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NEMA Standards Publication AB 4-2000

Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications

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National Electrical Manufacturers Association
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Foreword

This NEMA Standards Publication supersedes and fully replaces NEMA Standards Publication AB 4-1996. To assure that a meaningful publication was being developed, draft copies were sent to a number of individuals and organizations in the public sector having an interest in or responsibility for the purchase, testing, application, use, and preventive maintenance of these products. Their resulting comments and suggestions provided a vital user and general interest input prior to final NEMA approval and resulted in a number of substantive changes in this publication. This publication will be periodically reviewed by the Molded Case Breaker Section of NEMA for any revisions necessary to keep it up to date with advancing technology. As future revisions are proposed, it is intended that the same or similar individuals or organizations will be offered a further opportunity to participate in the development of the publication. Proposed or recommended revisions should be submitted to:

Vice President, Engineering
National Electrical Manufacturers Association
1300 North 17th Street
Rosslyn, Virginia 22209

This Standards Publication was developed by the Molded Case Circuit Breaker Section of the National Electrical Manufacturers Association. Section approval of this standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Molded Case Circuit Breaker Section had the following members:

ABB Control, Inc.—Wichita Falls, TX
Eaton Corporation—Pittsburgh, PA
General Electric—Plainville, CT
Moeller Electric Corporation—Franklin, MA
Siemens Energy & Automation, Inc.—Alpharetta, GA
SPD Technologies—Trevose, PA
Square D Company—Palatine, IL
Thomas & Betts Corporation—Memphis, TN

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Section 1
GENERAL

1.1 SCOPE

NEMA Standards Publication AB 4-2000 sets forth, for use by qualified personnel[1], a number of basic procedures that may be used for the inspection and preventive maintenance of molded case circuit breakers used in industrial and commercial applications rated up to and including 1000 V 50/60 Hz ac or ac/dc. Note: consult the manufacturer for dc-only or 400 Hz circuit breakers.

The methods outlined in AB 4-2000 may be used to verify specific characteristics of a molded case circuit breaker which was originally built and tested in compliance with the requirements of NEMA Standards Publication AB 1-1999. These methods are intended for field application and are, therefore, non-destructive in nature. Accordingly, these methods cannot be used to verify all performance capabilities of a molded case circuit breaker since verification of some capabilities requires tests of a destructive nature.

Many tests, including those of a destructive nature, as defined in AB 1-1999, are performed on representative samples of circuit breakers by the manufacturer, as part of a routine program of factory inspection.

The AB 4-2000 Standards Publication is not intended, nor is it adequate, to verify proper electrical performance of a molded case circuit breaker which has been disassembled, modified, rebuilt, refurbished, or handled in any manner not intended or authorized by the original circuit breaker manufacturer.

1.2 REFERENCED STANDARDS

In this publication, reference is made to the standards listed below. Copies are available from the indicated sources:

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

NFPA 70-1999 *National Electrical Code®*

NFPA 70E-2000 *Standard for Electrical Safety Requirements for Employee Workplace*

[1] For purposes of these guidelines, a qualified person is one who is familiar with the installation, construction, and operation of the equipment and the hazards involved. In addition, the person is trained:
—and authorized to test, energize, clear, ground, tag, and lockout circuits and equipment in accordance with established safety practices.
—in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, and flash resistant clothing, in accordance with established safety practices.
—in first aid.

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AB 1-1999 *Molded Case Circuit Breakers and Molded Case Switches*

AB 3-1996 *Molded Case Circuit Breakers and their Application*

250-1997 *Enclosures for Electrical Equipment (1000 Volts Maximum*)

Guidelines for Handling Water Damaged Electrical Equipment

Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

UL 489 *Molded Case Circuit Breakers and Circuit Breaker Enclosures*
(9th Edition, 1996)

UL 1087 *Molded Case Switches*
(2nd Edition, 1993)

UL 1053 *Ground Fault Sensing and Relaying Equipment*
(6th Edition, 1999)

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Section 2
GUIDELINES

2.1 THE NATIONAL ELECTRICAL CODE

The *National Electrical Code* states that the purpose of overcurrent protection, as provided by a properly applied circuit breaker[2], is "to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation."

The *National Electrical Code* and NEMA AB define a circuit breaker as: "A device designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating."

2.2 A MOLDED CASE CIRCUIT BREAKER

A molded case circuit breaker is one that is assembled as an integral unit in a supportive and enclosing housing of insulating material. Molded case circuit breakers have factory-calibrated and sealed elements. Any unauthorized modification may render the breaker incapable of performing its intended functions and may also jeopardize the manufacturer's warranty. Circuit breakers which are known to have been subjected to water damage, e.g., by flooding or sprinkler discharge, should be replaced.

2.3 TO AVOID DAMAGED OR OTHERWISE INOPERABLE CIRCUIT BREAKERS BEING INADVERTENTLY RETURNED TO SERVICE

To avoid damaged or otherwise inoperable circuit breakers being inadvertently returned to service, it is suggested that such breakers be destroyed or returned to the manufacturer.

2.4 GUIDANCE REGARDING INSPECTION AND PREVENTIVE MAINTENANCE PROCEDURES

Industrial users have requested guidance regarding inspection and preventive maintenance procedures which could be carried out on a regularly scheduled basis. Sections 3 through 6 of this publication set forth guidelines for inspection, preventive maintenance, and testing. These sections may be applied independently or in combination to establish such a program. For additional assistance, consult the manufacturer's published instructions.

2.5 IF IT IS NECESSARY TO RETURN A CIRCUIT BREAKER TO THE MANUFACTURER

If it is necessary to return a circuit breaker to the manufacturer, proper packaging should be used to avoid shipping damage.

2.6 FOR INFORMATION REGARDING MOLDED CASE CIRCUIT BREAKER PERFORMANCE AND APPLICATION

For information regarding molded case circuit breaker performance and application refer to NEMA Standards Publications AB 1 and AB 3.

2.7 WATER DAMAGED MOLDED CASE CIRCUIT BREAKERS

Water damaged molded case circuit breakers should be discarded. For additional information refer to the NEMA document *Guidelines for Handling Water Damaged Electrical Products*.

[2] Throughout this publication, the terms "circuit breaker" and "breaker" refer to a "molded case circuit breaker."

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WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death.

Unless otherwise specified in this publication, inspection, preventive maintenance, and testing must always be performed on equipment which is de-energized. Verify that there is no voltage present on incoming line terminals (or on control power terminals, if present) and between these terminals and ground to positively ascertain that the equipment is totally de-energized. The disconnecting or isolating means on the line side of the devices being checked or tested should be locked in the OFF position to assure that the equipment will remain de-energized during these procedures.

Safety related work practices described in NFPA 70E, Part II, should be followed at all times.

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Section 3
INSPECTION PROCEDURES

3.1 GENERAL

The following inspection practices are recommended.

3.2 EXPOSED FACE TEMPERATURE CHECK

3.2.1 Purpose

To determine if there is excessive temperature on the insulated face (cover) of the circuit breaker.

CAUTION: Severe burns can result from high temperatures. Do not hold hand or fingers in contact with surfaces if excessive heat is felt. Read procedure and results section below, before touching surfaces.

3.2.2 Procedure

With the breaker enclosed as in normal use, carrying normal load current, and with the door (if any) giving access to the breaker operating handle open, check the exposed accessible insulated face of the breaker and the adjacent, surrounding, dead front surfaces of the enclosure for their approximate operating temperature. This may be done by making a light contact with hand or fingers for a few seconds. Please note that after initial energization, the breaker may not reach full temperature rise until it has carried its load for at least three hours.

As an alternative to finger contact with the breaker, a thermographic survey may be made to identify excessive temperature conditions at the surface.

3.2.3 Results

If the surface temperature does not permit maintaining a light contact with the hand for at least three seconds, it may be an indication of overheating and further investigation is necessary.

3.3 INSPECTION OF ENCLOSURE INTERIOR

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment before performing any of the following operations. Follow instructions under procedure (listed below) and the warning in Section 2.

3.3.1 Purpose

To evaluate the operating environment, the apparent condition of the breaker's molded case, that proper conductors have been used, and if there is any physical indication of overheating.

3.3.2 Procedure

Follow these instructions with care. They include appropriate corrective action as necessary.

3.3.2.1 Operate the breaker to the OFF position. Turn OFF all power to the breaker to electrically isolate it from all other circuits.

3.3.2.2 Open the enclosure. Verify that there is no voltage on the incoming conductors (including control power conductors, if present) and between these conductors and ground to positively ascertain that the equipment is deenergized. Follow practices described in NFPA 70E, Part II, to perform these steps.

3.3.2.3 Verify that the breaker has been properly applied within its marked ratings. If the breaker has not been applied within its ratings, it should be replaced with a breaker suitable for the application.

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3.3.2.4 Examine the circuit breaker surfaces for the presence of dust, dirt, soot, grease, or moisture. If such contamination is found, the surfaces should be cleaned. Refer to Section 4.2.2.3 for cleaning and precautionary instructions.

3.3.2.5 Examine the breaker's molded case for cracks. The integrity of the molded case is important in withstanding the stresses imposed during short circuit interruptions. Breakers should be replaced if cracks are found.

3.3.2.6 Verify that the conductors are of the correct size and type for the application. Visually check all electrical connections to the circuit breaker to be certain that such connections are clean and secure. Loose or contaminated connections increase electrical resistance which can damage insulation and conductors and interfere with proper circuit breaker operation. Increased electrical resistance causes overheating of a connection. Such overheating is indicated by discoloration of the breaker's molded case, discoloration or flaking of external metal parts, or melting or blistering of adjacent wire insulation. Pitting or melting of connection surfaces is a sign of arcing due to a loose, or otherwise poor connection.

a. If there is no evidence of looseness, e.g., overheating, do not disturb or tighten the connections.
b. If there is evidence of overheating or arcing, an investigation of the cause should be made and corrective steps taken. (See Section 4.)

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Section 4
PREVENTIVE MAINTENANCE

4.1 GENERAL

Under normal conditions, properly applied molded case circuit breakers require maintenance only for verification of environmental conditions of the installation and of the enclosure type used for the circumstances. However, when inspections determine an abnormal condition and indicate the possibility of damage, it may be necessary to perform certain maintenance steps. This section is intended to assist the user in performing these steps.

These steps cover the only maintenance that should be performed on molded case circuit breakers unless specifically authorized by the circuit breaker manufacturer.

4.2 ENVIRONMENTAL EVALUATION

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment before performing any of the following operations. Follow instructions under procedure (listed below) and the warning in Section 2.

4.2.1 Purpose

To examine the operating environment and the breaker's physical condition. Preventive maintenance and corrective actions are included as appropriate.

4.2.2 Procedure

Follow these instructions with care.

4.2.2.1 De-energize the breaker and electrically isolate it from all other circuits.

4.2.2.2 Open the enclosure. Verify that there is no voltage on the incoming conductors (including control power conductors, if present) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

The circuit breaker enclosure must be opened to perform the following steps and, in some cases, it will be necessary to remove the circuit breaker from the enclosure.

4.2.2.3 Examine the circuit breaker surfaces for dust, dirt, soot, grease or moisture. If grease or evidence of moisture is found, or more than a thin film of dust, dirt or soot is seen, the breaker should be cleaned as suggested below.

The insulating surfaces of the breaker should be cleaned using a lint free, dry cloth, brush or vacuum cleaner. Avoid blowing material into the circuit breaker or into surrounding equipment.

CAUTION: Commercial cleaners and lubricants may attack and damage the plastic insulating materials of the breaker. Therefore, such cleaners should not be used. Only the methods described in paragraph 4.2.2.3 should be used.

Steps should be taken to eliminate the source of the contamination or to provide an appropriate enclosure that will protect against the future entry of contaminants. With respect to the prevention of moisture, the circuit breaker should be housed in an enclosure appropriate for the environment.

4.2.2.4 Examine the breaker and terminations for signs of overheating as described in paragraph 3.3.2.6. If such evidence is found, the following maintenance steps should be performed.

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4.2.2.4.1 A plug-on type circuit breaker should be carefully removed and examined. If the plug-on jaws of the circuit breaker are pitted, discolored, or melted on the surfaces that mate with the connecting bus bars, the circuit breakers should be replaced. No attempt should be made to dress the mating surfaces or bend the circuit breaker plug-on jaws.

If the connecting bus bars show signs of pitting or melting, they should also be replaced. If non-replaceable, the entire assembly should be replaced.

NOTE–Plug-on jaws should be examined for the presence of a connector compound. If present, this compound should not be removed unless it is contaminated. Before plugging the circuit breaker back on to the panelboard bus bars, apply a small amount of new compound to the jaws. Use only the compound recommended by the circuit breaker manufacturer.

4.2.2.4.2 Copper circuit breaker terminals and connecting straps (wire connectors and bus bars) can normally be cleaned. They should be carefully disassembled, cleaned and dressed using fine aluminum oxide paper. All metal and abrasive particles should be removed before reassembling.

NOTE–When performing this procedure, extreme care should be exercised to prevent any damage to plated connections or mechanical disturbance to the circuit breaker and to prevent any particles from entering the breaker.

If the damage is extensive, or can not be corrected by dressing the surfaces, the damaged parts should be replaced if they are intended by the manufacturer to be replaceable. If the damaged parts are not intended to be replaceable, the complete breaker and/or bus connections should be replaced.

4.2.2.4.3 Aluminum circuit breaker terminals and connecting straps (wire connectors and bus bars) must be replaced and can not be cleaned or repaired.

4.2.2.4.4 If wire conductors are damaged, the damaged lengths of the conductors should be removed. Before reinstalling the conductors see paragraph 4.4.

4.3 INTERCHANGEABLE TRIP UNITS[3]

4.3.1 If the circuit breaker has an interchangeable trip unit, remove the circuit breaker cover and visually check the connections of the trip unit to the circuit breaker frame for evidence of overheating. (See 3.3.2.6).

4.3.2 If there is no evidence of overheating or looseness, do not disturb or tighten the connections.

4.3.3 If there is evidence of looseness, overheating, or arcing at any of the trip unit connections, remove the trip unit and visually inspect the connecting surfaces.

4.3.3.1 If the connecting surfaces show evidence of overheating, the circuit breaker frame and trip unit should be replaced.

4.3.3.2 If the threaded inserts in the circuit breaker base are stripped or cross-threaded, the circuit breaker frame should be replaced.

4.3.3.3 If there is no evidence of pitting or melting on the connecting surfaces and the threaded inserts appear to be in good condition, reinstall the trip unit in accordance with the manufacturer's instructions.

4.4 WIRE CONNECTORS

4.4.1 If conductors are removed from the wiring connectors, the following steps should be performed:

[3]The nameplate or label of the circuit breaker should identify the device as a circuit breaker "frame" if the circuit breaker has an interchangeable trip unit.

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4.4.1.1 Examine wire connectors. If the wire connectors appear to be in good condition, they may be reused. If the connectors, screws, or their plating, appear worn or damaged, or there is evidence of cross threading or binding, the connector assembly should be replaced.

4.4.1.2 If the wire conductors are damaged, the damaged length of the conductors should be removed.

4.4.1.3 Appropriate joint compound must be used with aluminum conductors if specified by the circuit breaker manufacturer.

4.4.1.4 All wire connectors should be torqued in accordance with the nameplate marking or the circuit breaker manufacturer's instructions.

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Section 5
TEST PROCEDURES

5.1 GENERAL

Some industrial users have indicated that they are required to conduct operational tests of their circuit breakers. The AB 4 Standards Publication is not intended, nor is it adequate, to verify proper electrical performance of a molded case circuit breaker which has been disassembled, modified, rebuilt, refurbished, or handled in any manner not intended or authorized by the original circuit breaker manufacturer. The following non-destructive tests may be used to verify specific operational characteristics of molded case breakers: Mechanical operation test, insulation resistance test, individual pole resistance test (millivolt drop test), inverse time overcurrent trip test, instantaneous overcurrent trip test, and rated hold-in test.

5.2 MECHANICAL OPERATION TESTS

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying this equipment before performing any of the following operations. Follow instructions under procedure (listed below) and the warning in Section 2.

5.2.1 Purpose

To verify that the circuit breaker mechanism is operating freely.

5.2.2 Procedure

5.2.2.1 The power supplying the circuit breaker must be turned off so that the circuit breaker is not being caused to interrupt its load current while these tests are being conducted. The circuit breaker need not be removed from the equipment for these tests but it must be electrically isolated. Utilize practices described in NFPA 70E, Part II, to perform these steps.

NOTE–If the circuit breaker is equipped with an under-voltage trip release, energize the trip release to allow proper operation of the circuit breaker. (See 6.3 for proper procedure.)

5.2.2.2 The breaker handle should operate smoothly without binding.

5.2.2.3 Using an ohmmeter or other indicating device, verify that all circuit breaker contacts are open when the handle is in the OFF position and closed when the handle is in the ON position.

5.2.2.4 For breakers that are provided with mechanical trip provisions (generally indicated by a test button) operate the tripping means according to the manufacturer's instructions. With the breaker in the tripped position, verify that the contacts are open using an ohmmeter (or other indicating device). Reset the breaker according to the manufacturer's instructions and operate the breaker to the ON and OFF positions. Use an ohmmeter (or other indicating device) to verify that all the contacts are closing and opening respectively.

5.2.3 Results

The breaker should be replaced if:

a. The contacts are not open with the breaker in the tripped or OFF position
b. The contacts are not closed with the breaker in the ON position
c. The breaker does not reset
d. The mechanical trip provisions (if provided) do not trip the breaker

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5.3 INSULATION RESISTANCE TEST

NOTE–The circuit breaker should be removed from the equipment for this test. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment before removing the breaker and before performing any of the following operations. Follow instructions under procedure (listed below) and the warning in Section 2.

5.3.1 Purpose

To determine the adequacy of the insulation between line and load terminals, between poles, and between each pole and ground.

5.3.2 Equipment

This test requires an insulation resistance tester capable of applying a direct-current voltage of at least 500 volts. It should be also noted that more accurate information can be obtained when 1000 volt testers are used since they are more likely to detect deteriorated insulation systems.

5.3.3 Procedure

5.3.3.1 Operate the breaker to the OFF position. Turn OFF all power to the breaker to electrically isolate it from all other circuits.

5.3.3.2 Open the enclosure. Verify that there is no voltage on the incoming conductors (and on control power conductors, if present) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

5.3.3.3 Remove the breaker from the enclosure. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

WARNING: High voltages involved in this test could cause serious injury or death. Do not touch or permit anyone else to touch the breaker or the test leads when voltage is applied. Strict adherence to the safety procedures recommended by the manufacturer of the insulation resistance test equipment is required.

CAUTION: If applied incorrectly, the voltages utilized in the insulation resistance test may damage electronic or other accessory components. To avoid such damage, the following procedure should be adhered to closely. Do not apply test voltages to accessory terminals.

5.3.4 Test

NOTE–If the circuit breaker is equipped with an under-voltage trip release, energize the trip release to allow proper operation of the circuit breaker. (See 6.3 for proper procedure.)

5.3.4.1 Conduct this test with the circuit breaker mounted to simulate its installation in actual use. All exposed metal parts except line, load, and accessory terminals should be electrically connected to a metal baseplate.

5.3.4.2 Using an insulation resistance tester, apply a direct-current voltage of at least 500 volts to determine the resistance. Voltage is to be applied:

5.3.4.2.1 Between line and load terminals of each individual pole with the circuit breaker in the OFF position.

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5.3.4.2.2 Between terminals of adjacent poles with the circuit breaker in the ON position.

5.3.4.2.3 From line terminals to the metal baseplate with the circuit breaker in the ON position.

5.3.5 Results

All resistance readings should be one megohm or greater for each measurement. If any reading is less than one megohm, the circuit breaker should be replaced or the manufacturer should be consulted before restoring the circuit breaker to service. Any reading less than one megohm may indicate contaminated, flawed, or cracked insulating material.

5.3.6 Reinstall Breaker

If applicable, reinstall the circuit breaker following manufacturer's instructions. Also refer to Section 4.4 for information on reinstalling wire connectors or conductors

5.4 INDIVIDUAL POLE RESISTANCE TEST (MILLIVOLT DROP)

NOTE–The circuit breaker should be removed from the equipment for this test. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment before removing the breaker and before performing any of the following operations. follow instructions under procedure (listed below) and the warning in Section 2.

5.4.1 Purpose

To assess the electrical integrity of connections and contacts in a circuit breaker. This can be done by conducting a millivolt drop test across the line and load terminals of each pole with the circuit breaker contacts closed.

The millivolt drop of a circuit breaker pole can vary significantly due to inherent variability in the extremely low resistance of the electrical contacts and connectors. Such variations do not necessarily predict unacceptable performance and should not be used as the sole criteria for determination of acceptability. (See 5.4.5.)

5.4.2 Equipment

5.4.2.1 This test should be conducted using a 24 volt, or less, direct current power supply capable of supplying the rated current of the circuit breaker. For circuit breakers rated higher than 500 amperes, the power supply should be capable of delivering no less than 500 amperes.

5.4.3 Procedure

5.4.3.1 Operate the breaker to the OFF position. Turn OFF all power to the breaker to electrically isolate it from all other circuits.

5.4.3.2 Open the enclosure. Verify that there is no voltage on the incoming conductors (and on control power conductors, if present) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

5.4.3.3 Remove the breaker from the enclosure.

In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

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5.4.4 Test

NOTE–If the circuit breaker is equipped with an under-voltage trip release, energize the trip release to allow proper operation of the circuit breaker. (See 6.3.)

5.4.4.1 The test is performed as follows:

5.4.4.1.1 Apply test current across a pole equal to the breaker rating (or 500 Amperes minimum for breakers rated in excess of 500 Amperes). Record the millivolt drop and the test current. Do not maintain current for more than 1 minute.

5.4.4.1.2 De-energize the test circuit. Manually operate the breaker to the OFF and then ON positions.

5.4.4.1.3 Repeat steps 5.4.4.1.1 and 5.4.4.1.2 for a total of three readings on the pole being tested.

5.4.4.1.4 Repeat steps 5.4.4.1.1 through 5.4.4.1.3 for each of the remaining poles of the circuit breaker.

5.4.5 Results

The data will vary according to the breaker frame type, ampere rating and manufacturer. The manufacturer should be consulted to determine the acceptable level for the breaker under test. If the average test values on any pole of the breaker exceed the manufacturer's data, a potential overheating condition may be indicated and additional tests may be required. For additional guidance, consult the manufacturer.

5.4.6 Reinstall Breaker

If applicable, reinstall the circuit breaker following manufacturer's instructions. Also refer to Section 4.4 for information on reinstalling wire connectors or conductors.

5.5 INVERSE-TIME OVERCURRENT TRIP TEST

NOTE–The circuit breaker should be removed from the equipment for this test. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment before removing the breaker and before performing any of the following operations. Follow the instructions under procedure (listed below) and the warning in Section 2.

5.5.1 Purpose

To verify the operation of the inverse-time overcurrent tripping function of a circuit breaker. This test is not applicable to instantaneous only breakers or molded case switches.

5.5.2 Equipment

The circuit diagram using low voltage equipment shown in Figure 5-1 is suggested for testing circuit breakers having ratings up to 100 amperes. The circuit breakers (CB1 and CB2) have current and voltage ratings to match the ratings of the input test transformers (T1 and T2) with time-current tripping characteristics to sustain the longest test period anticipated. With the test transformers (T1 and T2) coordinated, current pulses up to 400% of the transformer ratings of not more than ten seconds, with a three-minute cooling period between pulses, should not thermally overburden the transformers.
For circuit breakers rated above 100 amperes or when greater accuracy is required, the use of custom built test equipment or the services of the manufacturer or other qualified testing organization should be considered.

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Circuit breakers with electronic trip units are often equipped with integral test provisions for verifying the functional operation of the trip unit. Where integral test provisions are not included, separate test devices are frequently available from the circuit breaker manufacturer. When using either of these alternate test means, the instructions of the manufacturer must be followed.

5.5.3 Procedure

5.5.3.1 Operate the breaker to the OFF position. Turn OFF all power to the breaker to electrically isolate it from all other circuits.

5.5.3.2 Verify that there is no voltage on the incoming conductors (and on control power conductors, if present) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

5.5.3.3 Remove the breaker from the enclosure. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

5.5.4 Test

NOTE–If the circuit breaker is equipped with an under-voltage trip release, energize the trip release to allow proper operation of the circuit breaker. (See 6.3 for proper procedure.)

NOTE–These tests should be conducted on individual circuit breaker poles using a test current of 300% of the circuit breaker's rated current. This test current has been chosen because it is relatively easy to attain and the wattage per pole is low enough that the transfer of heat into the adjacent poles is minor and does not appreciably affect the test results.

Conduct the test on each pole of the circuit breaker by connecting the line and load terminals of that pole to the test equipment by copper conductors not less than 4 feet (1.2m) in length sized in accordance with Table 5-1.

NOTE–Circuit breakers equipped with electronic trip units typically are provided with more than one long-time trip curve. The Tests in this section should be performed with the circuit breaker set at the longest time setting.

NOTE–Circuit breakers equipped with electronic trip units incorporating ground fault protection should be tested with two poles in series to avoid an early trip via the ground fault trip circuit.

NOTE–Plug-on or draw-out circuit breakers will require specialized connections or test fixtures.

A circuit breaker rated 1600 amperes or more may be tested with copper bus bars per Table 5-2 instead of cable. A circuit breaker rated more than 4000 amperes should be tested with copper bus bars unless it is marked for cable connections only.

Tests should be conducted with the circuit breaker at a room ambient of approximately 25°C (77°F).

5.5.4.1 Connect one pole (or two poles for electronic trip circuit breakers equipped with ground fault protection) as indicated above.

5.5.4.2 With the test circuit breaker closed, energize the test circuit and quickly adjust the transformer to the required 300% test current.

5.5.4.3 With the test current at the correct value, start timing.

5.5.4.4 Record trip time.

5.5.4.5 Repeat steps 5.5.4.1 through 5.5.4.4 on each of the other individual poles. (Where ground fault protection [GFP] is supplied, repeat steps 5.5.4.1 through 5.5.4.4 using two additional combinations of poles.) Tests on adjacent poles shall be made at no less than five minute intervals. For circuit breakers with thermal trip elements, wait at least 20 minutes before repeating tests on the same pole. For circuit

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breakers with electronic rms trip elements, consult the manufacturer's published instructions for required intervals between tests.

If the intervals are shortened, subsequent tests may result in premature tripping. If more accurate results are required, the between-test intervals should be extended to permit the temperature of the circuit breaker to return to that of the surrounding ambient air.

For information regarding testing of an electronic trip circuit breaker's ground fault trip element, consult the manufacturer's published instructions.

5.5.5 Results

The circuit breaker should trip within the maximum times shown in Table 5-3. Circuit breakers that do not trip within these maximum time limits should be withheld from further service.

NOTE–Variations in test equipment, test conditions or procedures can affect results. For any additional test information, consult the circuit breaker manufacturer.

NOTE–If there is concern that the trip time is too low, then the hold-in test should be conducted (see 5.7).

5.5.6 Reinstall Breaker

If applicable, reinstall the circuit breaker following manufacturer's instructions. Also refer to Section 4.4 for information on reinstalling wire connectors or conductors.

The following or similar equipment may be employed:

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A	Ammeter (rms)
T1	Adjustable Auto Transformer, 45 Amperes
T2	Test Transformer
CB1	Main Circuit Breaker, 50 Amperes
CB2	Control Circuit Breaker, 30 Amperes
TIMER	with Suitable Timing Ranges (not shown)

Figure 5-1
TYPICAL SCHEMATIC ARRANGEMENT FOR TESTING MOLDED CASE CIRCUIT BREAKERS RATED 100 AMPERES OR LESS

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Table 5-1
COPPER TEST CONDUCTOR SELECTION

BREAKER RATING (AMPERES*)	NUMBER OF PARALLELED CONDUCTORS	SIZE	
		75°C RATING	60°C RATING**
15 or less	—	14 AWG	14 AWG
20	—	12 AWG	12
25	—	10 AWG	10
30	—	10 AWG	10
40	—	8 AWG	8
50	—	8 AWG	6
60	—	6 AWG	4
70	—	4 AWG	4
80	—	4 AWG	3
90	—	3 AWG	2
100	—	3 AWG	1
110	—	2 AWG	1
125	—	1 AWG	1/0
150	—	1/0 AWG	—
175	—	2/0 AWG	—
200	—	3/0 AWG	—
225	—	4/0 AWG	—
250	—	250 kcmil	—
275	—	300 kcmil	—
300	—	350 kcmil	—
325	—	400 kcmil	—
350	—	500 kcmil	—
400	2	3/0 AWG	—
450	2	4/0 AWG	—
500	2	250 kcmil	—
550	2	300 kcmil	—
600	2	350 kcmil	—
700	2	500 kcmil	—
800	3	300 kcmil	—
1000	3	400 kcmil	—
1200	4	350 kcmil, or	—
	3	600 kcmil	—
1400	—	1/0 AWG	—
1600	5	400 kcmil, or	—
	4	600 kcmil	—
2000	6	400 kcmil, or	—
	5	600 kcmil	—
2500	8	400 kcmil, or	—
	7	500 kcmil, or	—
	6	600 kcmil	—
3000	9	400 kcmil, or	—
	8	500 kcmil, or	—
	7	600 kcmil	—
4000	12	400 kcmil, or	—
	11	500 kcmil, or	—
	10	600 kcmil	—

* For circuit breaker ratings other than shown, the next higher rating is to be used, e.g., if rated 35A, use 40 ampere value.
** Use this column for circuit breakers marked “For use only with 60°C wire insulation” or for unmarked breakers rated through 125 amperes.

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Table 5-2
SIZE OF COPPER BUSBAR CONNECTIONS

Circuit Breaker Frame Size In Amperes	Number of Busbars*	Size in Inches	Size in Millimeters
1600	2	1/4 x 3	6.4 x 76.2
2000	2	1/4 x 4	6.4 x 102
2500	2 or	1/4 x 5	6.4 x 127
	4	1/4 x 2-1/2	6.4 x 63.5
3000	4	1/4 x 4	6.4 x 102
4000	4	1/4 x 5	6.4 x 127
5000	6	1/4 x 5	6.4 x 127
6000	6	1/4 x 6	6.4 x 152

* Spacing between multiple busbars should be 1/4 inch (6.4 mm), with no intentional greater spacing, except as necessary at the individual terminals of the circuit breaker.

Table 5-3
VALUES FOR INVERSE TIME TRIP TEST
(At 300% of Rated Continuous Current of Circuit Breaker)

Range of Rated Continuous Current Amperes	Maximum Trip Time in Seconds For Each Maximum Frame Rating*	
	≤250V	251–600V
0–30	50	70
31–50	80	100
51–100	140	160
101–150	200	250
151–225	230	275
226–400	300	350
401–600	—	450
601–800	—	500
801–1000	—	600
1001–1200	—	700
1201–1600	—	775
1601–2000	—	800
2001–2500	—	850
2501–5000	—	900
6000	—	1000

* For integrally-fused circuit breakers, trip times may be substantially longer if tested with the fuses replaced by solid links (shorting bars).

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5.6 INSTANTANEOUS OVERCURRENT TRIP TEST

NOTE–The circuit breaker should be removed from equipment for this test. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment before removing the breaker and before performing any of the following operations. Follow the instructions under procedure (listed below) and the warning in Section 2.

5.6.1 Purpose

To verify the operation of the instantaneous trip functions under field test conditions. Accordingly, the tolerances given in Table 5-4 are necessarily broader than the manufacturer's factory tolerances.

5.6.2 Equipment

The same equipment as utilized in Section 5.5. is required with the following exceptions:

a. For the run-up method of testing a pointer-stop ammeter is recommended.
b. For the pulse method of testing, a calibrated image-retaining oscilloscope, or a high speed sampling rate digital ammeter (capable of accurately measuring a half-cycle pulse) is required instead of an ammeter.

5.6.3 Procedure

5.6.3.1 Operate the breaker to the OFF position. Turn OFF all power to the breaker to electrically isolate it from all other circuits.

5.6.3.2 Verify that there is no voltage on the incoming conductors (and on control power conductors, if present) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

5.6.3.3 Remove the breaker from the enclosure. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

5.6.4 Test

NOTE–If the circuit breaker is equipped with an under-voltage trip release, energize the trip release to allow proper operation of the circuit breaker. (See 6.3 for proper procedures.)

Since the instantaneous trip characteristics of the circuit breaker can be influenced by stray magnetic fields, the test setup must be made in such a way that the fields caused by the test equipment itself, by steel enclosures, mounting plates, or by the conductors to the circuit breaker, do not affect the test results. Results can also be influenced by the wave shape of the current and, therefore, it is desirable to have sinusoidal output from the supply equipment. Manufacturers may be consulted for individual recommendations on mounting and wire routing if desired.

The two methods which may be used for testing the instantaneous trip function are the "run-up" and the "pulse" methods.

NOTE–Circuit breakers with electronic trip units are often equipped with integral test provisions to verify the functional operation of the trip unit. Where integral test provisions are not included, separate test devices are frequently available from the circuit breaker manufacturer. When using either of these alternate test means, follow the instructions of the manufacturer.

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5.6.4.1 Run-Up Method

5.6.4.1.1 Connect one pole of the test breaker to the test equipment as indicated in Section 5.5, adjust the trip setting to the desired position, and operate the breaker to the ON position.

5.6.4.1.2 Set the current control to a point where approximately 60% of the marked trip setting will flow when the circuit is energized

5.6.4.1.3 Turn the power ON and increase the current until the circuit breaker trips. The recommended time for increasing the current is between two and five seconds. If the circuit breaker does not open within five seconds, the supply circuit should be turned OFF to prevent damage to the test equipment

This method requires operator skill in recognizing the relationships between actual current and the meter indication. If the current is increased too slowly, tripping may be caused by the time delay element, especially if more than one test is run. If the current is increased too rapidly, an erroneous current reading may be obtained because the meter lags behind the actual current value due to meter damping. This problem can be overcome and the accuracy of this method may be improved by the use of a calibrated oscilloscope to read the current level at the time the breaker trips.

5.6.4.2 Pulse Method

This method is more accurate than the run-up method, if done properly. However, it is subject to an error introduced by a distortion of the pulse current, commonly called offset or asymmetrical waveform, as depicted in Figure 5-2. This current offset can be minimized by controlling the closing of the circuit such that the circuit is closed at approximately the 90° point on the supply circuit voltage waveform.

The pulse method involves the following steps:

5.6.4.2.1 Connect one pole of the test breaker to the test equipment as indicated in Section 5.5, adjust the trip setting to the desired position, and operate the breaker to the ON position.

5.6.4.2.2 Apply a pulse of current, approximately 5 to 10 cycles in duration, and at a level approximately 5% below the lower tolerance limit specified in Table 5-4 for the breaker setting. The breaker should not trip.

5.6.4.2.3 Apply a pulse of current, approximately 5 to 10 cycles in duration and at a level equivalent to the high tolerance limit specified in Table 5-4. The breaker should trip.

Table 5-4
INSTANTANEOUS TRIP TOLERANCES FOR
FIELD TESTING OF CIRCUIT BREAKERS

		Tolerances of Manufacturers' Published Trip Range	
Breaker Type	**Tolerances of Settings**	**High Side**	**Low Side**
Adjustable[1]	+40% -30%	—	—
Non-adjustable[2]	—	+25%	-25%

[1] Tolerances are based on variations from the nominal settings.

[2] Tolerances are based on variations from the manufacturer's published trip band (i.e., -25% below the low side of the band; +25% above the high side of the band).

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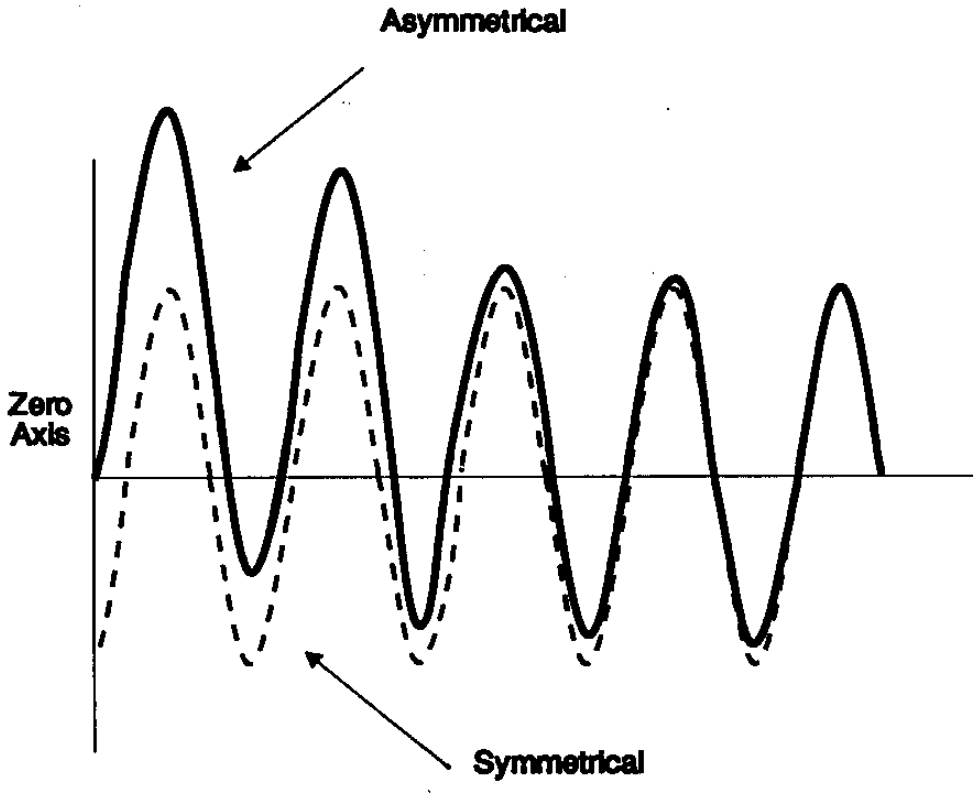


Figure 5-2
CURRENT WAVE SHAPES

5.6.5 Results

Test results should be in accordance with the values shown in Table 5-4.

If the results differ significantly from those values, reexamine the test circuit and circuit breaker mounting arrangements. (See 5.6.2.) If there are no apparent problems with the test circuit or mounting arrangements, consult the circuit breaker manufacturer.

5.6.6 Reinstall Breaker

If applicable, reinstall the circuit breaker following manufacturer's instructions. Also refer to Section 4.4 for information on reinstalling wire connectors or conductors.

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5.7 RATED HOLD-IN TEST

NOTE–The circuit breaker should be removed from the equipment for this test. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment before removing the breaker and before performing any of the following operations. Follow instructions under procedure (listed below) and the warning in Section 2.

5.7.1 Purpose

To verify the capability of a molded case circuit breaker to carry its rated current. It should be performed if the circuit breaker has been tripping under normal load conditions. (See 3.3.2.3).

5.7.2 Procedure

5.7.2.1 Operate the breaker to the OFF position. Turn OFF all power to the breaker to electrically isolate it from all other circuits.

5.7.2.2 Open the enclosure and verify that there is no voltage on the incoming conductors (and on control power conductors, if present) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

5.7.2.3 Remove the breaker from the enclosure. In cases where the circuit breaker can be safely isolated as installed, the test may be performed with the circuit breaker in its equipment.

5.7.3 Equipment

A low voltage power supply such as that described in Section 5.5.2 is required to conduct this test.

5.7.4 Test

NOTE–If the circuit breaker is equipped with an under-voltage trip release, energize the trip release to allow proper operation of the circuit breaker. (See 6.3 for proper procedures.)

5.7.4.1 The circuit breaker should be tested with the operating mechanism set to the ON position, in open air, with all poles connected in series by copper conductors not less than 4 feet (1.3 meters) in length. selected in accordance with Table 5-1. (See 4.4.4.)

The test should be performed at room ambient temperature approximately 25°C (77°F). The power supply should be adjusted to deliver rated current until the circuit breaker temperature stabilizes. Temperature stabilization usually occurs within one hour for breakers rated 100 amperes or less, but will take several hours for breakers of higher rating. Stabilization may be verified by taking three successive temperature measurements at intervals of 10 to 20 minutes between measurements at the same location on one or more of the circuit breaker connectors utilizing a temperature probe or thermocouple instrument.

5.7.5 Results

The circuit breaker should not trip during the test. If it does trip, reset the breaker and turn it ON again while continuing to monitor connector temperatures for an indication of temperature stabilization.

If the breaker continues to trip, it should not be returned to service.

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5.7.6 Reinstall Breaker

If applicable, reinstall the circuit breaker following manufacturer's instructions. Also refer to Section 4.4 for information on reinstalling wire connectors or conductors.

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Section 6
ACCESSORY DEVICE TEST PROCEDURES

6.1 GENERAL

If testing instructions for the specific accessory being tested are available from the manufacturer, those instructions should be followed to verify the operation of the accessory. If the manufacturer's instructions are not available, the tests described below may be used to verify the basic operation of the accessory.

6.2 SHUNT TRIP RELEASE TESTS

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment (unless otherwise directed) before performing any of the following operations. Follow the instructions under procedure (listed below) and the warning in Section 2.

6.2.1 Purpose

To verify that the shunt trip release device will trip the circuit breaker when energized.

6.2.2 Equipment

This test requires a power supply capable of delivering the shunt trip release rated current and voltage.

6.2.3 Procedure

6.2.3.1 Operate the breaker to the OFF position. Turn off all power to the circuit breaker, including control power to auxiliary devices, to electrically isolate it from all other circuits. The circuit breaker need not be removed from the equipment for these tests.

6.2.3.2 Open the enclosure. Verify that there is no voltage on the incoming conductors (including control power conductors) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

CAUTION: Circuit breakers and accessory devices can be damaged if power is applied to the wrong terminals. The specific lead wires or terminals for each accessory must be properly identified before conducting any of the following tests.

6.2.3.3 Remove the control circuit wires from the terminals (or leads) of the shunt trip release device.

6.2.3.4 Connect a test power supply to the terminals (or leads) of the shunt trip release device.

NOTE–If the circuit breaker is equipped with an under-voltage trip release in addition to the shunt trip release, energize the under-voltage trip release to allow proper operation of the shunt trip release. (See 6.3 for proper procedures.) Remove the control circuit wires from the terminals of the under-voltage release device and connect a test power supply to the terminals.

WARNING: Hazard of electrical shock or burn. When using the test power supply, do not touch its terminals or the terminals of the accessory during the test.

6.2.3.5 Operate the circuit breaker to the ON position.

6.2.3.6 Turn on the power supply to the shunt trip release device. The circuit breaker should trip.

CAUTION: If no tripping occurs within 1 to 2 seconds, turn off the test power supply to prevent possible damage to the shunt trip release coil.

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6.2.3.7 When the test is completed, turn off the test power supply, disconnect it from the shunt trip release device terminals (or leads), and reconnect the control circuit wires to the shunt trip release device terminals (or leads). If an under-voltage trip release device was connected, during the test, turn off the test power supply, disconnect the test power supply wires, and reconnect the control circuit wires to the under-voltage release device.

NOTE–It may be possible to test the operation of the shunt trip release device by leaving the control circuit wiring in place and energized, and then closing a contact in the control circuit. However, this method is not recommended unless the control circuits are thoroughly understood.

6.2.4 Results

The circuit breaker should trip when the power supply to the shunt trip release is turned on. If the circuit breaker does not trip, check the connections and repeat the test. If the breaker still does not trip, replace the shunt trip release, if replaceable. If it is not possible to replace the shunt trip release, the breaker should be replaced.

6.3 UNDER-VOLTAGE TRIP RELEASE TESTS

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment (unless otherwise directed) before performing any of the following operations. Follow the instructions under procedure (listed below) and the warning in Section 2.

6.3.1 Purpose

To verify that the under-voltage trip release device will trip the circuit breaker when de-energized.

6.3.2 Equipment

This test requires a power supply capable of delivering the under-voltage trip release device's rated current and voltage.

6.3.3 Procedure

6.3.3.1 Operate the breaker to the OFF position. Turn off all power to the breaker, including control power to auxiliary devices, to electrically isolate it from all other circuits. The circuit breaker need not be removed from the equipment for these tests.

6.3.3.2 Open the enclosure. Verify that there is no voltage on the incoming conductors (including control power conductors) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

CAUTION: Circuit breakers and accessory devices can be damaged if power is applied to the wrong terminals. The specific lead wires or terminals for each accessory must be properly identified before conducting any of the following tests.

6.3.3.3 Remove the control circuit wires from the terminals (or leads) of the under-voltage trip release device.

6.3.3.4 Connect a test power supply to the terminals (or leads) of the under-voltage trip release device.

WARNING: Hazard of electrical shock or burn. When using the test power supply, do not touch its terminals or the terminals of the accessory during the test.

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6.3.3.5 Turn on the test power supply.

CAUTION: The circuit breakers mechanism could be damaged by repeated operation of the circuit breaker with a de-energized undervoltage release.

6.3.3.6 Operate the breaker to the ON position.

6.3.3.7 Turn off the power supply to the under-voltage trip release. The circuit breaker should trip.

6.3.3.8 Re-latch and attempt to turn the circuit breaker to the ON position. The circuit breaker contacts should not close and remain closed. Momentary contact closure is acceptable.

6.3.3.9 When the test is completed, leave the power supply turned off, disconnect it from the under-voltage trip release device terminals (or leads), and reconnect the control circuit wires to the under-voltage trip release device terminals (or leads).

NOTE–It may be possible to test the operation of the under-voltage trip release device by leaving the control circuit wiring in place and energized, and then opening a contact in the control circuit. However, this method is not recommended unless the control circuits are thoroughly understood.

6.3.4 Results

The circuit breaker should trip, and it should not be possible to close the breaker contacts, when the power supply to the under-voltage trip device is turned off, as indicated in steps 6.3.3.7 and 6.3.3.8 of the above procedure. If the breaker does not perform as indicated, check the connections and repeat the test. If the breaker still does not perform as indicated, replace the under-voltage trip device, if replaceable. If the under-voltage trip device is not replaceable, replace the breaker.

6.4 ELECTRICAL OPERATOR TESTS

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment (unless otherwise directed) before performing any of the following operations. Follow the instructions under procedure (listed below) and the warning in Section 2.

6.4.1 Purpose

To verify that the electrical operator will operate the circuit breaker to the ON and OFF positions.

6.4.2 Equipment

This test requires a power supply capable of delivering the electrical operator rated current and voltage.

6.4.3 Procedure

6.4.3.1 Operate the breaker to the OFF position. Turn off all power to the breaker, including control power to auxiliary devices, to electrically isolate it from all other circuits. The circuit breaker need not be removed from the equipment for these tests.

6.4.3.2 Open the enclosure. Verify that there is no voltage on the incoming conductors (including control power conductors) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

CAUTION: Circuit breakers and accessory devices can be damaged if power is applied to the wrong terminals. The specific lead wires or terminals for each accessory must be properly identified before conducting any of the following tests.

6.4.3.3 Remove the control circuit wires from the terminals of the electrical operator~~s~~.

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6.4.3.4 Connect a test power to the terminals of the electrical operator marked “common” and “close” or “on.”

NOTE–If the circuit breaker is equipped with an under-voltage trip release in addition to the electrical operator, energize the trip release to allow proper operation of the electrical operator. (See 6.3 for proper procedures.) Remove the control circuit wires from the terminals of the under-voltage release device and connect a test power supply to the terminals.

WARNING: Hazard of electrical shock or burn. When using the test power supply, do not touch its terminals or the terminals of the accessory during the test.

6.4.3.5 With the circuit breaker in the OFF position turn on the test power supply. The circuit breaker contacts should close.

6.4.3.6 Turn the test power supply off. Disconnect its leads to the electrical operator.

6.4.3.7 Connect the test power supply leads to the terminals of the electrical operator marked “common” and “open” or “off.”

6.4.3.8 With the circuit breaker in the ON position, turn on the test power supply. The circuit breaker contacts should open.

6.4.3.9 When the test is completed, turn off the test power supply, disconnect it from the electrical operator terminals, and reconnect the control circuit wires to the electrical operator terminals. If an under-voltage trip release device was connected, refer to 6.3 for instructions.

NOTE–It may also be possible to test the operation of the electrical operator by leaving the control circuit wiring in place and energized and pushing the “open” and “close” buttons on the operator. Follow step 6.4.3.1 to insure that the main power to the circuit breaker is disconnected, but the power to the control circuits would be left in place.

6.4.4 Results

The breaker should operate to the ON and OFF positions when the above steps are followed. If the breaker does not operate properly, check the connections and ensure that there is no obvious obstruction of the operating mechanism and repeat the test. If the electrical operator still does not operate properly, it should be replaced.

6.5 AUXILIARY SWITCH TESTS

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment (unless otherwise directed) before performing any of the following operations. Follow the instructions under procedure (listed below) and the warning in Section 2.

6.5.1 Purpose

To verify that the auxiliary switch(s) change status when the circuit breaker contacts are opened and closed.

6.5.2 Equipment

This test requires an ohmmeter or continuity tester.

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6.5.3 Procedure

6.5.3.1 Operate the breaker to the OFF position. Turn off all power to the breaker, including control power to auxiliary devices, to electrically isolate it from all other circuits. The circuit breaker need not be removed from the equipment for these tests.

6.5.3.2 Open the enclosure. Verify that there is no voltage on the incoming conductors (including control power conductors) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

CAUTION: Circuit breakers and accessory devices can be damaged if power is applied to the wrong terminals. The specific lead wires or terminals for each accessory must be properly identified before conducting any of the following tests.

6.5.3.3 Remove the control circuit wires from the terminals (or leads) of the auxiliary switch(es).

6.5.3.4 Starting with the circuit breaker in the OFF position, use an ohmmeter or continuity tester connected to the terminals (or leads) of each auxiliary switch, to verify that its contact position (open or closed) is in agreement with the wiring diagram provided by the manufacturer.

NOTE–If the circuit breaker is equipped with an under-voltage trip release in addition to the auxiliary switch, energize the trip release to allow proper operation of the circuit breaker. (See 6.3 for proper procedures.) Remove the control circuit wires from the terminals of the under-voltage release device and connect a test power supply to the terminals.

WARNING: Hazard of electrical shock or burn. When using the test power supply, do not touch its terminals or the terminals of the accessory during the test.

6.5.3.5 Connect the ohmmeter or continuity tester to the terminals (or leads) of one switch to monitor the contact.

6.5.3.6 Operate the circuit breaker to the ON position. The auxiliary switch contact should change position.

6.5.3.7 Repeat steps 6.5.3.4 through 6.5.3.6 for each auxiliary switch.

6.5.3.8 When the test is completed, reconnect the control circuit wires to the circuit breaker auxiliary switch terminals (or leads). If an under-voltage trip release device was connected, refer to 6.3 for instructions.

6.5.4 Results

Each auxiliary contact should change position (move from open to closed or vice versa) as the circuit breaker is operated from the OFF to ON or ON to OFF positions. If the auxiliary switches do not perform correctly, check the connections and repeat the test. If performance is still incorrect, the auxiliary switches should be replaced; or if the auxiliary switch is not replaceable, replace the breaker.

6.6 ALARM SWITCH TESTS

WARNING: Hazardous voltages in electrical equipment can cause severe personal injury or death. Turn off the power supplying the equipment (unless otherwise directed) before performing any of the following operations. Follow the instructions under procedure (listed below) and the warning in Section 2.

6.6.1 Purpose

To verify that the alarm switch(s) contacts change position only when the circuit breaker trips.

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6.6.2 Equipment

This test requires an ohmmeter or continuity tester.

6.6.3 Procedure

6.6.3.1 Operate the breaker to the OFF position. Turn off all power to the breaker, including control power to auxiliary devices, to electrically isolate it from all other circuits. The circuit breaker need not be removed from the equipment for these tests.

6.6.3.2 Verify that there is no voltage on the incoming conductors (and on control power conductors) and between these conductors and ground to positively ascertain that the equipment is de-energized. Follow practices described in NFPA 70E, Part II, to perform these steps.

CAUTION: Circuit breakers and accessory devices can be damaged if power is applied to the wrong terminals. The specific lead wires or terminals for each accessory must be properly identified before conducting any of the following tests.

6.6.3.3 Remove the control circuit wires from the terminals (or leads) of the alarm switches.

6.6.3.4 Connect an ohmmeter or continuity tester to the terminals (or leads) of an alarm switch to monitor the contact position (open or closed).

NOTE–If the circuit breaker is equipped with an under-voltage trip release in addition to the alarm switch, energize the trip release to allow proper operation of the circuit breaker. (See 6.3 for proper procedures.) Remove the control circuit wires from the terminals of the under-voltage release device and connect a test power supply to the terminals.

WARNING: Hazard of electrical shock or burn. When using the test power supply, do not touch its terminals or the terminals of the accessory during the test.

6.6.3.5 Starting with the circuit breaker in the ON position, operate the circuit breaker to the OFF position. The alarm switch contacts should not change position.

6.6.3.6 Operate the circuit breaker back to the ON position. The alarm switch contacts should not change position.

6.6.3.7 Initiate a tripping action either by a manual means, if available, or by a shunt trip release or under-voltage trip release device. (See the manufacturer's instructions or 6.2 and 6.3 in the above procedures.) The alarm switch contacts should change position. (See 6.6.3.)

6.6.3.8 Repeat steps 6.6.3.5 through 6.6.3.7 for other alarm switches.

6.6.3.9 When the test is completed, reconnect the control circuit wires to the alarm switch terminals (or leads). If an under-voltage trip release device was connected, refer to 6.3 for instructions.

6.6.4 Results

The alarm switch contacts should change position only when the circuit breaker undergoes a tripping operation, and not when the circuit breaker is operated to the OFF or ON position. If the performance is not as indicated in the procedure, check the connections and repeat the test. If performance is still not as indicated, the alarm switch should be replaced, if replaceable. If the alarm switch is not replaceable, replace the breaker.

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