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(Revision of ANSI/IEEE C37.27-1972)

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American National Standard

application guide for low-voltage ac nonintegrally fused power circuit breakers (using separately mounted current-limiting fuses)

ANSI/IEEE C37.27-1987

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An American National Standard

IEEE Standard Application Guide for Low-Voltage AC Nonintegrally Fused Power Circuit Breakers (Using Separately Mounted Current-Limiting Fuses)

Sponsor

Switchgear Committee of the
IEEE Power Engineering Society

Secretariat

Institute of Electrical and Electronics Engineers
National Electrical Manufacturers Association

Approved May 21, 1981

IEEE Standards Board

Approved May 30, 1986

American National Standards Institute

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Foreword

(This Foreword is not a part of ANSI/IEEE C37.27-1987, IEEE Standard Application Guide for Low-Voltage AC Nonintegrally Fused Power Circuit Breakers [Using Separately Mounted Current-Limiting Fuses].)

This publication is one of a series of complementary American National Standards:

ANSI/IEEE C37.13-1981, IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures

ANSI/IEEE C37.14-1979, IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures

ANSI C37.16-1980, American National Standard Preferred Ratings, Related Requirements, and Applications Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors

ANSI C37.17-1979, American National Standard Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers

ANSI/IEEE C37.18-1979, IEEE Standard Enclosed Field Discharge Circuit Breakers for Rotating Electric Machinery

ANSI/IEEE C37.20-1969, IEEE Standard for Switchgear Assemblies Including Metal-Enclosed Bus (Includes Supplements ANSI/IEEE C37.20a-1970, ANSI/IEEE C37.20b-1972, ANSI/IEEE C37.20c-1974, and ANSI/IEEE C37.20d-1978)

ANSI/IEEE C37.29-1981, IEEE Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures

This application guide represents the standard practice in the United States relating to combination of low-voltage ac power circuit breakers (see ANSI/IEEE C37.13-1981) and low-voltage ac current-limiting cartridge fuses. This application guide specifically does not cover the combination of molded case circuit breakers and low-voltage current-limiting fuses. It does cover the combination of low-voltage air circuit breakers and separately mounted current-limiting fuses that together function as a coordinated protective device.

It is the policy of both the Institute of Electrical and Electronics Engineers and American National Standards Accredited Committee C37 to maintain this standard current with the state of the technology. Comments on this standard, as well as suggestions for additional material that should be included are invited. These should be addressed to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, with copy to the

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An American National Standard

IEEE Standard Application Guide for Low-Voltage AC Nonintegrally Fused Power Circuit Breakers (Using Separately Mounted Current-Limiting Fuses)

1. Scope

This guide applies to low-voltage power circuit breakers of the 600 V insulation class with separately mounted current-limiting fuses for use on ac circuits with available short-circuit current of 200 000 A (rms symmetrical) or less. Low-voltage integrally fused power circuit breakers and combinations of fuses and molded-case circuit breakers are not covered by this guide.

This guide sets forth recommendations believed essential for the selection of current-limiting fuses (see ANSI C97.1-1972 (R 1978) [3][1]) for use in combination with low-voltage power circuit breakers, rated in accordance with ANSI/IEEE C37.13-1981 [4].

2. References

When the following American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute, Inc, the latest revision shall apply:

[1] ANSI C37.16-1980, Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors.[2]

[2] ANSI C37.17-1979, Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers.

[3] ANSI C97.1-1972 (R 1978), Low-Voltage Cartridge Fuses 600 Volts or Less.

[4] ANSI/IEEE C37.13-1981, IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.

[5] ANSI/IEEE C37.14-1979, IEEE Standard for Low-Voltage DC Power Circuit Breakers in Enclosures.

[6] ANSI/IEEE C37.18-1979, IEEE Standard Enclosed Field Discharge Circuit Breakers for Rotating Electric Machinery.

[7] ANSI/IEEE C37.20-1969, IEEE Standard for Switchgear Assemblies Including Metal-Enclosed Bus (Includes Supplements ANSI/IEEE C37.20a-1970, ANSI/IEEE C37.20b-1972, ANSI/IEEE C37.20c-1974, and ANSI/IEEE C37.20d-1978).

[8] ANSI/IEEE C37.29-1981, IEEE Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures.

3. General

Combinations of low-voltage ac power circuit breakers and current-limiting fuses provide a broader range of circuit protection than either device can provide alone. Such combinations,

[1] The numbers in brackets correspond to those of the references listed in Section 2 of this standard.

[2] ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

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when properly selected, can retain the versatility of switching and overload protection which circuit breakers can provide, and can be applied on systems with available short-circuit current up to 200 000 A (rms symmetrical), which is appreciably higher than the short-circuit current rating of circuit breakers.

Fuses with identical continuous current ratings per ANSI C97.1-1972 (R 1978) [3] made by different manufacturers exhibit a range of clearing I^2t, temperature rise, time-current, maximum peak let-through current, and arc voltage characteristics. Therefore, it is not feasible to select a circuit breaker-fuse combination by continuous current ratings alone. The degree of protection provided for a circuit breaker by a fuse at current levels above the circuit breaker short-circuit current rating will vary with different values of maximum clearing I^2t, maximum peak let-through current, and arc voltages of the fuse. The duty on a circuit breaker may be more severe at short-circuit current levels slightly above its short-circuit rating than at very high short-circuit current levels. For a specific fuse type, the use of peak current as a criterion is only an approximation for the combined effects of maximum clearing I^2t, maximum peak let-through current, and arc voltage of the fuse.

The criteria necessary for making the proper fuse selection are as follows:

(1) Continuous current rating of the circuit breaker and fuse

(2) Available short-circuit current level at the application point

(3) Short-circuit current rating of the circuit breaker

(4) Time-current characteristics of the circuit breaker and the fuse

(5) Peak let-through current characteristic of the fuse

For each circuit breaker on a system there is a maximum fuse rating that will provide the required short-circuit protection for the circuit breaker. Also, there is a minimum fuse rating that will coordinate with the circuit breaker time-current characteristic as well as its continuous-current rating based on temperature rise limits. The selection of a fuse rating within these two limits will provide adequate protection for the circuit breaker and avoid unnecessary fuse opening for fault current within the short-circuit rating of the circuit breaker. Recommendations for establishing the range of fuse ratings to provide the required protection and coordination for a given application should be based on fuse and circuit breaker characteristics as provided in Section 4.

4. Coordination of Circuit Breaker and Fuse

A current-limiting fuse should be chosen that has operating characteristics that will protect the circuit breaker. A fuse of the type recommended by the circuit breaker manufacturer should be selected with a rating that complies with the following criteria.

4.1 Maximum Fuse Rating to Be Used. The maximum continuous current rating for the fuse that will adequately protect the circuit breaker should be determined by the following:

(1) The fuse should operate in its current-limiting region (starting at Point A of Fig 1), for all available short-circuit current extending from the circuit breaker short-circuit current rating at the specific application voltage up to and including the maximum available short-circuit current at the point of application of the system.

(2) The fuse should be selected so that the instantaneous peak let-through current of the fuse at an available rms symmetrical short-circuit current of either 100 000 A or the maximum that the system can provide at the point of application, whichever is greater, does not exceed twice the 240 V rms symmetrical short-circuit current rating of the circuit breaker as listed in Table 1 of ANSI C37.16-1980 [1], when equipped with direct-acting instantaneous trip elements (see Fig 1).

(3) When the circuit breaker is equipped with electromechanical trip devices having ratings less than the minimum ratings of 240 V as shown in Table 1 of ANSI C37.16-1980 [1], restrictions in short-circuit ratings for different maximum voltage ratings should be observed. The maximum fuse rating must be reduced to limit the peak let-through current to twice the 480 V or 600 V rms short-circuit current rating of the circuit breaker, whichever current applies to the trip device rating used.

The minimum trip coil ratings shown in Table 1 of ANSI C37.16-1980 [1] may not apply if the circuit breaker is equipped with a solid-state tripping device. In this case, the manufacturer should be consulted.

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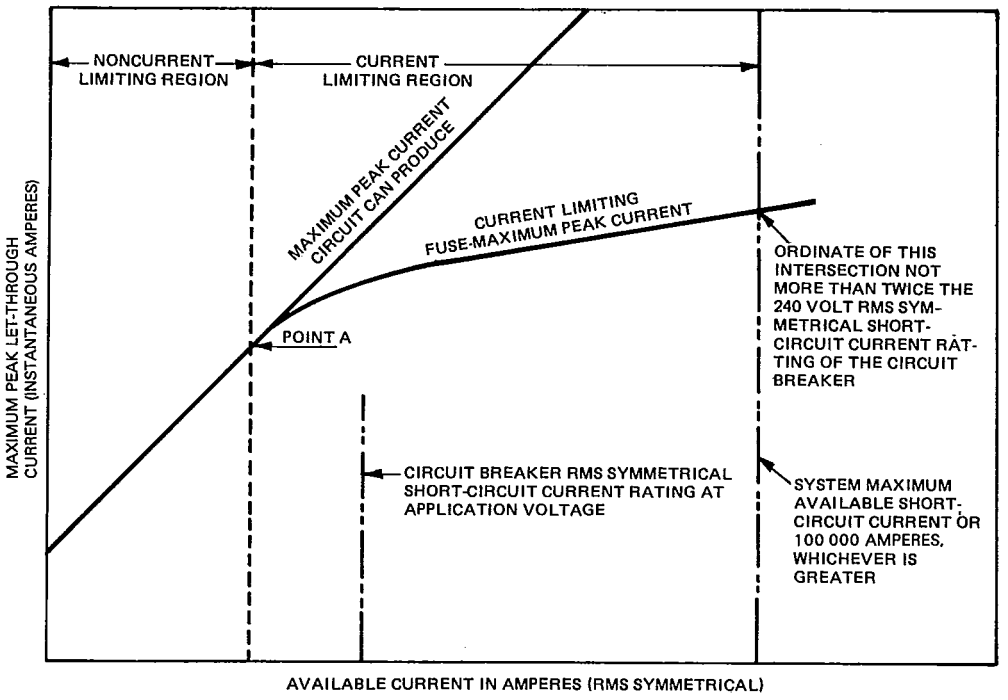

Fig 1
Illustrative Peak Let-Through Current Characteristic

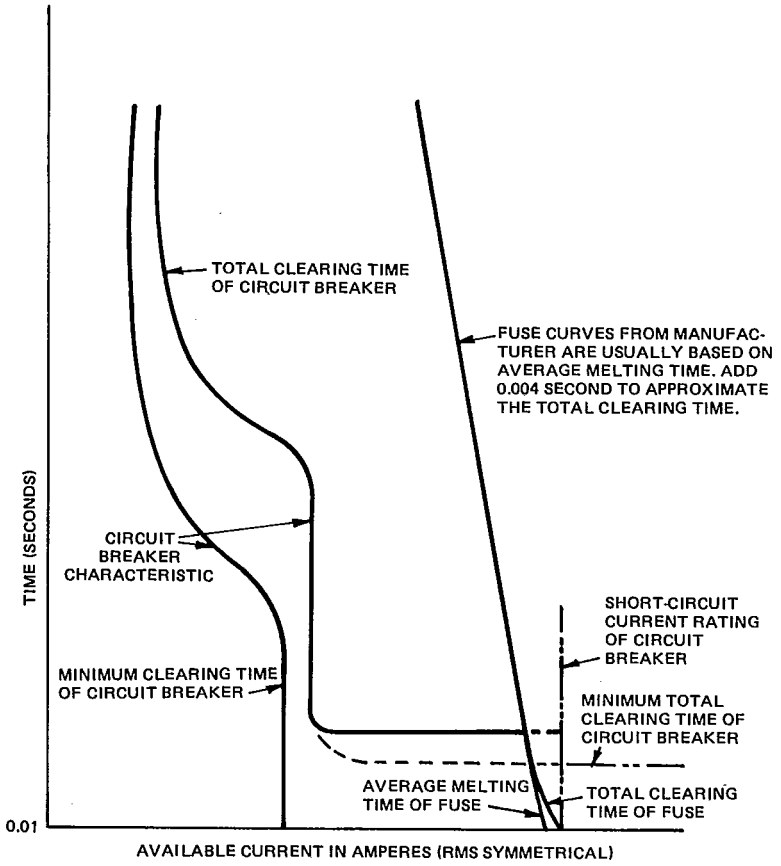

Fig 2
Typical Time-Current Characteristics with Maximum Fuse Rating

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(4) The total clearing time of the fuse should be equal to or less than the minimum total clearing time of the circuit breaker at a current equal to the short-circuit current rating of the circuit breaker at the system voltage (see Fig 2). Since the circuit breaker manufacturers published data is usually for the maximum total clearing time, subtract 0.016 s to approximate the minimum total clearing time of the circuit breaker.

4.2 Minimum Fuse Rating to Be Used. The minimum continuous current rating for the fuse to coordinate with the circuit breaker should be determined as follows:

(1) The fuse should be selected so that its average melting-time current characteristic curve does not overlap the circuit breaker total clearing time in the long-time-delay portion of the circuit breaker curve. The average melting time of the fuse t_2 should be at least twice the total clearing time of the breaker t_1 at the current level where the long-time-delay current characteristic shifts to the short-time-delay or instantaneous element (see fuse characteristic A of Fig 3).

(2) The addition of a short-time element makes it possible to use a fuse with a smaller continuous current rating than would otherwise be recommended (t_4 should also be at least twice t_3). (See fuse characteristic B of Fig 3.)

(3) The continuous current rating of the fuse is to be not less than 150% of the trip coil rating of the electromechanical trip device when located within 4 ft of the circuit breaker, and in no case should it be less than the trip coil rating.

This limitation may not apply when solid-state tripping devices are installed on the circuit breaker and the manufacturer should be consulted.

5. Location of Fuses

The fuse should preferably be on the power source side of the circuit breaker. When conditions prevent this, the two devices should be located as close to each other as practicable, and the installation should be arranged so as to minimize the chances of a fault occurring between the circuit breaker and fuse.

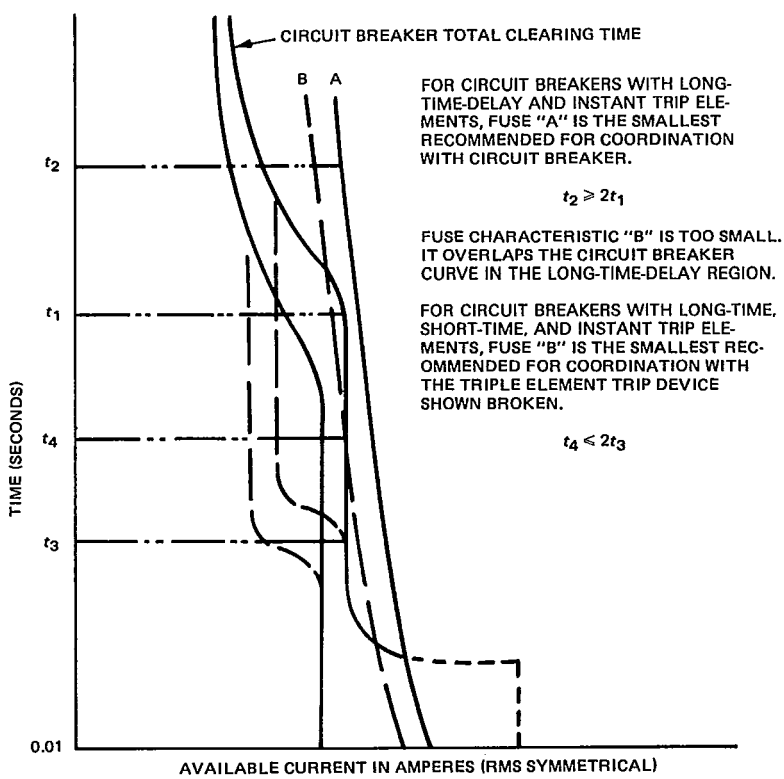

Fig 3
Typical Time-Current Characteristics with Minimum Fuse Rating

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Wherever fuses are located in the circuit, it should be possible to deenergize them during replacement.

6. Open Fuse Trip Devices

Integrally fused low-voltage power circuit breakers are equipped with open fuse trip devices. Applications of separately mounted current-limiting fuses with low-voltage power circuit breakers should be analyzed to establish the need for single-phase protection and the functions of open fuse trip devices utilized if required.

Open Fuse Trip Device: A device that operates to open (trip) all phases of a circuit by means of a circuit breaker in response to the opening, or absence, of one or more fuses integral to the circuit-breaker on which the device is mounted.

After operating, the device shall prevent closing of the circuit breaker until a reset operation is performed.[3]

7. Addition of Fuses to Existing Installations

Applications arise where it is desirable to add fuses in combination with circuit breakers already in the field. Since these circuit breakers may antedate the rating structure upon which this guide is based, the circuit breaker manufacturer should be consulted.

In addition, care should be exercised that the balance of the system is also adequately designed to withstand the higher short-circuit current.

8. Protection of Connected Equipment

When applied on high short-circuit current capacity systems the effects of the let-through characteristics of the fused power circuit breaker on the connected equipment should be considered. The presence of the current-limiting fuse as part of the fused circuit breaker does not necessarily imply that the connected equipment can adequately withstand these effects. It should be noted that the fused circuit breaker does not have any current limiting effect until the current associated with the fault exceeds the current required to make the fuse current-limiting.

Where fuses of different manufacture are being considered for the same system, the characteristics of all the fuses and circuit breakers in the system should be evaluated, since both the melting time current characteristic and peak let-through current of a given fuse rating may vary substantially.

9. Tested Combinations of Circuit Breakers and Fuses

It is recognized that the selection of a fuse by the criteria of this standard is conservative. Other selections of combinations can be used when tested in combination show acceptable performance.

[3] Since this type of device normally operates by sensing the potential across the fuses, it may not prevent closing of the circuit breaker with an open or missing fuse, but in most cases will cause an immediate trip if such an operation is performed. There is a practical limit of load impedance above which the device (sensing voltage across an open or missing fuse) will not function as described.

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