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# Short Circuit Test on Air Circuit Breaker and Molded case Circuit Breaker

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**ABSTRACT:** This paper presents a detailed analysis of short-circuit testing of low voltage electrical equipment. The fundamental kinds of short-circuit tests and their underlying theories in conjunction with a real time data of current and voltage waveforms to find the reasons and its remedies for better performance. The analysis is carried out in accordance with IS/IEC standards and summarized to present the reasons and possible remedial measures for prevention of failures during test.

**KEYWORDS:** Long-delay protection, Electrodynamic stress, Resetting time, Toggle link

## I. INTRODUCTION

Every electrical device that is used for any purpose needs to be certified. Product tests are conducted to conform the technical specifications provided by the manufacturer. Circuit breakers are switching devices that have the ability to instantly cut off an electrical circuit. They are employed to safeguard equipment and circuits from short circuits and over currents [1.]. The calculation of the short-circuit current is very important when planning electrical distribution networks. Short-circuits can occur because of isolation faults like an insulation breakdown, aging of the insulation material or continual stress on the insulating materials. The current during short circuits is usually higher than the rated currents for which a particular network was designed. These short-circuit currents evoke the strongest strains in resources. Therefore, all components in a network must be able to withstand these kinds of faults so that the effect of such abnormal current should not cause damage to vital components of electrical network. Hereby it is important to take into account the amounts of short-circuit currents and also the heat generated in the ohmic resistances. The requirement for a safe and economical design is the most accurate knowledge of the temporal current curves in the event of an error, because only then the proper security measures can be taken, namely the right choice of overcurrent protection devices which are used in case of failure of the automatic shutoff of the power supply.

## II. SHORT CIRCUIT IMPACT ON SWITCHGEAR

Due to the dynamic forces of the short-circuit current at the onset of the current fault and the thermal dissipation of the high energy created by the short-circuit power, short circuits put stress on the switchgear's mechanical components. Thermal short-circuit current is also one of the issues, which cause very high temperature. In order for the cables and busbars to sustain the load current, they are dimensioned accordingly. The short-circuit current would cause damage if it is rising the temperature for an extended length of time. Thus, the key element in calculating the short-circuit current tolerate the electrodynamic stress on the switchgear. The busbars and their fixations may be subjected to considerable stress from the dynamic short-circuit current forces. They must be able to sustain the maximum short-circuit current without causing the fixations to break or become permanently stained [2.]. In particular, the busbars vibration can lead to a breath fixations and flanges. Through computation, one may determine the busbars short-circuit current withstand. Manufacturers also offer data tables for the many types of busbars they produce whereas the short-circuit current withstand of the fixations can be only stated by tests.



**Figure-1 Molded case circuit breaker and Air circuit Breaker**

### III. TEST OPERATIONS

Each test of circuit breaker has its own sequence of operations. The following symbols are used for operation:

O - operation of opening

CO - operation of closing followed by automatic opening

t - time interval between two consecutive operations which must take 3 minutes or longer in a given switching

The maximum resetting time shall be 15 min or such longer time as may be stated by the manufacturer, but not exceeding 1 h, During this period the circuit breaker shall not be displaced. Attempts to reclose the circuit breaker during resetting time shall be spaced by at least 1 min [3.].

### IV. MCCB AND ACB

#### 4.1 Comparison of MCCB and ACB

The MCCB offers enhanced dependability while increasing current-carrying and breaking capacities. These advancements have led to an increase in the use of MCCBs in big capacity circuits where ACBs were previously more common. While both MCCB and ACB are circuit breakers used to protect low-voltage circuits, they differ in the following ways. It is essential to choose a unit with adequate dependability and the greatest cost performance for the relevant circuit requirements [4.].

#### 4.2 Tripping characteristics

While the ACB's characteristics are essentially modifiable, the MCCB's long-delay tripping characteristics are usually fixed. This is so that, when employing the ACB for a power breaker, the protective features of the transformer or generator can be easily achieved. employing an electronic MCCB with customizable long delay tripping features makes it simple to achieve the protective qualities when employing MCCB for these kinds of applications. Another way to run the voltage trip is to add a voltage trip to a general MCCB and use a relay for long-delay protection.

### 4.3 Switching mechanism

MCCB can be switched by turning the handle to ON or OFF. When the handle is turned to ON or OFF, the line of action of the retracting spring will go over the dead point of the toggle link, the toggle link will suddenly expand when the handle is turned to ON or bend when the handle is turned to OFF, and the contactors will quickly operate regardless of the handle operating speed.

### 4.4 Applications

- Since the MCCB and ACB opening times are different, it is not advised to use MCCB and ACB combinations for cascade protection.
- The MCCB's structure is straightforward and secure, requiring neither upkeep nor inspections. Nonetheless, the ACB needs to be properly maintained and inspected because it is built with a lot of modern elements. MCCB is therefore inappropriate for applications that require frequent short circuit interruptions.
- The short-time capacity of the ACB is large, and a MCR (making current release) can be mounted. It is easy to structure a selective braking system, and is suitable for applications as a main circuit breaker [4].

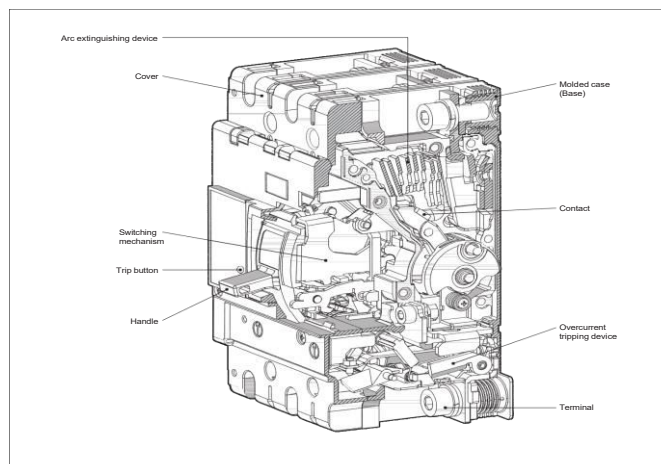


Figure-2 Construction of MCCB [4.]

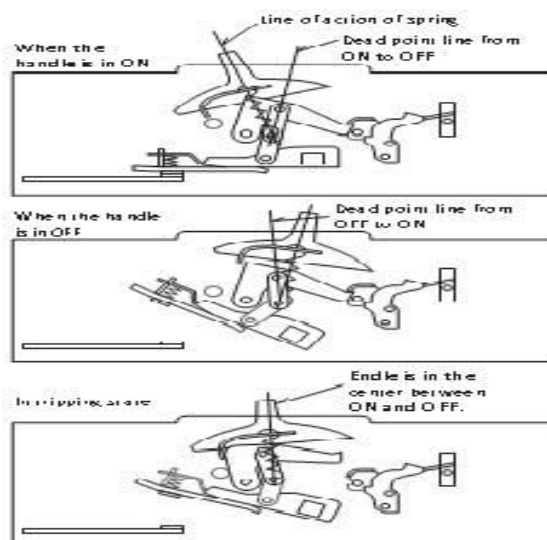


Figure-3 Switching Mechanism of MCCB

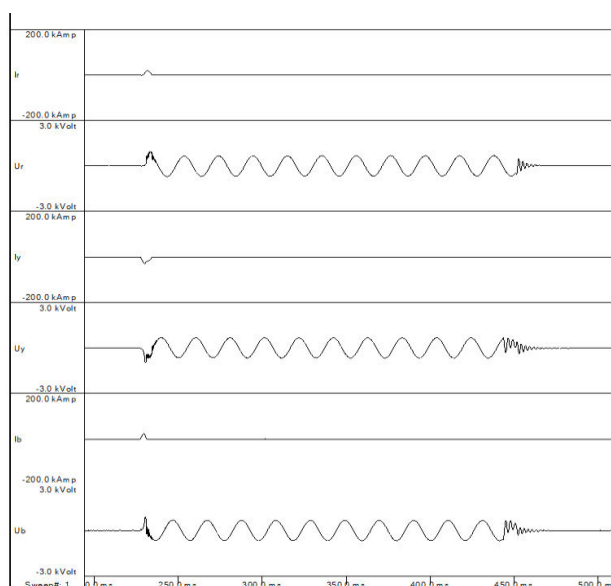


**V. SHORT CIRCUIT TEST AT CPRI**

During short circuit test When the breaker switches from conducting to non-conducting state, an electric arc forms during the opening contacts. Deionization processes must outnumber ionization processes in order for the arc to extinguish. Increasing arc resistance might cause the current to decrease over time. In the arc chamber, when it is expanded on the chamber plates, the arc resistance rises. The short-circuit current will cut off the arc when it hits zero.

**Case study on 800 V 400 A LTMCCB**

In this sample we have performed O-CO-CO Operation, before this operation we have taken prospective current and open circuit voltage according to customer requirement for 800V and 35 KA, after that sample was connected to the source terminal and we performed first O operation on the sample. During this operation breaker successfully performed O operation and no abnormality noticed during the operation.

**Figure-4 Oscillogram of First O operation**

After that we proceeded for next CO operation and in this operation, we have observed that a very heavy arcing noticed during the operation and MCCB body found completely damaged because of arcing produced during the operation and MCCB was not able to extinguish the arc in time.

As per data of test, During O operation MCCB took 10 ms to extinguish the arc but in next CO operation MCCB took 45 ms to extinguish the arc so the operating time increases approx. 4 times of the previous operation. and MCCB was not designed to sustain the arc for this much of time and due to this MCCB got heavily damaged during CO operation. These equipment's are specifically intended for testing at the accredited short-circuit testing facilities. Maximum short-circuit current 200 KA is available at CPRI Bhopal. Accredited short-circuit testing laboratory allow the manufacturers to replicate the short-circuit conditions that happened in electrical systems. Testing laboratories are able to set up voltage, current, and frequency levels that are required for electrical device testing. During the test in electrical network the equipment's are tested under the conditions which occur during real situation.

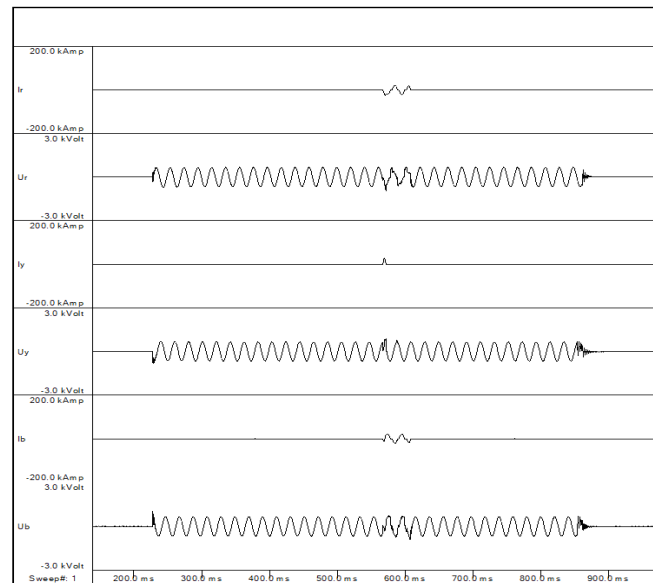


Figure-5 Oscillogram of CO operation

## VI. CAUSES OF FAILURE

The failure of a Molded Case Circuit Breaker (MCCB) can be caused by various factors, often related to electrical faults or issues in the power distribution system. Here are some possible causes:

- **Short circuit:**

A short circuit is one of the most common reasons for MCCB failure. If a severe short circuit occurs downstream of the MCCB, it can generate extremely high fault currents. The MCCB may fail to interrupt the fault current properly.

- **Overloading:**

Overloading an MCCB for an extended period can lead to overheating and eventual failure. It can overheat, potentially leading to a blast or damage.

- **Manufacturing or Quality issues:**

Faulty manufacturing or poor-quality components in the MCCB can lead to unexpected failures or malfunctions. These issues may not always be evident until a failure occurs.

- **Inadequate Maintenance:**

Lack of regular maintenance and inspection of MCCBs can contribute to their failure. Dust, corrosion, loose connections, or deteriorated insulation can compromise their performance and safety.

- **Environmental Factors:**

Extreme environmental conditions, such as excessive humidity, high temperatures, or exposure to corrosive substances, can accelerate the wear and tear of MCCBs leading to failures.

- **Improper Installation:**

Incorrect installation, incorrect sizing, or poor workmanship during installation can result in issues with both the MCCB and CT. For example, if the CT is not installed properly or is mismatched to the application, it can lead to problems

- **Circuit Resonance:**

In some cases, resonance conditions in the electrical circuit can lead to high voltages and currents, which can stress both the MCCB potentially causing failures. To prevent such simultaneous failures and ensure electrical safety, it's essential to conduct regular maintenance, follow proper installation procedures, and adhere to safety standards and guidelines. Additionally, using high-quality components and monitoring the electrical system for potential issues can help minimise the risk of MCCB failures. When failures do occur, a thorough investigation should be conducted to identify the root causes and take corrective actions to prevent future incidents.

## VII. CONCLUSION

1. As we have seen in Figure 5 of CO Operation If the operation mechanism starting time is too late, the moving contact will fall backward, which has a great disadvantageous effect on the interruption performance.
2. Operating mechanism should be designed such that it will extinguish the arc within stipulated time otherwise MCCB may get damaged heavily while its operation.
3. Adequate sizing and maintenance of an MCCB are key elements in order to guarantee safe and reliable operation in the long term.

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