Guide to the Preventive Maintenance of Molded-Case Circuit Breakers

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About the Authors

Jim Rosenfield is Vice-President of ROMAC Supply Company, a leading supplier of new and reconditioned electrical equipment based in Commerce, California. As Supervisor of Production and Testing, Mr. Rosenfield gained extensive experience with electrical apparatus. In a previous position as President of ROMAC's subsidiary, Power Controls, Inc., he manufactured electrical switchgear. Prior to joining ROMAC, he operated an electrical contracting business in the San Francisco Bay Area. He earned his Bachelor of Arts Degree from the University of California at Berkeley in 1972.

Druso Vellutino is Chief Engineer at ROMAC Supply Company. He brings over 30 years of experience in electrical project management and circuit breaker technology. In 1958, he received his engineering degree from National Engineering University of Peru. He began his career in the electrical industry at Lima Light & Power where he designed one of the first computerized preventive maintenance programs in 1964. In 1980, he became a project manager and electrical designer for Pacific Gas and Electric in San Francisco. He also served with Starkist Foods in Long Beach and Shell Oil Co. in Texas. He is licensed in California and in Texas as a Professional Engineer.

ROMAC SUPPLY COMPANY

ROMAC Supply Company is a respected service organization - a family-owned supplier of new, reconditioned and obsolete electrical apparatus and circuit breakers since 1960. At our five-acre facility in Los Angeles we maintain a vast inventory of new and used circuit breakers, motors, transformers, switchgear and controls. ROMAC is known for creative solutions to equipment problems and rapid materials sourcing. Romac people know that lives depend on their work.

Romac's 5-acre facility in City of Commerce, CA

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INTRODUCTION

Purpose

This publication is intended to present, for the use of qualified maintenance personnel, a number of basic procedures for the field inspection and performance verification of molded case circuit breakers used in industrial and commercial applications and rated up to 1,000 volts. It also covers the essential structure of and the need for a thorough plant preventive maintenance (PM) program for the plant electrical system.

The procedures outlined here will fit well into an organized PM Program. We have gathered this material from the key applicable publications of both the manufacturing community and the regulatory community, along with articles and viewpoints from some of the most qualified circuit breakers manufacturers, plant and shop engineers.

Preventive Maintenance is a Must

- Disaster struck at a large aircraft parts manufacturer when the 1,600 amp main circuit breaker which had not been maintained in over six years, disintegrated in flame and smoke.

  The breaker was attached to the main buss by spring-loaded finger-clusters. One phase connection on the breaker was slightly out of alignment causing heating in the connection. As the heat annealed the springs the connection grew poorer, causing the heating to worsen. The deterioration began to escalate as the connection loosened.

Arcing began inside the connection and then the insulating thermoplastic around the conducting parts began to slowly burn. Finally, the burning plastic gave way and a massive short circuit resulted. The entire 40-foot length of switchgear was severely damaged before an upstream protective device cleared the fault.

No one was killed, but the plant could not be brought fully back on-line for months. Other establishments suffering this sort of disaster have never re-opened.

- A failed 15,000 Volt switch was the cause of a devastating fire at a large luggage manufacturer. Four buildings were set ablaze, and the damage severely crippled the company. Hundreds of workers sat idle while the plant was rebuilt.

- When a 2,000 kVA transformer failed at a Washington lumber company, operations came to a halt. Thousands of lumbermen waited for a replacement transformer to be flown in by 747. It had to go from Los Angeles via Anchorage so the lumbermen could return to their jobs.

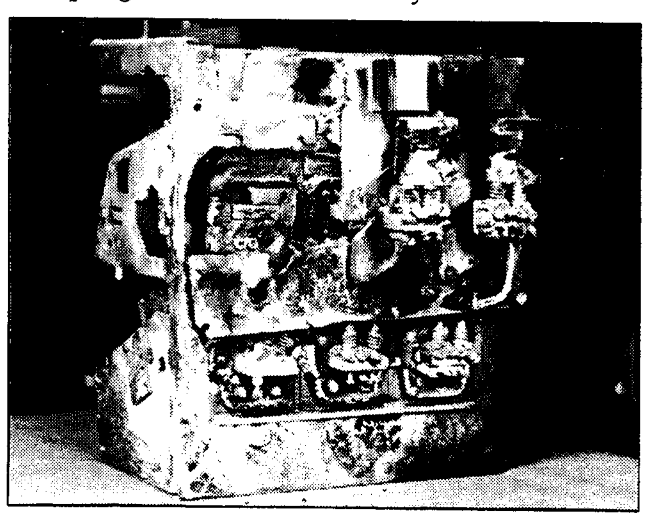
Modern electrical systems are built for very high safety and reliability. Failures and injuries are rare. Systems with high reliabiity tend to be ignored when it comes to maintenance because they seldom fail. As the above cases indicate, however, improperly maintained electrical apparatus can spell catastrophe for companies.

According to NFPA (National Fire Protection Association) Vice President for Fire Analysis and Research, Dr. John Hall, out of roughly 400 industrial & manufacturing fires which occur in the U.S. in an average year, 1.3% (representing $843.7 million in property damage) are due to protective device (breakers, fuses, switches) failures.

Electrical fires, smoke damage, destruction of the switchgear, personnel injuries, and death are some of the consequences. Prudent managers also focus on the possible impact of unscheduled downtime. These include production losses, the rupture of marketing relationships, loss of customer business. The business setbacks can be very costly.

Nearly all electrical installations in the United States are done under the provisions of the National Electrical Code (NEC), promulgated by the NFPA. The switchgear and all other components of the system must be accepted by the local authority. As a practical matter, this means that these components bear the listing mark of a nationally recognized certification authority, which validate their safety and the suitability.

Codes and standards afford companies a measure of protection, but almost no one requires preventive maintenance. It is up to the individual plant. Without *(a rigorously applied preventive maintenance procedure)* a plant's electrical system can fail disastrously. A PM program can dramatically decrease the



1,600 amp circuit breaker without preventive maintenance.

possibility of catastrophic failure or injury. It will almost certainly cut down on possibly disastrous unscheduled interruptions in production. In the majority of cases, circuit breakers fail because of lack of maintenance, cleaning and lubrication.

Because of the high cost and catastrophic character of electrical failures, the importance of implementing such a program cannot be overemphasized. Over the years, we have seen many users who say they cannot afford to shut-down to check their circuit breakers. In our view, they cannot afford not to.

A successful PM program for electrical equipment is one in which inspections, cleaning, adjustments and tests are carried out on a regularly scheduled basis. Results must be carefully logged. Comparisons with past data bring incipient problems to light. Dangerously deteriorating equipment can be located and repaired before dangerous failures occur.

Properly maintained electrical equipment will provide lasting service at the least cost over the longest term. Such a program will curtail the likelihood of unplanned outages and possible injuries. When properly maintained, there is no fixed limitation on the useful life of electrical gear.

The following guidelines should be built into every PM program for electrical systems:

Identify, locate and document every component of the system. An overlooked switch in a remote location could be the one that fails. The hard to reach component is likely to be the one least checked and maintained, and therefore, the likeliest to fail. Every component, therefore, must be located and tracked, so that it can be included in routine checks. Some well-organized operations feed this information into computerized data bases to assist them in producing timely system management reports. Reports can look at history of individual items or groups of items in the program. History can be used to establish in house benchmarks.

Devise a repeatable procedure and carry it out routinely. The procedure should be adopted and understood by all members of the maintenance department. Repeatable practices ensure thorough maintenance, while built-in checklists can ensure that no step is left undone. Some checks should be performed daily, while others can be done weekly, or monthly. Still others can be performed less often, but must be repeated regularly. Heavy load or load-critical conditions suggest more frequent checks. There are no hard and fast rules for how often the tests should be done, but a sample calendar of tests is included at the end of this booklet. Use it to set up your own schedule.

Procedures for each component of the system should be developed and approved by the appropriate staff and supported by the management. For most components in an electrical system, the manufacturer's documentation, including use, maintenance and reference guides will provide the backbone of the PM procedures. Use these documents to formulate the daily, weekly, monthly and annual checklists for each component.

When procedures have been developed for each component, look at the overall process to identify any overlooked elements, including the conductors and structures which connect the system together, such as conduits, cables and busses. For each element, the checklists should include previous values for the particular test or check. A very useful practice is to record "as found" values. Compare them to previous check values and compare to values after adjustments are made. Establish benchmarks for allowable variance for each check, and make sure any variance in excess of the allowable limit is investigated.

The complete set of procedures should be adopted by the plant leadership, from top management to operational personnel. Those doing the inspections and checks must be thoroughly trained on the procedures and tests, and their level of competence should be tested, from time to time, as a key element of the overall program.

It is essential to have the proper tools and measuring instruments at your disposal. In addition, the instruments need to be calibrated (annually) to the appropriate standards, usually National Institute of Standards and Tests (NIST), formerly the National Bureau of Standards, in the U.S.

Include in the procedure a set of regular checks to ensure that the program is actually being followed. Establish a periodic audit of the PM program and report the results to top management for action.

A program like this is much easier to describe than to put into practice. It takes a solid commitment from all layers of the organization -- from maintenance personnel to top management. If the leadership supports the values of prevention and safe operations, such a PM plan can help companies avoid the catastrophic losses which can result from the breakdown of improperly maintained electrical systems.

Definitions and Codes

The National Electrical Code (NEC) defines 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."

The NEC states that the purpose of overcurrent protection, as provided by a circuit breaker, is "to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation."

A molded case circuit breaker is one that is assembled as an integral unit in a supportive and enclosed housing of insulating material.

Molded case circuit breakers are tested and the tripping time calibrated at the manufacturer's plant. These tests are typically based on recognized standards, such as NEMA AB I, "Molded Case Circuit Breakers" or Underwriters Laboratories' Standard for Molded Case Circuit Breakers and Circuit Breaker Enclosures, UL 4993. Since circuit breakers have factory calibrated sensors and and some have sealed elements, any unauthorized modification generally jeopardizes the manufacturer's warranty. Non-sealed units are designed for periodic inspection, maintenance and calibration by qualified personnel.

A circuit breaker is only operated intentionally or automatically when abnormal current conditions exist. Thus, it is not unusual for a circuit breaker to be in service for extended periods and never he called upon to trip because of an overload or short circuit or to be opened manually.

Therefore, a program of inspection and preventive maintenance, according to the manufacturers' recommendations, is necessary to ensure that the circuit breaker will perform as required when it is needed.

Checking the condition and basic electrical operation of circuit breakers is important. However, values obtained according to the procedure for overcurrent trip tests should not be directly compared with published time/current characteristic curves which are developed under closely specified and controlled conditions. When questionable conditions or results are obtained during inspection and performance tests, the manufacturer or a reputable service organization should he consulted. If it is necessary to return a circuit breaker to the manufacturer, proper packaging and packing material should he used to avoid shipping damage.

Elements of a Successful Preventive Maintenance Program

Experience has shown that molded case circuit breakers require very little maintenance. A few simple inspection and maintenance procedures carried out on a regularly scheduled basis are recommended. Under normal conditions of use, when setting up such an inspection and maintenance schedule, it is suggested that the following procedures be followed. For additional assistance in establishing a proper inspection and maintenance schedule for your particular application consult the manufacturer or a knowledgeable service organization.

With the breaker enclosed as in normal use and under load, check the face of the breaker (if visible) and the adjacent dead front surfaces of the enclosure. If the surface temperature does not permit maintaining contact with the palm of the hand for at least 3 seconds, it may he an indication of trouble and investigation is necessary. Please note that after initial energization, the breaker may not reach maximum temperature until it has carried a load for 3 hours.

Visual Inspection and Operation

The following steps can be performed without removing the circuit breaker from its cubicle or mounting:

Operate the breaker "ON" and "OFF" 5 or 6 times to insure that the mechanical linkages are free.

Trip, reset, and close the breaker several times if the breaker is provided with mechanical trip provisions. This will insure that latching surfaces are operational.

Warning: Hazard of electrical shock or burn exists whenever working in or around electrical equipment. Inspection and maintenance steps must be made only on circuit breakers and equipment which are de-energized, disconnected, and isolated so that no accidental contact can be made with live parts.

Open the enclosure and verify that the breaker has been properly applied as to its type and rating in accordance with the manufacturer's instructions.

Clean the circuit breaker exterior surfaces of any dust, dirt, soot, grease, or moisture. Use a lint free dry cloth, brush, or vacuum cleaner. Avoid blowing dirt into the circuit breaker or other equipment. If such contamination is found, it is recommended that steps he taken to eliminate the source. Do not "blow off" circuit breakers with air. Most air lines contain some moisture. Moisture on and in the circuit breaker directly reduces its dielectric capacities and should be avoided. You may safely "blow off" components with pressurized nitrogen, but take care not to blow contamination into the circuit breaker. If necessary, use isopropyl or denatured alcohol to clean stubborn stains. Never use water or petroleum-based cleaning solvents as they may damage various types of insulation.

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

Check all electrical components, especially connection lugs, for evidence of overheating or looseness and verify that the ampacity of the conductors is correct. Overheating of a connection is indicated by discoloration of metal parts, melting or blistering of adjacent wire insulation or pitting or melting of connection surfaces due to arcing.

A plug-on type circuit breaker should be removed and examined. If the plug-on parts of the breaker are damaged (melted, pitted or discolored) the breaker should be replaced. Do not attempt to dress or bend the mating surfaces to fit. If the connecting busbars show signs of pitting or melting they should be replaced.

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

If there is evidence of overheating, copper circuit breaker terminals and branch bus bars normally can be cleaned by carefully disassembling the connection and carefully dressing the contact surfaces with fine aluminum oxide paper. Aluminum wire connector lugs or branch bus bars that are damaged by overheating or arcing must be replaced. Be sure to remove all metal and abrasive particles before reassembling. Extreme care should be exercised to prevent any damage to plated connections and to prevent any particles from entering the circuit breaker.

Remove any damaged portion of the wire or cable. After cleaning or replacement, all connections should be tightened to recommended torque levels. Use manufacturer-recommended dressings.

Operate the breaker "ON" and "OFF" and trip it several times to insure that the mechanism is free and in proper working order.

Internal Cleaning Procedure

This procedure is for circuit breakers which are designed to have interior components maintained. (Breakers with riveted covers or sealed bolts are not intended to be so maintained).

Remove the cover of the circuit breaker. Make sure primary contacts are open and closing springs are discharged. Remove any dust, dirt or other contamination using a stiff brush, vacuum cleaner or compressed nitrogen. Carefully inspect the contacts for evidence of overheating, pitting, arcing, melting or corrosion. Molded-case breaker contacts can be cleaned with a soft, dry cloth. Dressing the contacts with a file or emery cloth is generally NOT recommended on this type of circuit breaker. If the contacts are damaged beyond use, the breaker should be replaced.

If the circuit breaker has an interchangeable trip unit, remove the circuit breaker cover and check the internal connections at terminals of the trip unit for overheating or looseness. If there is no evidence of overheating or looseness do not disturb or tighten the connections.

If there is evidence of overheating at any of the trip unit connections, the trip unit should be removed. Verify that the threaded inserts in the circuit breaker base have not been stripped or cross-threaded. If the threaded inserts are damaged the circuit breaker should be replaced. If the inserts are in good condition, clean the connections as noted above, tighten the connection bolts following the manufacturer's instructions and replace the circuit breaker cover. Do not cross-thread the trip-unit connection bolts.

Lubrication

After cleaning, relubricate the mechanism. Refer to the recommendations and specifications in the manufacturer's maintenance guide.

Testing the Circuit Breaker

Mechanical Trip Test

Trip, reset, and close the breaker several times if the breaker is provided with mechanical trip provisions. Such action will insure that latching surfaces are free.

CAUTION: Certain commercial cleaners attack the thermo-plastic materials of the breaker. Verify suitability of any cleaner before using.

Contact resistant test.

Electrical Control Test

This procedure is useful for circuit breakers with electrical close or trip capabilities. Inspect control wiring terminals, and repair loose connections. Use the manufacturer's wiring diagram or develop one for the record, and confirm proper operation. Make sure the limit switches work properly. Check auxiliary and contact switches.

Electrically operated breakers can be "timed". This means that the interval between when an electrical "trip" signal is sent and when the current path is interrupted can be measured. This is considered the most reliable indicator of mechanism misadjustment or incipient failure. It is recommended wherever possible.

Insulation Resistance Test

The insulation resistance test, or dielectric strength test, is used to determine the quality of the insulation between live parts in adjacent poles of a circuit breaker and from each pole to ground.

CAUTION: Prior to conducting this test, consult the manufacturer's instructions, since the high voltages used may damage electronic components.

The resistance test is made with a direct-current voltage to determine the actual resistance of the insulation. Such resistance tests should be conducted with megohm type devices having outputs of 500-1000 volts for molded case beakers. We can recommend the Biddle, Series 2 1000 VDC model or the Biddle motorized High Range 2,500 VDC model. A functional equivalent may be used. If resistance values are below 1 megohm per kilovolt, the manufacturer should be consulted or the circuit breaker or the component (e.g.: bottles) replaced. Due to the high voltages involved, strict adherence to the safety procedures recommended by the manufacturer of the insulation resistance test device is required.

Perform the following steps:

- Check the resistance between line and load terminals of individual poles with the circuit breaker in the "OFF" position.
- Check the resistance between terminals of adjacent poles and from terminals to any metallic supporting structure with the circuit breaker in the "ON" position.
- The latter test should be conducted with the circuit breaker bolted to a metallic baseplate to simulate in-service mounting. Any exposed metallic parts of the circuit breaker shall also be connected to the base plate.

WARNING: Before performing any of the following operations, de-energize and isolate the equipment and check the voltage of all incoming line terminals and between these terminals and ground to positively ascertain that the equipment is totally de-energized, and will remain de-energized during these procedures. The disconnecting or isolating means on the line side of the devices being checked should be locked in the "Off" position.

Contact Resistance Test
Extensive operation of the circuit breaker under load conditions beyond that for which the circuit breaker was intended, along with faults and short circuits can cause deterioration of the contacts. The electrical integrity of connections and contacts can be detected by testing the resistance across the line and load terminals of each pole with the circuit breaker contacts closed.

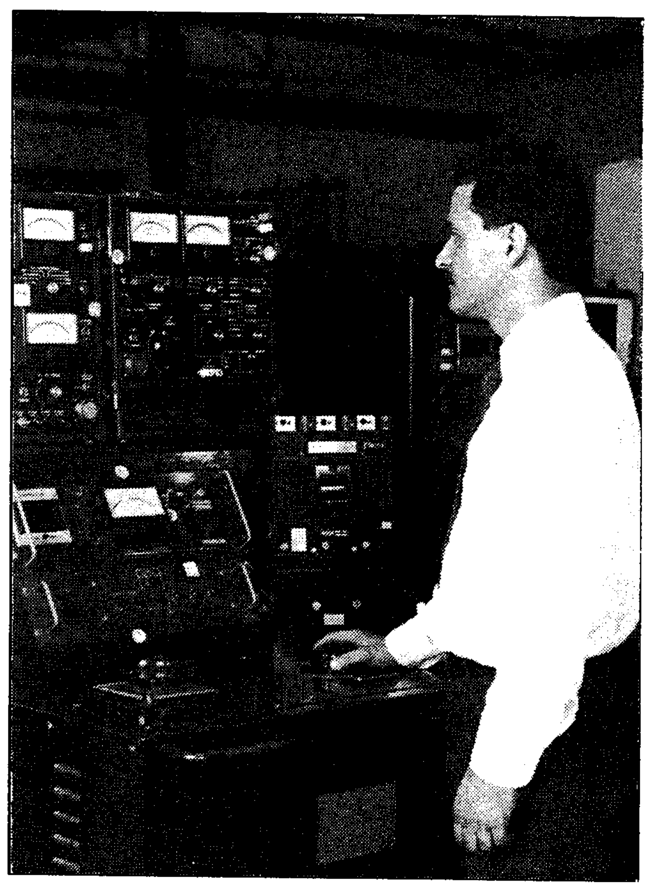
Although some sources prefer measuring contact resistance using a bridge, we feel that we get more reliable values by measuring the voltage drop across the circuit breaker while a relatively high known current is flowing through the breaker. In brief, we use a "Ductor" - the BIDDLE CAT 247000-3, SER. 6531 Digital Low Resistance Ohmmeter (DLRO). We also recommend using the 100 amp power supply to get the most accurate reading (figure 3). This device reports the resistance across the contacts in micro-ohms. A comparison between the poles of the breaker or similar breakers can be made. A difference of as much as 2:1 may indicate that the breaker's contacts should be cleaned. This test is an important indicator of the acceptability for continued use of the circuit breaker.

Time-Delay Tripping Test
The overcurrent tripping characteristics of a circuit breaker can be verified by using a high current source with an electrically operated timer. An industry standard current-injection test set is the Multi-Amp Mod. BTS50 for up to 7500 Amp. or the Mod. CB7120 for lesser currents up to 2000 Amp, or equivalent instruments .

A general indication of the proper action of the overload tripping components of the circuit breaker can be verified by selecting certain percentages of the breaker rating, such as 300 percent, and applying this separately to each pole of the circuit breaker to determine if it will open automatically in the time specified by the manufacturer's time-current calibration curves. When comparing test results with the manufacturer's published curve, remember that these results reflect particular environmental conditions (ambient temperature and humidity). Field test values are likely to vary substantially from laboratory values. Use manufacturer's literature to establish acceptable variances.

Instantaneous Magnetic Tripping Test
These tests are intended to verify functioning of the instantaneous trip systems of the breaker with marked instantaneous trip settings. Consult the manufacturer regarding applicable test criteria for breakers without such markings.

In verification testing, it is most important to determine that the instantaneous trip feature is operating and will trip the circuit breaker. For preventive maintenance, exact determination of magnetic trip values is not essential. If you do desire to test precise adherence to published values, then careful control of environmental conditions is necessary.



Overcurrent tripping test.

Rated Current Hold
This test is intended to verify the capability of a molded case circuit breaker to carry its rated current and needs to be performed only if the circuit breaker has been tripping under normal load conditions.

This test should be performed at normal room ambient (25°C) utilizing a low voltage power supply.

The circuit breaker should be tested with all poles connected in series by conductors approximately 4 feet long per terminal (8 feet between poles) of the proper ampacity. All connectors shall be tightened to the recommended torque marked on the circuit breaker (or values found in UL 489).

The circuit breaker should not trip when rated current is applied for a period of 1 hour for breakers rated <100 amperes or 2 hours for breakers rated greater than 100 amperes. If tripping does occur, reset and operate the device several times under load then test again. If tripping continues, the circuit breaker should be replaced.

Return to service
After completing the test, return the breaker to cubicle ensuring correct fit and alignment. If breaker has a test position, check for proper operation with control power energized. Return to service using the manufacturers guidelines.

Summary
Highly reliable electrical systems are the strong, quiet foot-soldiers of industry. Because there are so few problems, these devices may be overlooked -- taken for granted. Since electrical failures can be severely disruptive to businesses and pose extreme safety risks for personnel, a conscientious PM program is recommended for your entire electrical system and its components. Properly maintained electrical systems give the most cost-effective performance over the long run. Other benefits include enhanced safety for personnel and freedom from unplanned interruptions of operations.

Professional plant maintenance operations cannot afford to give inadequate attention to their electrical systems. The resources required are not great and should be readily available. Special test equipment can be rented from numerous sources. If appropriately trained test personnel are not available, competent electrical testing firms may be retained where required.

What is required is the dedication of management and plant maintenance personnel to proper procedures, to safety, to plant longevity and to continuous, uninterrupted plant operations. With a little attention, these goals are well within reach.

Bibliography
"Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications", National Electrical Manufacturers' Association (NEMA) AB4-1991

"Procedures for Field Inspection and Performance Verification of Molded case Circuit Breakers Used in Commercial and Industrial Applications", NEMA, AB-2-1984 (Rescinded)

"Inspection and Testing, Molded-case Circuit Breakers", General Electric GET2779G0584-BAT

"Testing and Maintenance of Molded-Case Circuit Breakers", General Electric GET-2963

"Electrical Equipment Maintenance, NFPA 70B, 1990 Edition", National Fire Protection Association, 1990

"Eight Steps to Circuit Breaker Safety", Kroes, Roger; CEE News, March 1993.

"Testing, Four Tests for Switchgear", Casubon, J. R. Norman, Electrical Apparatus, June, 1974

"A Working Manual on Molded Case Circuit Breakers", Fourth Edition, Westinghouse Corporation

Sample Schedule of Tests

This sample schedule of Circuit Breaker Maintenance steps should be adjusted to consider your loading, criticality and environmental conditions. More severe environments, heavy loading and extreme criticality suggest more frequent tests. Ultimately, your schedule should be integrated into a program for maintenance of the entire plant electrical system. A table of plant system recommended tests is include as Table 1.

DAY-IN and DAY-OUT:
Walk by each switch, panelboard, or breaker cubical and be alert to electrical insulation smell, abnormal bulging, heating or burning. Conditions like these should be investigated immediately. In cold or wet climates verify that switchgear cubical heaters are functioning. Open cubical doors and feel for normal heat in the atmosphere around the device or by touching the "dead front" of the switch equipment. Take care never to touch energized conductors, and never allow yourself to become grounded. While the cubical door is open, observe any nuts, bolts or other parts on the floor. If the circuit breaker is "racked in", do not touch the circuit breaker.

QUARTERLY:
Remove each removable breaker from its cubical and test contact resistance with a 100 amp "Ductor". If more than 150 micro-ohms the circuit breakers should be investigated. (Series trip units may cause the Ductor to read 300 to 500 micro-ohms so a record of each breaker should be kept and the Ductor reading of the serial trip coil values should be deducted from the over-all readings).

Wipe down the circuit breaker with a clean dry cloth or blow off with pressurized nitrogen to remove dust and dirt.

SEMI-ANNUALLY:
Operate each breaker at least three times in each six month period.

ANNUALLY:
Time-test the opening and closing speed of each electrically trippable circuit breaker. Check the manufacturer's recommendations for acceptable range of closing and opening speed.

BI-ANNUALLY:
Test each electrical tripping device with 50% of normal operating voltage. This test will insure that the mechanism is completely free. Test the closing mechanism with 70% of normal operating voltage. Megger test phase-to-phase and phase-to-ground, followed by hipot test for medium voltage breakers. Clean cubical.

EVERY 5 to 7 YEARS:
Verify all bolted bus connections with a torque wrench test. Megger buses before and after cleaning and record results. Look for large changes in readings as evidence that connections are loosening and may require more frequent checks.

Primary injection test all breakers, tripping sensors, coils and relays.
This is the electrical activation of all units sensitive to current or voltage. Use "primary injection" – send a current through the primary of the sensing coils.

The most frequent deficiencies found in testing are improper tripping of breakers on either long time-delay or instantaneous settings, broken mountings, loose connections, improper meter wiring, and missing or broken interlock arrangements.

Recommended Electrical Tests of System Components

A. High-voltage cables and switches:
1. Megger test on cables per IPCEA S-19-81 and NEMA WC-3 1964.
2. High-voltage DC overpotential test on cables-high pot test according to USASi-C8-13-1960. C8-36-1964. IPCEA S-19-81, IPCEA S-61-402
3. Oil for dielectric strength.
4. Ductor test for switch contacts resistance.
5. Switch operations, manual, and via auxiliary control circuits.

B. Transformers:
1. Oil dielectric strength.
2. Megger test of windings.
3. Overpotential tests per NEMA TRI-2.055 and USASI C57.12
4. Transformer turns ratio test (TTR).

C. Protective Relays:
1. Inspection.
2. Adjustments.
3. Calibration.
   a. Insulation resistance.
   b. Zero check.
   c. Pick-up and/or drop out.
   d. Time characteristics.
   e. Target and seal in.

D. Circuit Breakers
1. Dielectric strength with megger.
2. Contact resistance with 100 amp Ducter
3. Electrical trip with 50% operating voltage, electrical close with 70% voltage.
4. By individual phase:
   a. Long-time delay (LTD) at 300 per cent of rated current.
   b. Short-time delay (STD) at 150 percent.
   c. Instantaneous at setting.

E. Ground Fault
1. Current setting.
2. Time setting.

F. Motor Controls
1. Proper heater selection
2. Resistance

G. System Ground
1. Size
2. Resistance

H. Buses
1. Voltage drop at connections
2. Torque connections.

ONE-STOP CIRCUIT BREAKER SERVICE and SUPPLY

ROMAC has the nation's most comprehensive inventory of new, rebuilt and obsolete circuit breakers. We service, repair, and supply virtually any type or brand of circuit breaker, as well as current and obsolete panel boards, mounting hardware kits, accessories and components. Furthermore, if the circuit breaker you need isn't in stock, we can find it through our advanced electronic locator system.

Our process for reconditioning circuit breakers has set the standard in the used apparatus industry. Our professional quality control department employs state-of-the-art testing apparatus. Instrument calibration is traceable to NIST (National Institute of Standards and Testing). All reconditioned equipment undergoes a rigorous quality assurance process.

ROMAC responds to emergencies with fully guaranteed equipment 24-hours a day, 7 days a week, fulfilling your needs overnight when others require weeks. We offer both equipment supply and technical service through expert salespeople, electrical engineers and technical specialists.

Inventory

- 5 acres of circuit breakers and electrical apparatus
- Motor circuit protectors, non-auto switches, high-break models and current limiting styles
- New, surplus or fully reconditioned and guaranteed breakers from our stock
- Parts for most breakers
- Complete range of accessories and options.

Service

- Complete breaker rebuild
- 24-hour emergency response
- Breaker testing and verification
- Trip unit recalibration
- Ambient compensation
- Vacuum and static trip retrofits
- Instrument & relay calibration
- We locate the parts or accessories you need

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