ANSI/IEEE C37.29-1981
(Revision of ANSI/IEEE C37.29-1974)
(Reaffirmed 1985)

An American National Standard

IEEE Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures

Sponsor
Switchgear Committee
of the
IEEE Power Engineering Society

Secretariat

Institute of Electrical and Electronics Engineers, Inc.
NationalElectrical Manufacturers Association

Approved December 18, 1980
Reaffirmed September 19, 1985
Reaffirmed February 15, 1990

IEEE Standards Board

Approved September 2, 1981
Reaffirmed June 30, 1988
Reaffirmed July 19, 1990

American National Standards Institute

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Foreword

(This Foreword is not a part of ANSI/IEEE C37.29-1981, IEEE Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures.)

This standard supersedes ANSI C37.29-1974 and IEEE Std 508-1974. It has been revised to reflect changes in the related ANSI/IEEE C37.13-1981. Section 9. of this standard, Test Procedures, constitutes a separate standard, ANSI C37.52-1974 (R1980). The power circuit protectors described in this standard are based on low-voltage ac power circuit breakers covered by ANSI/IEEE C37.13-1981, although power circuit protectors based on molded case circuit breakers may also meet the requirements of this standard.

The Standards Committee on Power Switchgear, C37, which reviewed and approved this Guide, had the following personnel at the time of approval:

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J. E. Beehler *(Executive Vice-Chairman of High Voltage Switchgear Standards)*
W. E. Laubach *(Executive Vice-Chairman of Low Voltage Switchgear Standards)*
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At the time it approved this standard the Low-Voltage Switchgear Devices Subcommittee had the following Membership:

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J.T. Carroll	J.F. Sellers	J.P. Werner
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The working group of the Low-Voltage Switchgear Devices Subcommittee that prepared the revision of this standard were:

J.L. Drown, *Chair*

R.J. Alton	E.J. Huber	J.P. Werner
J.L. Drown	R.A. McMaster	

When it approved this standard on December 18, 1980, the IEEE Standards Board had the following membership:

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An American National Standard

IEEE Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures

1. Scope

This standard covers enclosed low-voltage ac power circuit protectors:

1) Stationary type of 2-pole or 3-pole construction
2) Having one or more rated maximum voltages of 508 V and 254 V rms for application on systems having nominal voltages of 480 V and 240 V rms
3) Manually operated or power operated
4) With current limiting fuses such that the entire device is suitable for application on circuits capable of delivering not more than 200 000 A rms symmetrical short-circuit current.

NOTE — In this standard, the use of the words *circuit protector* shall be considered to mean enclosed *low-voltage ac power circuit protector.*

2. References

When the American National Standards referred to in this standard are superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply.

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

[2] ANSI C37.52-1974 (R1980), American National Standard Test Procedures for Low-Voltage AC Power Circuit Protectors Used in Enclosures.

[3] ANSI/EEE C37.20-1969, IEEE Standard for Switchgear Assemblies Including Metal-Enclosed Bus. (1974 Consolidated Edition includes supplements a, b, c, and d.)

[4] ANSI/EEE C37.100-1981, IEEE Standard Definitions for Power Switchgear.

[5] IEEE Std 4-1978, IEEE Standard Technique for High-Voltage Testing.

[6] IEEE Std 141-1976, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants.

[1]ANSI documents are available from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

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[7] IEEE Std 241-1974, IEEE Recommended Practice for Electric Power Systems in Commercial Buildings.

[8] IEEE Std 242-1975, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

3. Service Conditions

A circuit protector conforming to this standard shall be suitable for operation up to and including all of its standard ratings, providing that:

1) The temperature of the air surrounding the circuit protector is not below − 5°C
   NOTE — When properly applied in metal-enclosed switchgear or individual enclosures, a circuit protector will operate within the limits of ambient temperature of the air surrounding the enclosure as specified in ANSI/ IEEEC37.20-1969 [3].
2) The altitude does not exceed 6600 ft (2000 m)
3) The relative humidity is such that there will be no condensation on the circuit protection parts at any time
4) None of the conditions as listed in 10.3.2 prevail

For application of circuit protectors under service conditions other than those above, refer to Section 10., Application Guide.

4. Definitions

The definitions of most terms used in this standard are found in ANSI/IEEE C37.100-1981 [4].[2]

Additional definitions are as follows:

power circuit protector: An assembly consisting of a modified low-voltage power circuit breaker, which has no direct-acting tripping devices, with a current-limiting fuse in series with the load terminals of each pole.

switching current: The value of rms symmetrical current expressed in amperes, which the power circuit breaker element of the circuit protector interrupts at the rated maximum voltage and rated frequency under the prescribed test conditions.

open-fuse trip device: A device that operates to open (trip) all poles of a circuit protector in response to the opening, or absence, of one or more fuses integral to the circuit protector on which the device is mounted. After operating, the device shall prevent closing of the circuit protector until reset operation is performed.

NOTE — Since some open-fuse-trip devices may operate by sensing the voltage across the fuses, they may not prevent closing of the circuit protector 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.

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

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5. Ratings

5.1 General

The rating of low-voltage ac power circuit protectors is a designated limit of operating characteristics based upon service conditions in Section 3. and shall include the following:

1) Rated maximum voltage(s)
2) Rated frequency
3) Rated continuous current
4) Rated switching current
5) Rated short-circuit current
6) Rated control voltage(s)

The designated ratings in ANSI C37.16-1980 [1] are preferred, but are not considered to be restrictive.

5.2 Rated Maximum Voltage

The rated maximum voltage of a circuit protector is the highest rms voltage three-phase or single-phase at which it is designed to perform in accordance with the applicable requirements of this standard. The circuit protector shall be rated at one or more of the following voltages: 508 V—254 V.

5.3 Rated Frequency

The rated frequency of a circuit protector is the frequency at which it is designed to perform. The circuit protector shall be rated at 60 Hz.

5.4 Rated Continuous Current

The rated continuous current of a circuit protector is the designated limit of current in rms amperes at rated frequency which it shall be required to carry continuously without exceeding the temperature limitations designated in Section 7.. The preferred continuous current ratings are listed in ANSI C37.16-1980 [1].

5.5 Rated Switching Current

The rated switching current of a circuit protector is the maximum value of rms symmetrical current expressed in amperes which the circuit breaker element of a power circuit protector shall be required to interrupt at the rated maximum voltage and rated frequency under the prescribed test conditions. The rated switching current is normally 12 times the rated continuous current. Preferred rated switching currents are listed in Table 20 of C37.16-1980 [1].

5.6 Rated Short-Circuit Current

The rated short-circuit current of a circuit protector is the designated limit of available (prospective) three-phase current at which it shall be required to perform its short-circuit current duty cycle at rated maximum voltage under the prescribed test conditions. This current is expressed as the rms symmetrical value of current measured from the available current wave envelope at a time $^1/_2$ cycle after short-circuit initiation.

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Circuit protectors shall be capable of performing the short-circuit current duty cycle with all degrees of current asymmetry produced by three-phase or single-phase circuits having a short-circuit power factor of 20% or greater (*X/R* ratio 4.9 or less).

Table 1— Functional Components

Functional Component	Operating Mechanism Type	
	Manual	Power
(1) Current-limiting fuse—one per pole	X	X
(2) Open fuse trip device	X	X
(3) Contact position indicator	X	X
(4) Independent manually operated mechanism, trip free, with attached operating handle	X	—
(5) Power operated-mechanism, trip free, with anti-pump feature and maintenance closing device	—	X
(6) Shunt trip device with necessary control auxiliary switches	—	X
(7) Stored energy indicator	X*	X*
(8) Nameplate(s) with markings in accordance with 6.1	X	X

*Required only on a closing mechanism which provides for stored energy operation when the mechanism can be left in the charged position.

The short-circuit current duty cycle shall consist of an opening operation and a close-open operation, separated only by the time necessary to replace fuses and reset the open fuse trip device.

The preferred three-phase short-circuit current ratings are listed in Table 20 of ANSI C37.16-1980 [1]. The preferred single-phase short-circuit current ratings, as noted in the footnote under these tables, are 87% of the three-phase ratings, based on the rated maximum voltage being impressed across a single pole. For other single-phase applications, see 10.1.4.

5.7 Rated Control Voltage

The rated control voltage is the voltage at which the mechanism of the circuit protector is designed to operate when measured at the control power terminals of the operating mechanism with the highest operating current flowing. Rated control voltages and their ranges are listed in Table 23 of ANSI C37.16-1980.

6. Functional Components

The functional components required for manual and power operated circuit protectors are listed in Table 1. Additional accessory devices may be available. The manufacturer should be consulted for specific information.

6.1 Nameplate(s)

The following minimum information shall be given on the nameplates of all circuit protectors:

1) Manufacturer’s name
2) Type of circuit protector (manufacturer’s type designation)

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3) Rated continuous current
4) Applicable fuse type and size limitation
5) Rated maximum voltage(s)
6) Rated short-circuit current
7) Rated switching current
8) Rated frequency
9) Rated control voltage (where applicable)
10) Year of manufacture, by date or code
11) Identification number
12) Manufacturer's Data Sheets or instruction book reference

6.2 Contact Position Indicator

The following colors shall be used:

1) Red background with the word CLOSED in white or aluminum (contrasting) letters to indicate closed contacts
2) Green background with the word OPEN in white or aluminum (contrasting) letters to indicate open contacts

6.3 Stored Energy Indicator

The following colors shall be used:

1) Yellow background with black lettering to indicate that the closing mechanism is charged
2) White background with black lettering to indicate that the closing mechanism is discharged

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Table 2— Limits of Temperature

	Limits of Temperature Rise Over Air Surrounding Enclosure (°C)	Limit of Total Temperature (°C)
Class 90 Insulation	50	90
Class 105 Insulation	65	105
Class 130 Insulation	90	130
Class 155 Insulation	115	155
Class 180 Insulation	140	180
Class 220 Insulation	180	220
Circuit Protector Contacts Conducting Joints and Other Parts except the following:	85	125
Line and Load Terminal Connections*	55	95
Fuse Terminals (unless used as Line or Load Terminals Connections)	†	†

*Terminal connection temperatures are based on connections to bus in low-voltage metal-enclosed switchgear. If connections are made to cables, recognition must be given to possible thermal limitations of the cable insulation and appropriate measures taken.
†No specified limit except not to damage adjacent parts.

7. Temperature Limitations and Classification of Insulating Materials

7.1 Temperature Limits

The temperarature limits on which the rating of circuit protectors is based are determined by the characteristics of the insulating materials used and the metals which are used in current-carrying parts and springs.

7.2 Limits of Observable Temperature Rise

The observable temperature rise of the various parts of the circuit protector above the temperature of the air surrounding the circuit protector test enclosure, when subjected to temperature tests in accordance with this standard shall not exceed the values given in Table 2. This table applies only to a circuit protector having all contacts silver-surfaced, silver, silver alloy, or equivalent, and in addition, having all conducting joints, moving or fixed, including terminal connections either

1) silver-surfaced and held mechanically or
2) brazed, welded, or silver-soldered or
3) fixed rigid mechanical joints surfaced with suitable material other than silver.

7.3 Classification of Insulating Materials

For the purpose of establishing temperature limits, insulating materials shall be classified as follows:

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Class 90 Insulating. Materials or combinations of materials such as cotton, silk, and paper without impregnation. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 90 °C.

Class 105 Insulation. Materials or combinations of materials such as cotton, silk, and paper when suitably impregnated or coated or when immersed in a dielectric liquid such as oil. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 105 °C.

Class 130 Insulation. Materials or combinations of materials such as mica, glass fiber, asbestos, etc, with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 130 °C.

Class 155 Insulation. Materials or combinations of materials such as mica, glass fiber, asbestos, etc, with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 155 °C.

Class 180 Insulation. Materials or combinations of materials such as silicone elastomer, mica, glass fiber, asbestos, etc, with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 180 °C.

Class 220 Insulation. Materials or combinations of materials that by experience or accepted tests can be shown to be capable of operation at 220 °C.

Over Class 220 Insulation. Insulation that consists entirely of mica, porcelain, glass, quartz, and similar inorganic materials. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at temperatures over 220 °C.

NOTES:

1 — Insulation is considered to be *impregnated* when a suitable substance provides a bond between components of the structure and also a degree of filling or surface coverage sufficient to give adequate performance under the extremes of temperature, surface contamination (moisture, dirt, etc), and mechanical stress expected in service. The impregnant must not flow or deteriorate enough at operating temperature to seriously affect performance in service.

2 — The electrical and mechanical properties of the insulation must not be impaired by the prolonged application of the limiting insulation temperature permitted for the insulation class. The word *impaired* is here used in the sense of causing any change that could disqualify the insulating material from continuously performing its intended function, whether it is creepage, spacing, mechanical support, or dielectric barrier action.

3 — In the preceding definitions, the words *accepted tests* are intended to refer to recognized test procedures established for the thermal evaluation of materials by themselves or in simple combinations. Experience or test data used in classifying insulating materials are distinct from the experience or test data derived for the use of materials in complete systems. The thermal endurance of complete systems may be determined by test procedures specified by the responsible technical committees. A material that is classified as suitable for a given temperature in the preceding may be found suitable for a different temperature, either higher or lower, by an insulation system test procedure. For example, it has been found that some materials suitable for operation at one temperature in air may be suitable for a higher temperature when used in a system operated in an inert gas atmosphere.

4 — It is important to recognize that other characteristics, in addition to thermal endurance, such as mechanical strength, moisture resistance, and corona endurance, are required in varying degrees in different applications for the successful use of insulating materials.

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8. Insulation (Dielectric) Withstand Voltage Requirements

8.1 Circuit Protectors

Circuit protectors, when tested in accordance with Section 9., shall be capable of withstanding without damage, the following power frequency test voltages (dry test) for a period of 60 s. The test voltages shall be essentially sinusoidal with a crest value equal to 1.414 times the specified values. The frequency of the test voltage shall be within ±20% of rated frequency of the circuit protector being tested. The test voltages are as follows:

1) Primary circuit of a new completely assembled circuit protector—2200 V
2) Secondary control wiring (except items 3, 4, and 5)—1500 V
3) Motors shall be tested at their specified dielectric withstand voltage but not less than 1000 V
4) Control devices and circuits operating at 80 V ac rms (110 V dc) or less not connected directly to primary or external secondary control circuits—500 V
5) For undervoltage trip devices operating at a voltage about 250 V ac—twice rated voltage plus 1000 V
6) After interruption of a short-circuit current duty cycle and before servicing the withstand test voltage shall be 60% of the values listed in (1)—(5) above
7) After storage or installation in the field, a circuit protector which has not been subjected to a short-circuit current interruption or has been serviced after interruption shall withstand 75% of the values listed in (1)—(5) above

8.2 Dielectric Test Procedures

The dielectric test procedures and the method of voltage measurement shall be in accordance with IEEE Std 4-1978 [5].

9. Test Procedures

Refer to ANSIC37.52-1974 (R1980) [2], American National Standard for Test Procedures for Low-Voltage AC Power Circuit Protection Used in Enclosures.

10. Application Guide

This guide covers the application of circuit protectors on low-voltage ac systems and appliesto circuit protectors rated in accordance with Section 5.

10.1 General

Circuit protectors should be applied within their assigned voltage(s), frequency, continuous current, switching current, and short-circuit current ratings as defined in this standard, with proper consideration given to the service conditions stated in Section 3. They should be selected to provide the protection required by the other-components of the circuit. For other applications not covered by this standard, the manufacturer should be consulted.

10.1.1 Voltage

The voltage of the system to which circuit protectors are applied, including any possible variations, should not exceed the rated maximum voltages listed in 5.2. For applications at voltages between those listed, a circuit protector having the next higher rated maximum voltage should be selected.

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10.1.2 Frequency

The normal applicable frequency for circuit protectors is 60 Hz (see 5.3). Application at 50 Hz does not require any special consideration.

10.1.3 Continuous Current

The circuit protector should be applied to a circuit having a maximum continuous-load current no greater than the continuous current rating of the circuit protector or of the fuse installed, whichever is less.

10.1.4 Short-Circuit Current

Circuit protectors may be applied on a system when the calculated maximum available short-circuit current on the source side of the protector is not more than the short-circuit current rating of the circuit protector, except as modified by the power factor considerations in 10.1.4.3.

For three-phase ac circuits, the available current to be calculated is the maximum rms symmetrical value of the three-phases at an instant one-half cycle after the short-circuit occurs. This value is the total available current from all sources, including synchronous and induction motors.

For single-phase ac circuits, the current should be calculated using the same considerations as used for three-phase circuits. When a circuit protector is applied in such a way on a single-phase circuit that the system voltage impressed across a single pole is no greater than 58% of any one of the rated maximum voltages, the maximum available short-circuit current may be equal to 100% of the corresponding three-phase short-circuit current rating.

In determining the suitability of a circuit protector for the short-circuit current conditions of a system, consideration should be given to:

1) Source contribution
2) Motor contribution
3) Effects of power factor

IEEE Std 141-1976 [6], IEEE Std 241-1974 [7], and IEEE Std 242-1975 [8] are recommended for guidance in calculating short-circuit currents.

10.1.4.1 Source Contribution

The symmetrical short-circuit current, consisting of the sum of all sources, should be calculated by taking into account all impedances up to the source side of the circuit protector but not including any of the circuit protector impedance. Small impedances, such as cable impedances, should be taken into account, since they may greatly affect the result.

10.1.4.2 Motor Contribution

The part of the symmetrical short-circuit current due to motor contributions may be calculated as follows:

Induction and synchronous motors connected to the bus, act as generators, and at one-half cycle after the short-circuit occurs, contribute current that may be calculated from the subtransient reactance of the motor plus the impedance of the interconnecting cable. Where the impedances for the installation are not known, it should be assumed that the induction motors contribute 3.6 times their full-load current and that synchronous motors contribute 4.8 times their full-load current.

When the motor load of the installation is not known, the following assumptions should be made:

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1) For nominal system voltages of 120 V and 208Y/120 V, it should be assumed that the connected load is 50% lighting and 50% motor load. This corresponds to an equivalent symmetrical contribution of approximately twice the full-load current
2) For nominal system voltages of 240 V to 480 V, it should be assumed that the load is 100% motor load and in the absence of exact information, that 25% of the motors are synchronous and 75% induction. This corresponds to an equivalent symmetrical contribution of approximately four times the full-load current.

10.1.4.3 Power Factor Considerations

Normally the short-circuit power factor of the system need not be considered in applying circuit protectors. This is based on the fact that the power factor of 20% (*X/R* ratio of 4.9), on which the ratings of the circuit protectors in this standard have been established, amply covers most applications. There are, however, some specific applications when the available short-circuit current approaches 80% of the protector short-circuit current rating, which may require additional consideration because of lower short-circuit power factors:

1) Local generation at circuit protector voltage in unit sizes greater than 500 kVA
2) Gas filled and dry-type transformers in sizes 1000 kVA and above. All types, 2500 kVA and above
3) Transformers with impedances higher than those specified in C57 series. (American National Standard Requirements, Terminology, and Test Code for Distribution, Power and Regulating Transformers, and Reactor Other than Current-Limiting Reactors)
4) Current-limiting reactors at circuit protector voltage in source circuits
5) Current-limiting busway at circuit protector voltage in source circuits

To determine the short-circuit current rating of the circuit protector required for these applications, two approaches are possible:

1) If the short-circuit *X/R* ratio of the power system has not been determined, the calculated short-circuit current should be multiplied by 1.26
2) If the short-circuit *X/R* ratio of the power system is known, the appropriate multiplying factor can be selected from the table below:

System Short-Circuit Power Factor Percent	System *X/R* Ratio	Multiplying Factor for Calculated Short-Circuit Current
20	4.9	1.00
15	6.6	1.07
12	8.27	1.11
10	9.95	1.15
8.5	11.72	1.18
7	14.25	1.21
5	20.0	1.26

10.2 Protection of Connected Equipment

When applied on high short-circuit current-capacity systems, the effects of the let-through characteristics of power circuit protectors on the connected equipment must be considered. The presence of the current-limiting fuse as a part of the power circuit protector does not necessarily imply that this connected equipment can adequately withstand these effects.

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It should be noted that the power circuit protector does not have any current-limiting effect until the current associated with the fault exceeds the threshold current of the fuse.

10.3 Service Conditions Affecting Circuit Protector Applications

10.3.1 Altitude Correction

Circuit protectors, when applied at altitudes greater than 6600 ft (2000 m), should have their dielectric withstand, continuous current, and rated maximum voltage ratings multiplied by the following correction factors to obtain values at which the application is made. The switching current and short-circuit current ratings are not affected by altitude.

Altitude*		Rating Correction Factor	
Feet	Meters	Continuous Current	Voltage
6600 (and below)	2000	1.00	1.00
8500	2600	0.99	0.95
13000	3900	0.96	0.80

*Values for intermediate altitudes may be derived by linear interpolation.

10.3.2 Other Service Conditions

Certain service conditions may require unusual construction or operation, and these should be brought to the attention of those responsible for the application, manufacture, and operation of the circuit protector. Wherever possible, steps, such as inclusion of heaters, placement in controlled atmosphere areas, or others, should be taken at the site of the installation to nullify the deleterious effect of the following:

1) Exposure to damaging fumes or vapors, excessive or abrasive dust, explosive mixture of dust or gases, steam, salt spray, excessive moisture, dripping water and other similar conditions
2) Exposure to abnormal vibration, shocks, or tilting
3) Exposure to excessively high or low temperature
4) Exposure to unusual transportation or storage conditions
5) Exposure to extreme solar temperatures
6) Unusual operating duty, frequency of operation, and difficulty of maintenance

10.4 Application Limitations Relating to Repetitive Duty Maintenance

Power-operated circuit protectors, when operating under service conditions listed in Section 3., can be expected to operate the number of times specified in Table 21 of ANSIC37.16-1980 [1].

These limitations apply to all parts of a circuit protector that function during normal operation. They do not apply to other parts that function only during infrequent abnormal circuit conditions.

As soon as possible after performance at or near its rated switching current, or whenever fuse replacement is made, a circuit protector should be removed from service and inspected, cleaned, and if necessary, otherwise maintained before being returned to service. Where insulation resistance levels have been lowered to 60% by surface deposits of interruption products, removal by cleaning will permit the 75% field dielectric test values of 8.1(7) to be met.

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10.5 Application Limitations Relating to Mechanism Types

Power circuit protectors should be limited to applications which do not present a safety hazard to operating personnel standing directly in front of them. For this reason, power circuit protectors are segregated into two classifications according to the type of closing mechanism.

10.5.1 Power Operation

Circuit protectors with operating mechanisms that provide for power operation in closing may be used up to the applicable short-circuit current rating of the protector.

10.5.2 Independent Manual Operation

Circuit protectors with operating mechanisms that provide for independent manual operation in closing may be used up to the applicable short-circuit current rating of the protector.

10.6 Application of Circuit Protector Without Enclosures

Application of circuit protectors without enclosures is not recommended.

10.7 Application of Circuit Protector with Dependent Manual Closing Mechanisms

Application of circuit breakers with dependent manual mechanisms is not recommended.

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