent Rated
See Continuous Rated.

Interphase Barrier
See Section 6, page 28.

Interrupting Capacity
See Interrupting Rating.

Interrupting Rating
The interrupting rating is the maximum short-circuit current that an overcurrent protective device can safely interrupt.

Inverse Time
See Section 5, page 18.

Ionized
See Deionize.

Keeper Nut
See Section 6, page 27.

Key Interlock
See Interlock Device.

LED
Light emitting diode.

Let-Through Current
Let-through current is the maximum instantaneous or peak current which passes through a protective device. See Section 14, page 146 and Section 10, page 88.

Line and Load Terminals
See Section 6, page 26.

Linear Current Flow
Linear current flow is essentially current flow in the same direction. See Section 5, page 15 and Section 12, page 106.

Load Center
A load center is an assembled piece of equipment housing circuit breakers and connections. It accepts an incoming power connection and controls the power division to branch circuits, while providing circuit protection.

Locked Rotor Current
The locked rotor current of a motor is the amount of current drawn by that motor at the very instant of start-up, when starting from full stop.

Long Time Pickup and Delay
See Section 5, page 22 and Section 7, page 40.

Low Level Fault
A low level fault can range in magnitude from just above acceptable full load current to 10 or more times normal current. This type of fault does not usually cause noticeable damage immediately, but, undetected, will eventually lead to damage and/or equipment problems.

Magnetic Field Strength
See Electromagnetics discussion at the end of the Glossary.

Magnetic Flux
See Electromagnetics discussion at the end of the Glossary.

Magnetic-Hydraulic
See Section 15, page 153.

Magnetic Only
See Motor Circuit Protector.

Magnetic Short-Circuit Protection
See Section 5, page 19.

Main
The main can refer to the circuit conductors and components which supply an electrical system between the main overcurrent device to the feeder overcurrent devices. Main can also refer to the main overcurrent device within the electrical system only. See Feeders and Branch Circuit.

Main Contact
See Section 5, page 15.

Manganin Shunt Element
See Section 14, page 137.

Microcomputer
See Section 7, page 45.

Microprocessor-based
See Digital Device.

Miniature Circuit Breaker
See Section 15, page 152.

Molded Case Circuit Breaker
See Section 4, page 8.

Molded Case Switch
See Section 14, page 150.

Monitor
See Current Transformer.

Motor Circuit Protector (MCP)
See Section 13, page 124.

Motor Control Center
A motor control center is a piece of equipment that centralizes motor starters, associated equipment, bus and wiring in one continuous enclosed assembly.

Movable Primary Contact
See Section 12, page 107.

Multiplexed
See Section 7, page 45.

NEC
National Electrical Code
The National Electrical Code is a set of electrical installation standards applicable throughout the United States and published by the National Fire Protection Association. The NEC works in conjunction with UL requirements and usually carry mandatory compliance.

NEMA
National Electrical Manufacturers Association

NEMA is an association of electrical manufacturers who establish manufacturing techniques and standards to meet the requirements of UL. These standards are intended to eliminate misunderstandings between manufacturers and purchasers, and assist purchasers in the selection process.

NEMA Enclosure

See Section 6, page 32.

Nuisance Tripping

A nuisance trip is an unintentional trip at below set pickup currents, usually the result of circuit conditions or equipment applications.

100% Rated

See Section 14, page 139 and Standard Rated.

Operating Mechanism

See Section 5, page 15.

Overcurrent

An overcurrent is a current that exceeds a continuous current rating and includes overloads, short-circuits and ground faults.

Overload

See Section 5, page 16.

Panelboard

A panelboard is a metal enclosed assembly designed for low voltage power distribution. It is available up to 600 volts maximum and utilizes bolt-on circuit breakers.

Peak Current (Peak Value)

Since alternating current varies continuously from 0 to maximum to 0, first in one direction and then in the other, it is not readily apparent what the true value really is. The current at the top of the wave (maximum point) is the peak current. See Section 5, page 20.

Pivoted Reverse Loop

See Section 12, page 107.

Plug-In Adapter

See Section 6, page 27.

Plug Nut

See Section 6, page 27.

Pole

See Section 9, page 78.

Power Circuit Breaker

See Section 4, Page 8.

Power Factor

See Section 10, page 82.

Power Generation

See Section 9, pages 74 and 75.

Power Transmission

See Section 9, pages 74 and 75.

Printed Circuit Board

See Section 7, page 44.

Push To Trip

See Section 5, page 15.

Quick-Make, Quick-Break

See Section 5, page 15.

Rating Plug

See Section 7, page 39 and Current Transformer.

Rear Connected Stud

See Section 6, page 27.

Recognized Component (UR)

See Section 4, page 10.

Repeatability

See Section 7, page 38.

Resistance

Resistance is anything that restricts current flow and is represented by the letter "R."

Reverse Feed

See Section 9, page 80.

Reverse Loop Contact

See Section 5, page 15 and Section 12, page 107.

Root Mean Square Current (rms)

Root mean square current is also referred to as effective current and is the square root of the average of all the instantaneous currents (current at any point on a sine wave) squared. See Section 5, page 20.

Selectively Coordinated System

See Section 8, page 65.

Selective Override Trip

This instantaneous trip function is set to pickup and trip at the level of the short time rating of the breaker, and is supplied on trip units without an adjustable instantaneous trip function.

Selectivity

See Section 5, page 22.

Sensor

See Current Transformer.

Series-Combination

See Section 8, page 64 and Section 12, page 111.

Series-Combination Rated System

See Section 8, pages 65 and 67.

Shock Out

Shock out is the unintentional mechanical trip of a circuit breaker. This phenomenon can be the result of a number of things and can happen when the breaker is sitting in the closed position, or even when a breaker is being manually operated with the operating handle.

Short-Circuit

See Section 5, page 16.

Short Time Pickup and Delay

See Section 5, page 22 and Section 7, page 41.

Short Time Withstand Rating

The short time withstand rating of a breaker is the maximum value of current the breaker is designed to let through and handle safely for a short period of time in the closed position, without the contacts welding or any other type of damage.

Shunt Trip

See Section 6, page 24.

Single Phasing

When one phase of a three phase system opens, primary and/or secondary single phasing occurs. Gone undetected or improperly protected, this situation can result in serious motor damage. When one phase opens, the current increases in the remaining phases are dramatic because of the unbalanced overcurrent condition.

Slash Voltage Rating

See Dual Voltage Rating.

Sliding Bar Interlock

See Interlock Device.

Slot Motor

See Section 14, pages 145 and 147.

Solenoid

A solenoid is a coil of insulated wire in which a magnetic field is established by a flow of current. Solenoids are often used in combination with a metal core that is free to move under the influence of the magnetic field.

Standard Rated

See Section 14, page 139 and 100% Rated.

Stationary Primary Contact

See Section 12, page 107.

Switchboard

A switchboard is a metal enclosed assembly used for low voltage power distribution up to 600 volts AC, utilizing a variety of circuit breakers, switches and associated equipment.

Symmetrical Current

A symmetrical current wave is symmetrical about the zero axis. This wave has equal magnitudes above and below the zero axis. See Section 10, page 83.

Terminal Cover

See Section 6, page 28.

Terminal End Cover

See Section 6, page 28.

Terminal Shield

See Section 6, page 28.

Thermal Magnetic Protection

See Section 5, page 20 and Section 9, page 78.

Thermal Overload Protection

See Section 5, pages 16, 18 and 22.

Thermistor

A thermistor is a resistor made of semiconductors having resistance that varies rapidly and predictably with temperature.

Time-Current Curve

See Section 5, page 16 and Section 7, page 38.

Transient Inrush

See Section 13, page 129.

Trip-Free

See Section 5, page 15.

Trip Unit

See Section 5, page 16.

Twisted Pair

A pair of shielded cables twisted together and used primarily for the purpose of carrying information is simply referred to as a twisted pair.

UL
Underwriters Laboratories, Inc.

See Section 4, page 10 and Section 11, page 92.

Undervoltage Release (UVR)

See Section 6, pages 24 and 25.

Ungrounded

See Grounded.

Uninterruptible Power Supply (UPS)

See Section 14, page 138.

Up-Over-Down Method

See Section 8, page 70 and Section 10, page 89.

Upstream Device

See Downstream Device.

Utilization Equipment

When power reaches its destination and is distributed to equipment for use, to run a motor for example, the motor is the utilization equipment.

Voltage Rating

See Section 9, page 77.

Walking Beam Interlock

See Interlock Device.

X/R Ratio

See Section 10, page 82.

Zone Selective Interlocking

See Section 7, page 43.

LTR-NRC-06-47
Attachment 2

Technical Data for AB DE-ION® Circuit Breakers

Page numbers included in Attachment 2 are as follows:
AB DE-ION® Circuit Breakers, Pages 1, 2, 3, 4
Molded Case Circuit Breakers Electrical Aftermarket Products and Services, Types EB and EHB
Molded Case Circuit Breakers Electrical Aftermarket Products and Services, Types FB and HFB
Molded Case Circuit Breakers Electrical Aftermarket Products and Services, Types EB, EHB, FB and HFB – Accessories and Modifications
AB DE-ION® Circuit Breakers – Application Data
AB DE-ION® Circuit Breakers – Dimension Sheet (2 pages)

Westinghouse Electric Company LLC
P.O. Box 355
Pittsburgh, PA 15230-0355

May, 1976
Supersedes AD 29-160, pages 1-16 dated January, 1971; pages 16.1-16.2 dated October, 1971; and pages 16.3-16.4 dated February, 1973.
Mailed to: E, D, C29-100A, 31-400A, 31-500A

Standard, SELTRONIC®, MARK 75®, and TRI-PAC® Designs

AB De-ION® Circuit Breakers

Index

Standard, SELTRONIC and MARK 75 Circuit Breakers

General Circuit Breaker Information

AB DE-ION molded case circuit breakers are designed to provide circuit protection for low voltage distribution systems. They are described by NEMA as, "..... a device for closing and interrupting a circuit between separable contacts under both normal and abnormal conditions," and further as,"...... a breaker assembled as an integral unit in a supporting and enclosing housing of insulating material". The N.E.C. describes them as, "A device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a predetermined overload of current, without injury to itself when properly applied within its rating."

So designed, AB DE-ION circuit breakers protect conductors against overloads and conductors and connected apparatus, such as motors and motor starters, against short circuits.

All Westinghouse molded case circuit breakers are built to meet the requirements of NEMA Standard AB-1-1975.

Circuit Breaker Components and Their Functions

Being essentially a high interrupting capacity switch with repetitive elements, AB DE-ION circuit breakers are comprised of three main functional components. These are: trip elements, operating mechanism and arc extinguishers.

Trip Elements

The function of the trip element is to trip the operating mechanism in the event of a prolonged overload or short circuit current. To accomplish this, a thermal-magnetic trip action is provided.

Standard Breakers

Thermal trip action is achieved through the use of a bimetal heated by the load current. On a sustained overload, the bimetal will deflect, causing the operating mechanism to trip. Because bimetals are responsive to the heat emitted by the current flow, they allow a long time delay on light overloads, yet they have a fast response on heavier overloads.

Magnetic trip action is achieved through the use of an electro magnet in series with the load current. This provides an instantaneous tripping action when the current reaches a predetermined value. Front adjustable magnetic trip elements are supplied as standard on 225 amp frame breaker and above (except CA & DA) and on the 100 and 150 amp magnetic only breakers, all other thermal magnetic breakers have non-adjustable magnetic trip elements.

SELTRONIC Breakers

Both the thermal type trip action and the magnetic trip of SELTRONIC breakers are achieved by the use of current transformers and solid state circuitry that monitors the current and initiates tripping through a flux transfer shunt trip when an overload or short circuit is present.

All multiple pole circuit breakers have trip elements in each pole and a common trip bar. An abnormal circuit condition in any one pole will cause all poles to open simultaneously.

Operating Mechanism

The function of the operating mechanism is to provide a means of opening and closing the breaker contacts. All mechanisms are of the quick-make, quick-break type and are "trip free." "Trip free" mechanisms are designed so that the contacts cannot be held closed against an abnormal circuit condition and are sometimes referred to as an "over center toggle mechanism". In addition to indicating whether the breaker is "on" or "off", the operating mechanism handle indicates when the breaker is "tripped" by moving to a position midway between the extremes. This distinct trip point is particularly advantageous where breakers are grouped, as in panelboard applications, because it clearly indicates the faulty circuit.

Arc Extinguishers

The function of the DE-ION arc extinguisher is to confine, divide and extinguish the arc drawn between opening breaker contacts. It consists of specially shaped steel grids isolated from each other and supported by an insulating housing. When the contacts are opened, the arc drawn induces a magnetic field in the grids, which in turn draws the arc from the contacts and into the grids. The arc is thus split into a series of smaller arcs and the heat generated is quickly dissipated through the metal. These two actions result in a rapid removal of ions from the arc, which hastens dielectric build-up between the contacts and results in rapid extinction of the arc.

Westinghouse Family of Molded Case Circuit Breakers

In secondary distribution systems, there ae many varied applications of molded case circuit breakers. To better cover this wide range of applications, Westinghouse offers a family of DE-ION circuit breakers within a given frame size.

This family of breakers includes:
Thermal Magnetic (Std. and SELTRONIC)
Magnetic Only (Std. and SELTRONIC)
Ambient Compensating
Saf-T-Vue®
MARK 75 (Std. and SELTRONIC)
TRI-PAC

Thermal Magnetic Circuit Breakers

Thermal magnetic breakers are general purpose devices suitable for the majority of breaker applications and are considered the industry standard. Combining thermal and magnetic trip actions, they provide accurate overload and short circuit protection for conductors and connected apparatus.

Magnetic-Only Circuit Breakers

Magnetic-only breakers are similar to standard thermal magnetic breakers except that they do not have thermal trip elements. They are equipped with front-adjustable magnetic trip elements and are used where only short circuit protection is required. Because the adjustment feature allows closer short circuit protection, these breakers are commonly preferred for motors and resistance welder circuits.

Ambient Compensating Circuit Breakers (Standard Breakers Only)

Ambient compensating breakers are similar to standard thermal magnetic breakers in that they are thermal magnetic and provide overload and short circuit protection. The difference is that ambient compensating breakers automatically compensate for variations in ambient temperature. This provides a near-constant current rating over a wide range of temperatures. In effect, this breaker minimizes the need for derating in higher ambients, and uprating in lower ambients.

Because these breakers will carry their rated current in higher ambients, circuit conductors must be sized accordingly. Generally, standard thermal magnetic breakers, which derate in about the same ratio as the average conductor ratings, are best suited for conductor protection.

Typical applications of ambient compensating breakers include:

1. Conductors not subjected to same temperature changes as the breaker.

   a. Wiring located inside of a building having temperature control, but the protecting breaker mounted outside for convenience.

   b. Wiring buried underground, but breaker exposed such as in some outdoor pump controller applications.

2. Where overload protection of wiring is not of prime importance.

3. In portable engine generator sets, where varied climates and temperatures are encountered and the generator is designed to the anticipated temperature extremes.

Because the above applications are in the minority, ambient compensating is not supplied as standard

SELTRONIC breakers are insensitive to temperature changes. However, they include circuitry to protect the components from abnormally high temperatures.

Saf-T-Vue® Circuit Breakers

Saf-T-Vue breakers are similar to standard molded case breakers except that they are equipped with a window of transparent thermoplastic over the breaker contacts. This allows you to see whether the contacts are open or closed. These breakers fulfill the needs of industrial plants where safety codes require visible contacts as an additional safety precaution for maintenance personnel. They can be supplied with thermal magnetic, magnetic-only or ambient compensating trip elements to cover a wide scope of applications. They are not available in MARK 75 or TRI-PAC breakers.

MARK 75 Circuit Breakers

MARK 75 breakers are similar to standard molded case breakers. They are, however, designed with increased interrupting capacities – up to 75,000 amperes asymmetrical at 240 volts Ac. The improved performance makes these breakers ideally suited for use in network systems and other applications where unusually high fault currents exist. Standard MARK 75 breakers are equipped with thermal magnetic trip actions. Magnetic-only and ambient compensating① trip elements are also available. MARK 75 molded cases are of a gray polyester material which easily distinguishes them from standard breakers, which are black.

TRI-PAC Circuit Breakers

TRI-PAC circuit breakers offer an even higher interrupting capacity than MARK 75 breakers. They are similar to standard thermal magnetic breakers except that they incorporate a current limiting device. This enables them to be used in secondary distirbution systems where fault currents up to 200,000 symmetrical rms, amperes are available. Thus, as their name implies, they are a triple package of protection – (1) time delay thermal trip for overload protection, (2) instantaneous magnetic trip for normal fault current protection, and (3) current limiting action for higher fault current protection – combined and coordinated in a single compact and economical device. Because they limit current, TRI-PAC breakers can be used to protect smaller AB breakers and other connected apparatus in addition to protecting feeder and branch circuits. More specific information on TRI-PAC breakers is contained elsewhere in this publication.

Characteristic Trip Curves (Except TRI-PAC)

Characteristic trip curves are found in Application Data 29-161 A WE A which is available on request.

The band curves shown for each breaker type represent current tripping limits for the breaker and are within limits established by the Underwriters' Laboratories. For a given current, at rated ambient, a breaker will clear the circuit automatically at some total time within the two extreme values defined by "maximum" and "minimum" curves. For example, a 1 pole, 15 ampere Quicklag would trip in not less than 10 seconds and in not more than 150 seconds on a 30 ampere current. Because of this allowed spread, users should not specify exact tripping times.

The upper left portions of these curves show the inverse time delay tripping of the breakers due to thermal action. The lower right segments of these curves portray the magnetic tripping action of the breakers. In the case of the front adjustable thermal-magnetic breakers, the magnetic tripping elements may be adjusted to trip at values within a specific current range. This adjustment is shown on their respective characteristic tripping curves. When these breakers leave the factory their magnetic trip elements are set at the high side of their tripping range. Adjustment downward may be made to fit the requirements of the installation. Currents equal to or greater than these magnetic settings will cause instant tripping. Curves shown are family curves and are suitable for most applications; for more accurate application, a detailed curve of the particular type and ampere rating of the breaker should be requested.

The total time taken by a breaker to clear a fault consists of the mechanical operating time plus the time of actual current interruption. Characteristic family curves show total clearing times. Magnetic only breakers have no time delay in tripping. The tripping characteristics of these breakers are similar to the right hand portion of the standard breakers, except with the vertical lines extended to the top of the curve.

Circuit Breaker Ratings

A circuit breaker is rated in rms amperes, (at a specific ambient) voltage, frequency (usually 60 hertz), and interrupting capacity (in rms symmetrical and assymmetrical amperes). AB De-ion circuit breakers listed in the 29-000 section of the Westinghouse catalog are rated

① Except for SELTRONIC breakers.

a maximum of 3000 amperes continuous and 600 volts Ac, 250 volts Dc. For a summary list of ratings, voltages and interrupting capacities, see selection chart on page 4.

Circuit breakers are not horsepower rated.
Unlike switches, circuit breakers are not horsepower rated because they are able to safely interrupt currents far in excess of the locked rotor value for any motor with which they may be applied. This ability is recognized in the N.E.C. as stated in paragraph 430-109, and is proven by the Underwriters' tests described in U/L Bulletin number 489, "Standard for Branch Circuit and Service Circuit Breakers".

For example, a breaker must pass the U/L overload test consisting of breaking a current 600% of its ampere ratings. As motor branch circuit breaker ratings are usually 125% to 250% of motor full-load currents, this test establishes the ability of the breaker to more than interrupt locked rotor currents. Following the overload test and others, the breaker is called upon to successfully clear its rated short circuit current which is a minimum of 5000 amperes. This also is many times higher than motor locked rotor current. Because by definition a circuit breaker is required to "open under abnormal conditions...without injury to itself", the breaker must still be in operating condition after the test.

Underwriters' Laboratories Test Requirements

Standard Tests

1. The tripping mechanism shall be enclosed to prevent tampering.

2. The mechanism shall trip free of the handle on overload.

3. All breakers shall be calibrated to carry their continuous rating in an ambient temperature of 40°C.①

4. 200% calibration check.

5. 135% calibration check.

6. Overload tests at 600% normal current at rated voltage.

   Up to 1600 Amperes: 50 operations
   2000, 2500 Amperes: 25 operations
   3000, 4000 Amperes: Three operations at 600% followed by 25 operations at 200%.

7. Temperature rise check at 100% rated load continuously without exceeding specified temperature limits.

8. Endurance test:

Ampere Rating	Operations Full Load	No Load	Per Minute
0 – 100	6000	4000	6
101 – 225	4000	4000	5
226 – 600	1000	5000	4
601 – 800	500	3000	1
801 – 2500	500	2000	1
2501 – 4000	400	1100	1

9. After endurance test, the breaker must again pass a calibration test at the 200% and 135% ratings.

10. It must next pass short circuit tests at its rated voltage at the value shown in the following chart.

Breaker Rating Volts	Amps	Test Circuit For Three Pole Breakers: Individual Poles Amps	Common Poles Amps	Total No. of Tests
250 & Below	100 & Below	4,330	5,000	7
Above 250	100 & Below	8,660	10,000	7
Any	101 – 800	8,660	10,000	7
Any	801 – 1200	12,120	14,000	7
Any	1201 – 1600	14,000	20,000	8
Any	1601 – 2000	14,000	25,000	8
Any	2001 – 2500	20,000	30,000	8
Any	2501 – 3000	25,000	35,000	8
Any	3001 – 4000	30,000	45,000	8

11. After the short circuit test, the breaker must again pass a calibration test at 200% of its rating.

12. Successful breakers passing all of the above tests must then pass a dielectric withstand for one minute without breakdown. The test consists of a 60 hertz potential of 1000 volts plus twice the rated voltage between line and load terminals with the breaker open and in the "tripped" position, between terminals of opposite polarity with the breaker closed and between live parts and the enclosure with the breaker open and closed.

13. A sample lot of breakers, as defined by U.L., INC., must pass the above sequence of tests without failure to achieve the initial standard U.L. listing. Once standard listing is achieved then higher interrupting ratings may be obtained by submitting sample lots of breakers to additional interrupting tests conducted for the particular rating desired. These additional tests will be conducted in accordance with the following sequence:

High Interrupting Capacity Tests

1. 200% Calibration Check.

2. Short circuit interruption. Two three-phase tests, one "open" followed by a "close-open" at the desired rating.

3. 250% Calibration check.

4. Finally, a dielectric withstand similiar to the one described above must be passed. The voltage for this test is twice rated but not less than 900 volts.

① Additional tests as an enclosed device required for listing as 100% application device.

AB DE-ION® Circuit Breaker Interrupting Ratings

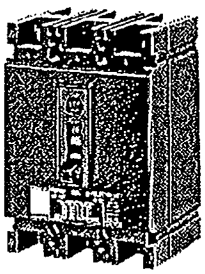
Circuit Breaker Ratings Type	Cont Amp. Rating	No. Poles	Volts Ac	Fed Spec. W-C-375a Class	U.L. Listed Interrupting Capacities—RMS Symmetrical Amps Ac Rating Volts 120/240	240	277	480	600	Dc Rating Volts(5) 125	250
Lighting Circuit Breakers											
QC, HQP, BAB	10-70	1	120/240	1a	10,000	......	......	......	......	......	......
	15-125	2	120/240	1a	10,000	......	......	......	......	......	......
HQC, HQNP, BA	15-50	2	240	1b	......	10,000	......	......	......	......	......
	15-100	3	240	1b	......	10,000	......	......	......	......	......
BA	15-30	1	277	2a	......	......	10,000	......	......	......	......
QHP, QHC, HBA	15-30	1-2	120/240	⑦	65,000	......	......	......	......	......	......
	15-20	3	240		......	65,000	......	......	......	......	......
QPGF, QBGF	15-30	1-2	120/240	⑦	10,000	......	......	......	......	......	......
QPHGF, QBHGF	15-30	1	120/240	⑦	22,000	......	......	......	......	......	......
QPH, QCH, QBH	15-70	1	120/240		22,000	......	......	......	......	......	......
	15-100	2	120/240	⑦	22,000	......	......	......	......	......	......
	15-100	3	240		......	22,000	......	......	......	......	......
CA	125-225	2-3	240	⑦	......	10,000	......	......	......	......	......
CAH	125-225	2-3	240		......	22,000	......	......	......	......	......
QA	250-400	2-3	240	⑦	......	22,000	......	......	......	......	10,000(4)
Industrial Circuit Breakers											
EB Standard	15-100	1	120	2b	10,000(1)	......	......	......	......	5,000	......
	15-100	2-3	240	2c	......	10,000	......	......	......	......	5,000(2)
EHB Standard	15-100	1	277	2a	......	......	14,000	......	......	10,000	......
	15-100	2	480	2d	......	18,000	......	14,000	......	......	10,000
	15-100	3	480	2d	......	18,000	......	14,000	......	......	......
FB(3) Standard	15-150	2	600	2d	......	18,000	......	14,000	14,000	......	10,000
	15-150	3	600	2d	......	18,000	......	14,000	14,000	......	......
JB-KB Standard	70-250	2	600	3b	......	25,000	......	22,000	22,000	......	10,000
	70-250	3	600	3b	......	25,000	......	22,000	22,000	......	......
LB-LBB Standard	70-400	2	600	4b	......	42,000	......	30,000	22,000	......	10,000
	70-400	3	600	4b	......	42,000	......	30,000	22,000	......	......
LA Standard	250-600	2	600	4b	......	42,000	......	30,000	22,000	......	10,000
	250-600	3	600	4b	......	42,000	......	30,000	22,000	......	......
LC Seltronic	75-600	2-3	600	4b	......	42,000	......	30,000	22,000	......	......
MC Seltronic	400-800	2-3	600	5a	......	42,000	......	30,000	22,000	......	......
NC Seltronic	600-1200	2-3	600	5a	......	42,000	......	30,000	22,000	......	......
PC Seltronic	1000-3000	2-3	600	⑦	......	125,000	......	100,000	100,000	......	......
PCC(6) Seltronic	1000-3000	2-3	600	⑦	......	125,000	......	100,000	100,000	......	......
High Interrupting Capacity Circuit Breakers											
HFB Mark 75	15-30	1	277	⑦	......	......	65,000	......	......	10,000	......
	40-100	1	277	⑦	......	......	25,000	......	......	10,000	......
	15-150	2	600	2f	......	65,000	......	25,000	18,000	......	10,000
	15-150	3	600	2f	......	65,000	......	25,000	18,000	......	......
HKB Mark 75	70-250	2	600	⑦	......	65,000	......	25,000	22,000	......	10,000
	70-250	3	600	⑦	......	65,000	......	25,000	22,000	......	......
HLB Mark 75	125-400	2	600	4c	......	65,000	......	35,000	25,000	......	10,000
	125-400	3	600	4c	......	65,000	......	35,000	25,000	......	......
HLA Mark 75	250-600	2	600	4c	......	65,000	......	35,000	25,000	......	10,000
	250-600	3	600	4c	......	65,000	......	35,000	25,000	......	......
HLC Mark 75	75-600	2-3	600	4c	......	65,000	......	35,000	25,000	......	......
HMC Mark 75	400-800	2	600	5b	......	65,000	......	50,000	25,000	......	......
	400-800	3	600	5b	......	65,000	......	50,000	25,000	......	......
HNC Mark 75	600-1200	2-3	600	5b	......	65,000	......	50,000	25,000	......	......
FB Tri-Pac	15-100	2-3	600	2e	......	200,000	......	200,000	200,000	......	⑧
LA Tri-Pac	70-400	2-3	600	3c/4a	......	200,000	......	200,000	200,000	......	⑧
NB Tri-Pac	300-800	2-3	600	6	......	200,000	......	200,000	200,000	......	......
PB Tri-Pac	600-1600	2-3	600	⑦	......	200,000	......	200,000	200,000	......	......

① 120 volt only.
② 125/250 Volts Dc only.
③ Available in 4 pole version.
④ 2 pole only.
⑤ Higher NEMA ratings available.
⑥ U.L. listed at 100% rating.
⑦ Not defined in W-C-375a.
⑧ 100,000 based on NEMA test procedure.

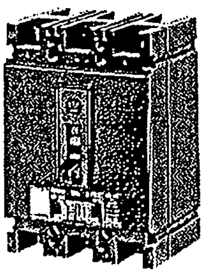
Molded Case Circuit Breakers
Electrical Aftermarket Products and Services

Types EB and EHB

Replacement Capabilities



EB: 120, 240 Vac; 125/250 Vdc



EHB: 277, 480 Vac; 250 Vdc

Table 3-12. Type EB 1-, 2-, 3-Poles; 240 Vac Maximum; Thermal Magnetic and Saf-T-Vue®

Shaded gray area denotes obsolete or discontinued products and services. [1]

Continuous Ampere Rating at 40°C	1-Pole, 120 Vac, 125 Vdc [2]	2-Pole, 240 Vac, 125/250 Vdc [2]	3-Pole, 240 Vac, 125/250 Vdc [2]	
	Standard	Standard	Standard	Saf-T-Vue [3]
	Catalog Number			
15	EB1015 [4]	EB2015	EB3015	EB3015S
20	EB1020 [4]	EB2020	EB3020	EB3020S
25	EB1025	EB2025	EB3025	EB3025S
30	EB1030	EB2030	EB3030	EB3030S
35	EB1035	EB2035	EB3035	EB3035S
40	EB1040	EB2040	EB3040	EB3040S
45	EB1045	EB2045	EB3045	EB3045S
50	EB1050	EB2050	EB3050	EB3050S
60	EB1060	EB2060	EB3060	EB3060S
70	EB1070	EB2070	EB3070	EB3070S
80	EB1080	EB2080	EB3080	EB3080S
90	EB1090	EB2090	EB3090	EB3090S
100	EB1100	EB2100	EB3100	EB3100S
	Approximate ship weight is 2 lbs.	Approximate ship weight is 3 lbs.	Approximate ship weight is 4-1/2 lbs.	

[1] These frames are obsolete. For replacement solutions see the cross-reference on Pages 3-97 – 3-118.
[2] dc ratings apply to substantially non-inductive circuits.
[3] Not UL listed.
[4] Switching duty rated for 120 Vac fluorescent light applications only.
Note: Includes Load Terminals Only.

Table 3-13. Type EHB 1-, 2-, 3-Poles; 480 Vac Maximum; Thermal Magnetic and Saf-T-Vue

Shaded gray area denotes obsolete or discontinued products and services. [5]

Continuous Ampere Rating at 40°C	1-Pole, 277 Vac, 125 Vdc [6]	2-Pole, 480 Vac, 250 Vdc [6]	3-Pole 480 Vac	
	Standard	Standard	Standard	Saf-T-Vue [7]
	Catalog Number			
15	EHB1015 [8]	EHB2015	EHB3015	EHB3015S
20	EHB1020 [8]	EHB2020	EHB3020	EHB3020S
25	EHB1025	EHB2025	EHB3025	EHB3025S
30	EHB1030	EHB2030	EHB3030	EHB3030S
35	EHB1035	EHB2035	EHB3035	EHB3035S
40	EHB1040	EHB2040	EHB3040	EHB3040S
45	EHB1045	EHB2045	EHB3045	EHB3045S
50	EHB1050	EHB2050	EHB3050	EHB3050S
60	EHB1060	EHB2060	EHB3060	EHB3060S
70	EHB1070	EHB2070	EHB3070	EHB3070S
80	EHB1080	EHB2080	EHB3080	EHB3080S
90	EHB1090	EHB2090	EHB3090	EHB3090S
100	EHB1100	EHB2100	EHB3100	EHB3100S
	Approximate ship weight is 2 lbs.	Approximate ship weight is 3 lbs.	Approximate ship weight is 4-1/2 lbs.	

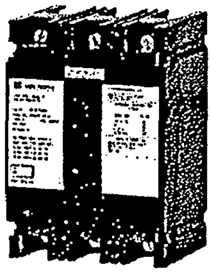
[5] These frames are obsolete. For replacement solutions see the cross-reference on Pages 3-97 – 3-118.
[6] dc ratings apply to substantially non-inductive circuits.
[7] Not UL listed.
[8] Switching duty rated for 277 Vac fluorescent light applications only.
Note: Includes Load Terminals Only.

Table 3-14. UL Listed Interrupting Ratings [9]

Maximum Volts	Amperes
EB Breakers	
120 and 240 ac	10,000 Asymmetrical, Symmetrical
125/250 dc	5,000 [10]
EHB, FB Breakers	
240 ac	20,000 Asymmetrical, 18,000 Symmetrical
277 ac (EHB)	15,000 Asymmetrical, 14,000 Symmetrical
480 ac	15,000 Asymmetrical, 14,000 Symmetrical
600 ac (FB)	15,000 Asymmetrical, 14,000 Symmetrical
250 dc	10,000 [10]

[9] Interrupting capacities shown do not apply to molded case switches.
[10] dc ratings apply to substantially non-inductive circuits.

Replacement Capabilities



FB, HFB: 600 Vac; 250 Vdc

Table 3-15. Type FB, HFB 1-, 2-, 3-, 4-Poles; 600 Vac Max.; Thermal Magnetic MARK 75® Saf-T-Vue
Shaded gray area denotes obsolete or discontinued products and services. ①

Continuous Ampere Rating at 40°C	1-Pole 277 Vac 125 Vdc ②	2-Pole 600 Vac 250 Vdc ②		3-Pole 600 Vac			4-Pole ③④ 600 Vac
	MARK 75 ⑤	Standard	MARK 75 ⑤	Standard	Saf-T-Vue ③	MARK 75 ⑦	Standard
	Catalog Number						
15	HFB1015 ⑧	FB2015	HFB2015	FB3015	FB3015S	HFB3015L	FB4015
20	HFB1020 ⑧	FB2020	HFB2020	FB3020	FB3020S	HFB3020L	FB4020
25	HFB1025	FB2025	HFB2025	FB3025	FB3025S	HFB3025L	FB4025
30	HFB1030	FB2030	HFB2030	FB3030	FB3030S	HFB3030L	FB4030
35	HFB1035	FB2035	HFB2035	FB3035	FB3035S	HFB3035L	FB4035
40	HFB1040	FB2040	HFB2040	FB3040	FB3040S	HFB3040L	FB4040
45	HFB1045	FB2045	HFB2045	FB3045	FB3045S	HFB3045L	FB4045
50	HFB1050	FB2050	HFB2050	FB3050	FB3050S	HFB3050L	FB4050
60	HFB1060	FB2060	HFB2060	FB3060	FB3060S	HFB3060L	FB4060
70	HFB1070	FB2070	HFB2070	FB3070	FB3070S	HFB3070L	FB4070
80	HFB1080	FB2080	HFB2080	FB3080	FB3080S	HFB3080L	FB4080
90	HFB1090	FB2090	HFB2090	FB3090	FB3090S	HFB3090L	FB4090
100	HFB1100	FB2100	HFB2100	FB3100	FB3100S	HFB3100L	FB4100
110	—	—	—	FB3110	FB3110S	HFB3110	—
125	—	—	—	FB3125	FB3125S	HFB3125	—
150	—	—	—	FB3150	FB3150S	HFB3150	—

① These frames are obsolete. For replacement solutions see the cross-reference on Pages 3-97 – 3-118.
② dc ratings apply to substantially non-inductive circuits.
③ Not UL listed
④ All four poles have thermal magnetic trip elements. Can be supplied with three protected poles and one unprotected, non-automatic pole if required. Order by description with no price or dimensional differences.
⑤ 15 – 30 A rated 75,000 AIC.
40 – 100 A rated 30,000 A asymmetrical,
25,000 A symmetrical.
⑥ 2-pole breakers are supplied in 3-pole frames with current carrying parts omitted from center pole.
⑦ *Includes line and load terminals. MARK 75 frame color changed from gray to black in mid-2002.*
⑧ Switching duty rated for 277 Vac fluorescent light applications only.

Table 3-16. UL Listed Interrupting Ratings ⑨

Maximum Volts	Amperes
MARK 75 Type HFB	
240 ac	75,000 Asymmetrical, 65,000 Symmetrical
277 ac ⑩	75,000 Asymmetrical, 65,000 Symmetrical
480 ac	30,000 Asymmetrical, 25,000 Symmetrical
600 ac	20,000 Asymmetrical, 18,000 Symmetrical
250 dc (2-Pole)	20,000 ⑪⑫

⑨ Interrupting capacities shown do not apply to molded case switches.
⑩ 15 – 30 A rated 75,000 AIC.
40 – 100 A rated 30,000 A asymmetrical,
25,000 A symmetrical.
⑪ dc ratings apply to substantially non-inductive circuits.
⑫ Ratings above 10,000 amperes not UL listed.

Table 3-17. Special Breakers Type FB, Magnetic Only, Front Adjustable
Shaded gray area denotes obsolete or discontinued products and services. ⑬

Continuous Ampere Rating	Magnetic Trip Range Amperes	2-Pole, 600 Vac		3-Pole, 600 Vac		
		Standard	MARK 75	Standard	Saf-T-Vue	MARK 75 ⑭
		Catalog/Style Number				
3	7 – 22	FB2022MRL	HFB2022ML	FB3022MRL	FB3022SMRL	HFB3022ML
5	15 – 45	FB2045MRL	HFB2045ML	FB3045MRL	FB3045SMRL	HFB3045ML
10	35 – 110	FB2110MRL	HFB2110ML	FB3110MRL	FB3110SMRL	HFB3110ML
25	32 – 80	2610D53G12	4994D96G12	2610D53G30	4998D89G30	2610D57G30
25	66 – 190	FB2190MRL	HFB2190ML	FB3190MRL	FB3190SMRL	HFB3190ML
30	50 – 150	1268C14G05	—	1268C14G06	—	—
30	90 – 270	FB2270MRL	HFB2270ML	FB3270MRL	FB3270SMRL	HFB3270ML
50	66 – 190	1268C14G01	—	1268C14G02	—	—
50	160 – 480	FB2480MRL	HFB2480ML	FB3480MRL	FB3480SMRL	HFB3480ML
70	100 – 270	2610D53G13	4994D96G13	2610D53G31	2610D58G31	4994D96G31
100	150 – 480	1268C14G03	—	1268C14G04	81E4647	65E4667
100	450 – 1550	FB21550MRL	HFB21550ML	FB31550MRL	FB31550SMRL	HFB31550ML

⑬ These frames are obsolete.
⑭ Includes line and load terminals. MARK 75 frame color changed from gray to black in mid-2002.

Replacement Capabilities (Continued)

Accessories and Modifications

Terminals

Breakers include load terminals only. Terminals are Underwriters Laboratories listed as suitable for wire type and size. When used with aluminum conductors, use joint compound. When line terminals are required, order by style number from the table at no charge with the breaker.

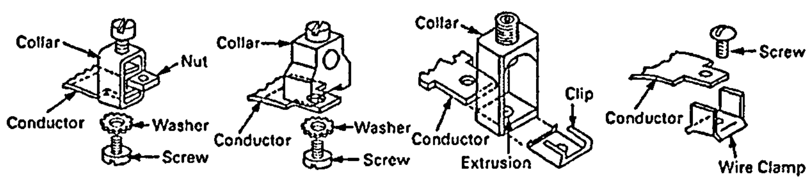
Note: Magnetic only breakers include both line and load terminals.

Note: Suffix "L" on catalog number indicates line and load terminals included. If factory installation is required, specify on order.

Table 3-18. Terminals

Maximum Amperes	Wire Type	Wire Range	Package of Three Line Terminals [1] Style Number
Standard Pressure Type Terminals			
20 (EB, EHB)	Al/Cu	#14 – #10	624B100G14
100	Al/Cu	#14 – 1/0	624B100G02
150	Al/Cu	# 4 – 4/0	624B100G17
Optional Al/Cu Pressure Terminals			
50	Al/Cu	#14 – #4	624B100G10
100	Al/Cu	# 4 – 4/0	624B100G17

[1] Style listed is for package of three terminals.



Style 624B100G02
Insert collar enclosing conductor as shown. Locate nut on top of conductor and tighten securely with screw and washer. Caution: Collar must surround conductor.

Style 624B100G10
Assemble collar on top of conductor as shown. Tighten securely with screw and washer.

Style 624B100G17
Insert collar enclosing conductor and center on extrusion on collar. Install clip with legs on top of conductor and snap end around bottom of collar.

Style 624B100G14
Assemble wire clamp to bottom of conductor as shown.

Figure 3-2. Terminals

Shaded gray area denotes obsolete or discontinued products and services.

LFB Current Limiter Attachment

The LFB Current Limiter is an attachment that bolts to the load end of a standard FB thermal magnetic or magnetic only breaker, providing 200,000 Amperes Interrupting Capacity (AIC) at up to 600 Vac. Limiters for thermal magnetic breakers are listed with Underwriters Laboratories. Current limiters must be applied as indicated in the table.

Standard LFB terminals are suitable for Cu/Al cable. Ratings through 70 amperes accept (1) #14 – #2, and 100 and 150 amperes accept (1) #1 – 4/0.

Note: Cannot be used with plug-in adapters.

Note: Ratings through 70 amperes can be supplied with terminals for Cu cable only (#14 – #2). Order by description.

Table 3-19. LFB Current Limiter Attachment
Shaded gray area denotes obsolete or discontinued products and services. [1]

Breaker Rating, Amperes	Limiter Catalog Number
For Thermal Magnetic Breakers [2]	
15 – 70	LFB3070R [3]
80 – 150	LFB3150R [4]
For Magnetic Only Breakers [5]	
3	LFB3003MR
5	LFB3005MR
10	LFB3010MR
25	LFB3025MR
30	LFB3030MR
50	LFB3050MR
70	LFB3070MR
100	LFB3100MR
150	LFB3150MR

[1] These frames are obsolete. For replacement solutions see the cross-reference on Pages 3-97 – 3-118.
[2] Ratings through 70 amperes can be supplied with terminals for Cu cable only (#14 – #2). Order by description.
[3] Superseded by LFD3070R.
[4] Superseded by LFD3150R.
[5] Replace with Series C HMCP and ELC current limiters or replace with MCP and EL current limiters.

Shaded gray area denotes obsolete or discontinued products and services.

Special Calibrations

Special calibration price additions apply to ampere ratings not listed as standard or for ambients other than 40°C or 50°C. For frequencies other than 0 – 60 Hz ac, refer to Eaton. See Application Data 29-160 for information regarding special conditions. Maximum calibration for 400 Hz is 135 amperes.

Note: Not UL listed.

50°C Calibration

Add suffix "V" to catalog number for complete breaker, listed above, when ordering breakers to be used in 50°C ambients.

Note: Not UL listed.

Ambient Compensating Breakers

To order, add suffix letter "A" to standard thermal magnetic breaker catalog number.

Available in all standard ratings of EB, EHB, FB and HFB breakers up to ratings of 100 amperes. Factory adder 20%.

Note: Not UL listed.

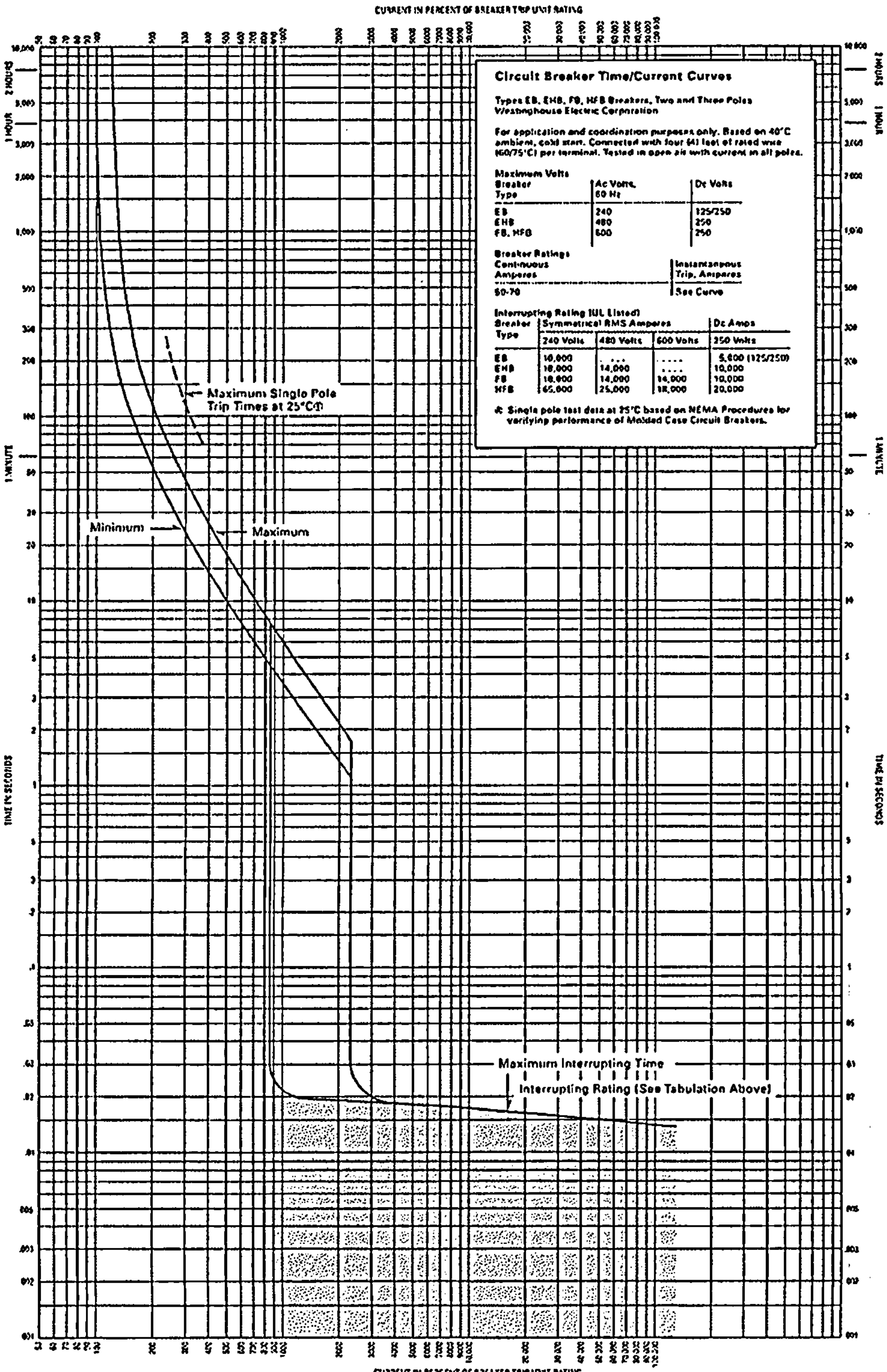
Federal Specification Classifications

EB, EHB, FB and HFB breakers meet requirements of Federal Specification W-C-375b as follows:

- EB: 1-pole, Class 11a; 2-, 3-poles, Classes 10b, 11b, 12b.
- EHB: 1-pole, Class 13a; 2-, 3-poles, Class 13b.
- FB: 2-, 3-poles, Class 18a;
- HFB: 1-pole, Class 13a; 2-, 3-poles, Class 22a.

AB DE-ION Circuit Breakers

Types EB, EHB, FB; MARK 75 Type HFB; 50-70 Amperes, 2, 3 Poles



Curve No. SC-3510-77

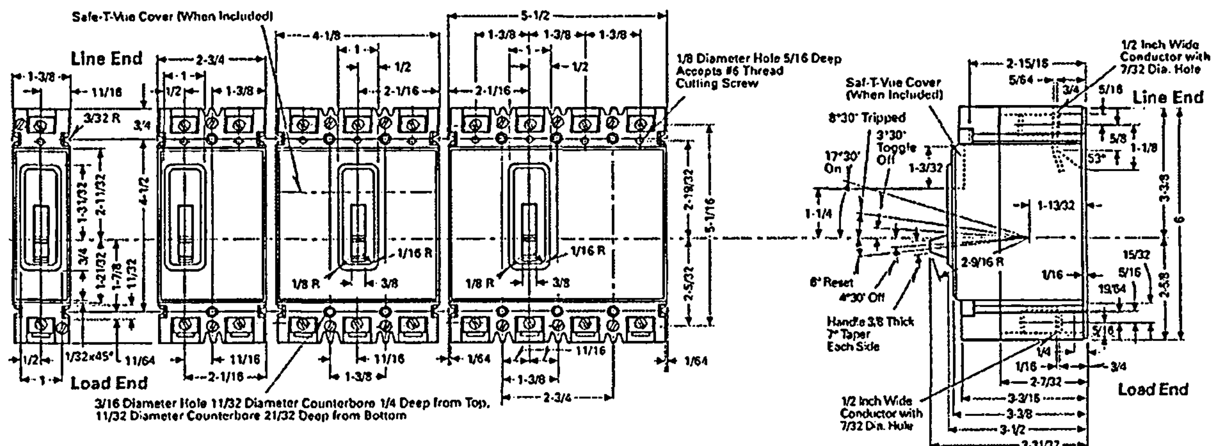
Dimension Sheet

Types EB, EHB, FB, MARK 75® HFB

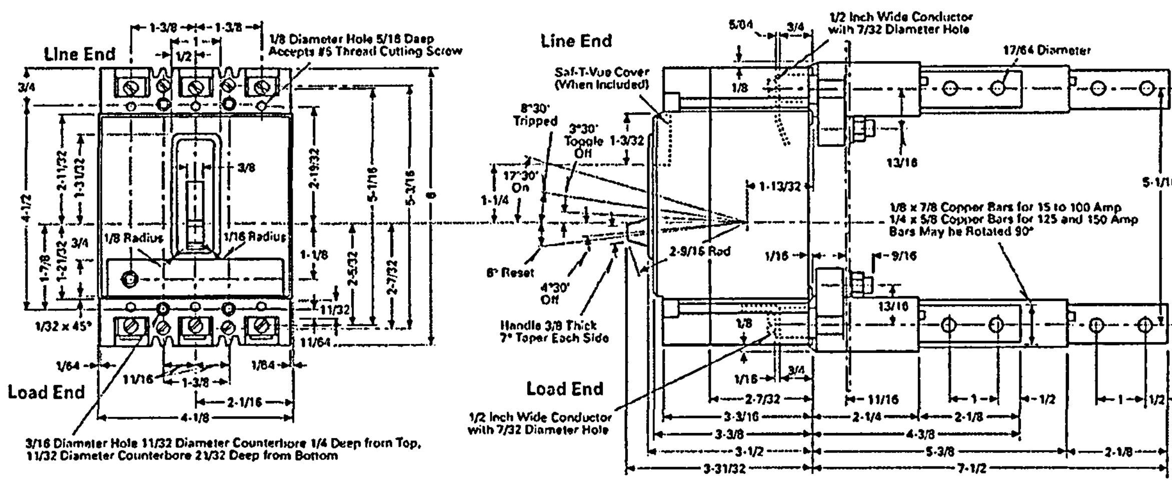
Outline Dimensions
Drilling Plans

AB DE-ION®
Circuit Breakers

Types EB, EHB, FB, MARK 75 HFB 1-, 2-, 3-, 4-Pole Thermal Magnetic Breakers (See Note Below)



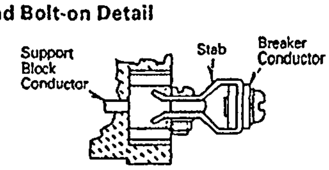
2- and 3-Pole FB and HFB Magnetic Only Breakers
Current carrying parts are omitted from center pole for 2-pole breakers.



Note: MARK 75 HFB Thermal Magnetic Breakers Two-pole breakers are furnished in three-pole frame with current carrying parts omitted from center pole.

Support Blocks for Line and Load Ends are not Supplied with Breaker and Must be Ordered Separately. Refer to Drawing 506C144 When Ordering Support Blocks. All Parts Necessary to Convert a Standard Breaker are Included.

Plug-in and Bolt-on Detail



Plug-in
Bolt stab to breaker conductor, then plug into support block.

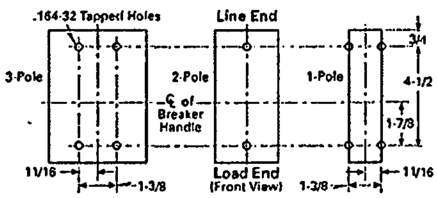
Bolt-on
Bolt stab to support block, then bolt support block assembly to breaker conductors.

Dimension Sheet

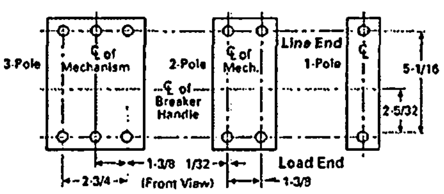
Drilling Plans for Types EB, EHB, FB, MARK 75 Type HFB Breaker

Drilling Plans 1-, 2- and 3-Pole
2-Pole MARK 75 and 2-Pole Magnetic Only Use 3-Pole Drilling

For Mounting Bolts

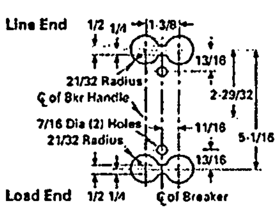


For Rear Connected Studs

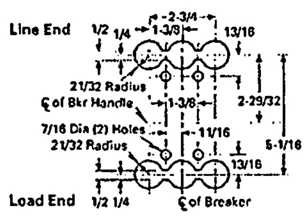


Plug-in Block

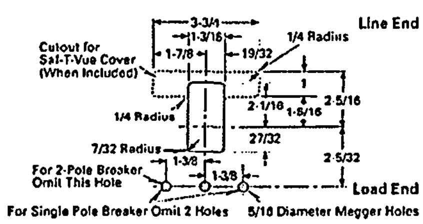
15 to 150 Amp 2-Pole Breakers (Thermal Magnetic)



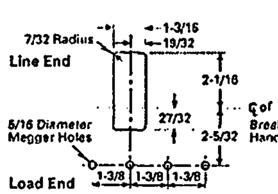
15 to 150 Amp 3-Pole Breakers, 2-Pole Magnetic Only and MARK 75 Breakers



Front Cover Cutout
1-, 2- and 3-Pole

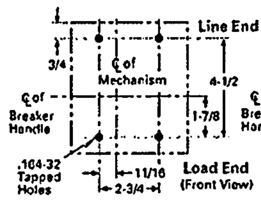


Front Cover Cutout
4-Pole

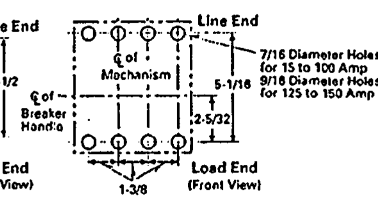


Drilling Plans 4-Pole

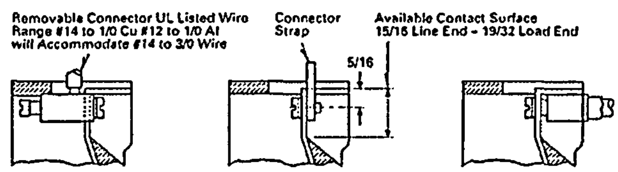
For Mounting Bolts



For Rear Connected Studs



Terminal Arrangements

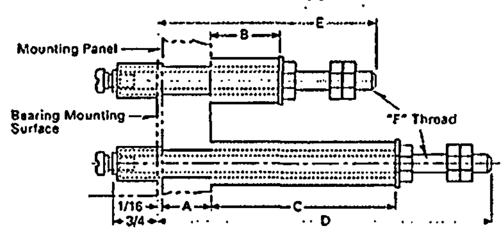


Wire Connection

Bus Connection

Stud Connection

Rear Connected Studs (Not Supplied With Breaker)



Stud Ampere Rating	Stud Style Number	Panel Thickness A	Tube Length B	Tube Length C	Tube Style Number	D	E	F
For 15 to 100 Amp Breakers								
100 A Short	451D874G01	1	1-1/16		32B9446H20			
100 A Short	451D874G01	11/16 to 15/16	1-3/8		32B9446H21			
100 A Short	451D874G01	3/8 to 5/8	1-11/16		32B9446H22	6-1/8	3-5/8	5/16 - 18
100 A Short	451D874G01	1/4 to 5/16	2		32B9446H23			
100 A Long	451D874G02	1		3-7/16	32B9446H24			
100 A Long	451D874G02	11/16 to 15/16		3-3/4	32B9446H25			
100 A Long	451D874G02	3/8 to 5/8		4-1/16	32B9446H26			
100 A Long	451D874G02	1/4 to 5/16		4-3/8	32B9446H27			
For 125 to 150 Amp Breakers								
150 A Short	374D883G01	1	1-1/16		374D883H06			
150 A Short	374D883G01	1/16 to 15/16	1-3/8		374D883H07			
150 A Short	374D883G01	3/8 to 5/8	1-11/16		374D883H08	7-1/2	4-1/4	7/16 - 14
150 A Short	374D883G01	1/4 to 5/16	2		374D883H09			
150 A Long	374D883G02	1		3-7/16	374D883H10			
150 A Long	374D883G02	11/16 to 15/16		3-3/4	374D883H11			
150 A Long	374D883G02	3/8 to 5/8		4-1/16	374D883H12			
150 A Long	374D883G02	1/4 to 5/16		4-3/8				

Ordering Instructions: Stud complete consists of one stud assembly and one tube as per chart. Order long and short studs and tubes as required to obtain proper bus spacing.