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**application guide for
transient recovery voltage for
ac high-voltage circuit breakers
rated on a symmetrical current basis**

C37.0721-1971



american national standards institute, inc.

**American National Standard
Application Guide for Transient Recovery Voltage for
AC High-Voltage Circuit Breakers
Rated on a Symmetrical Current Basis**

Secretariat

Electrical and Electronics Technical Advisory Board

Approved May 26, 1971

American National Standards Institute, Inc

American National Standard

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Foreword

(This Foreword is not a part of American National Standard Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis, C37.0721-1971.)

This standard is one of a series of complementary standards on ac high-voltage circuit breakers rated on a symmetrical current basis, as follows:

C37.03-1964 (R1969)	Definitions for AC High-Voltage Circuit Breakers
C37.04-1964 (R1969)	Rating Structure for AC High-Voltage Circuit Breakers (Including Supplements C37.04a-1964 (R1969) and C37.04b-1970)
C37.05-1964 (R1969)	Methods for Determining the Values of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage for AC High-Voltage Circuit Breakers
C37.06-1971	Schedules of Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers
C37.07-1969	Interrupting Capability Factors for Reclosing Service for AC High-Voltage Circuit Breakers
C37.09-1964 (R1969)	Test Procedure for AC High-Voltage Circuit Breakers (Including Supplement C37.09a-1970)
C37.010-1964 (R1969)	Application Guide for AC High-Voltage Circuit Breakers
C37.11-1957 (R1966)	Requirements for Power Circuit Breaker Control
C37.12-1969	Guide Specifications for AC High-Voltage Circuit Breakers (Rated on a Symmetrical Current Basis and a Total Current Basis)

American National Standard C37.0721-1971 is one of several additional standards being developed on specific subjects applicable to ac high-voltage circuit breakers rated on a symmetrical current basis. Each will be published as soon as the work is completed and it has been approved, rather than waiting until all are complete to effect a complete revision of the basic standards. This approach will make the standards more readily available to the industry. It is planned in the future, to integrate these standards into revisions of the basic American National Standards on circuit breakers. The additional standards are:

C37.071-1969	Requirements for Line Closing Switching Surge Voltage Control
C37.072-1971	Requirements for Transient Recovery Voltage
C37.0721-1971	Application Guide for Transient Recovery Voltage
C37.0722-1971	Preferred Transient Recovery Voltage Ratings and Related Required Capabilities
C37.073	Requirements for Capacitance Current Switching
C37.0731	Application Guide for Capacitance Current Switching
C37.0732	Preferred Ratings for Capacitive Switching
C37.074	Requirements for Switching Impulse Voltage Insulation Strength
C37.076	Requirements for Pressurized Components
C37.077	Requirements for Current Transformers

C37.078	Requirements for External Insulation (Outdoor)
C37.0781	Dielectric Test Values for External Insulation (Outdoor)
C37.079	Guide to the Testing of Circuit Breakers with Respect to Out-of-Phase Switching

This standard was developed by the IEEE Switchgear Committee and the NEMA Switchgear Section and reviewed by the C37 Subcommittee on High-Voltage Circuit Breakers prior to approval by the Standards Committee on Power Switchgear, C37.

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N. Y. 10018.

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American National Standard

Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

NOTE: Refer to American National Standard C37.072-1971 for requirements for transient recovery voltage and refer to American National Standard C37.0722-1971 for preferred transient recovery voltage ratings and related required capabilities.

1. Scope

This standard covers the application guide for transient recovery voltage requirements for ac high-voltage circuit breakers rated above 1000 volts and on a symmetrical current basis.

The capability limits of these circuit breaker interrupting devices are determined largely by the transient recovery voltages. The guide for application is not included in other existing circuit breaker standards.

2. Purpose

The purpose of this standard is to provide an application guide on requirements for transient recovery voltage for ac high-voltage circuit breakers rated on a symmetrical current basis. American National Standard Requirements for Transient Recovery Voltage for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis, C37.072-1971, and American National Standard Preferred Transient Recovery Voltage Ratings and Related Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis, C37.0722-1971, cover definitions, rating structure, test procedures and preferred transient voltage ratings and related required capabilities. American National Standards C37.03-1964, C37.04-1964, C37.05-1964, C37.06-1971, C37.07-1969, C37.09-1964, C37.010-1964, C37.11-1957, and C37.12-1969, and their supplements, apply in other respects to these circuit breakers. Eventually this standard, American National Standards C37.072-1971 and C37.0722-1971 will be incorporated in the basic standards.

3. Transient Recovery Voltage

3.1 General. (During the interruption process

the arc voltage, which occurs across the terminals of a pole of a circuit breaker prior to current zero, approaches the normal-frequency pole-unit recovery voltage occurring after current zero, in a manner called the transient recovery voltage. If the circuit breaker is able to withstand the transient recovery voltage, and also the normal-frequency pole-unit recovery voltage, the circuit interruption will be successful.

Transient recovery voltages can be oscillatory, triangular, or exponential and can occur as a combination of these forms. The most severe oscillatory or exponential recovery voltages occur across the first pole to open of a circuit breaker interrupting a three-phase ungrounded symmetrical fault at its terminal, when the system voltage is maximum. Therefore, only three-phase ungrounded terminal faults need be considered when determining the transient recovery voltage capabilities of a circuit breaker. The triangular recovery voltages are associated with line faults. The initial rate of rise of the recovery voltages for line faults becomes greater the closer the fault is to the circuit breaker, however, the magnitude of this line side triangular wave decreases as the rate of rise increases. Generally, the source recovery voltage is much slower and only the triangular recovery voltage is effective in the early time of the transient recovery voltage. The amplitude of the recovery voltages for these line faults is determined on a single-phase basis during their early portions. The ability of a circuit breaker to withstand these triangular wave forms (short-line fault recovery voltages) depends a great deal on the type and design of the circuit breaker. A test procedure to demonstrate this capability is outlined in Section 5 of American National Standard C37.072-1971.

However, because different circuit breaker

designs have different recovery voltage characteristics, this test does not conclusively demonstrate any given circuit breaker's short-line fault interrupting ability for all short-line faults. Section 4.1.4.2 of American National Standard C37.072-1971 further clarifies a circuit breaker's short-line fault interrupting capabilities.

3.2 Transient Recovery Voltage Considerations

3.2.1 Effect of Circuit Breaker on Transient Recovery Voltage. The circuit transient recovery voltage can be modified or changed by the circuit breaker's design or by the circuit breaker's action. Therefore, the transient recovery voltage measured across the terminals of two different types of circuit breakers under identical conditions can be different. To recognize the modifying abilities of each of the various circuit breakers, when either calculating an actual transient recovery voltage or when specifying a rated value for the circuit breaker, would be an immense task.

To simplify both rating and application, the power system electrical characteristics are defined or calculated ignoring the effect of the circuit breaker. Thus, the transient recovery voltage which results when an ideal circuit breaker interrupts is used as the reference for both rating and application. This transient recovery voltage is called the pole-unit circuit transient recovery voltage. An ideal circuit breaker has no modifying effects on the electrical characteristics of a system and, when conducting, its terminal impedance is zero; at current zero its terminal impedance is infinite.

3.2.2 Transient Recovery Voltage Tests. It is possible to obtain the circuit transient recovery voltage by current injection techniques when the system is deenergized; or by measuring the transient recovery voltage response during interruption by a circuit breaker that has characteristics which approach the ideal circuit breaker, or, by measuring the actual transient recovery voltage of a circuit breaker and recognizing the circuit breaker's recovery voltage modification ability, calculating the actual circuit transient recovery voltage. The ability of any given type of circuit breaker to modify this circuit transient recovery voltage is considered in American National Standards C37.04-1964 and C37.09-1964. Each cir-

cuit breaker is tested to demonstrate that it has the ability to successfully interrupt under most system circuit conditions.

3.3 Method of Rating and Application

3.3.1 Selection of a Circuit Breaker. The transient recovery voltage ratings for circuit breakers are applicable at the rated symmetrical short circuit current and at the maximum rated voltage of the circuit breaker. For fractional values of the rated symmetrical short circuit current, related transient recovery voltage capability multipliers are given in Table 5 of American National Standard C37.0722-1971.

The transient recovery voltage ratings define a withstand boundary. The circuit transient recovery voltage and crest points of (1-cosine) waves that exceed this boundary at rated short circuit current, or the modified boundary for currents other than rated represent conditions in excess of the circuit breaker's rated or related capability. Either a different circuit breaker must be used, or the system must be modified in such a manner as to change its transient recovery voltage characteristics. The addition of capacitors to a bus or line is one method that can be used to change the system's recovery voltage characteristics.

3.3.2 Effect of the Asymmetry on Transient Recovery Voltage. The transient recovery voltages that occur when interrupting asymmetrical current values are generally less severe than when interrupting the related symmetrical current. Circuit breakers have the capability of interrupting these asymmetrical currents providing the circuit breakers are applied within their rating.

3.4 Calculating Circuit Transient Recovery Voltages. The calculation of circuit transient recovery voltages (system recovery voltages unmodified by the action of the circuit breaker) is complex. First it is necessary to determine the effective inductances and capacitances at the frequencies of the transient recovery voltage near the circuit breaker location; the number of lines or cables connected to the bus at the time of the fault, their equivalent surge impedance, their length, and their remote terminations and interconnections; the magnitude of the fault current, and the amount that is contributed from