IEEE Standard for Definite-Purpose Switching Devices for Use in Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

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IEEE Power Engineering Society

Sponsored by the
Switchgear Committee

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Abstract: Definite-purpose switching devices for use in metal-enclosed low-voltage power circuit breaker switchgear are covered in this standard. The switching devices shall be fused, drawout type, three-pole construction, with one or more rated maximum ac voltages of 600 V, 508 V, and 254 V for application on systems having nominal ac voltages of 600 V, 480 V, and 240 V. The switching devices are power operated with integral or separately mounted overcurrent protective devices. Service conditions, ratings, functional components, temperature limitations and classifications of insulating materials, insulation (dielectric) withstand voltage requirements, test procedures, and application are addressed in this standard. The switching devices are normally used in applications that require frequency of operation greater than normal operations expected of low-voltage power circuit breakers.

Keywords: definite-purpose switching device, low-voltage ac power circuit breaker

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Introduction

> This introduction is not part of IEEE Std C37.13.1-2006, IEEE Standard for Definite-Purpose Switching Devices for Use in Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

This is a new standard written specifically to provide requirements for switching devices other than low-voltage power circuit breakers installed in low-voltage power circuit breaker switchgear. Definite-purpose switching (DPS) device in this standard means a switching device used on a frame in a manner similar to a power circuit breaker and installed in low-voltage power circuit breaker switchgear.

This standard was developed because several incidents in the industry indicated that switching devices (switching devices utilizing contactors) were being improperly designed, applied, and installed in low-voltage power circuit breaker switchgear.

This standard is limited to DPS devices using contactors protected by current-limiting fuses. Additional types of DPS devices may be addressed in future revisions of this standard.

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This issue is dedicated to our friend and colleague, Shaun Slattery, who passed away during its preparation.

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Contents

IEEE Standard for Definite-Purpose Switching Devices for Use in Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

1. Overview

1.1 Scope

The scope of this standard is to provide requirements for low-voltage (600 V (ac) and below) definite-purpose switching (DPS) devices (other than power circuit breakers) for use in metal-enclosed, low-voltage, power circuit breaker switchgear described in IEEE Std C37.20.1™-2002.[1] These switching devices may be used in motor control or other repetitive duty applications and have the following characteristics:

a) Drawout type, three-pole construction

b) Integral current-limiting fuses for short-circuit protection

c) Power operated, with integral or separately mounted overcurrent protective device

In this standard, the term "DPS device" denotes a definite-purpose switching device conforming to the requirements of this standard.

1.2 Purpose

This standard provides guidance in evaluating switching devices, other than low-voltage power circuit breakers conforming to IEEE Std C37.13™, that are intended to be applied in metal-enclosed, low-voltage power circuit breaker switchgear.

[1] For information on references, see Clause 2.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI C37.16-2000, American National Standard Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors.[2]

ANSI C37.50-1989 (Reaff 2000), American National Standard Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures.

IEEE Std 4™, IEEE Standard Techniques for High-Voltage Testing.[3, 4]

IEEE Std C37.13™, IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.

IEEE Std C37.20.1™-2002, IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

UL 248-1 (2000), Low-Voltage Fuses—Part 1: General Requirements.[5]

UL 248-8 (2000), Low-Voltage Fuses—Part 8: Class J Fuses.

UL 248-10 (2000), Low-Voltage Fuses—Part 10: Class L Fuses.

UL 248-12 (2000), Low-Voltage Fuses—Part 12: Class R Fuses.

3. Special terms

For the purposes of this standard, the following term and definition applies. *The Authoritative Dictionary of IEEE Standards Terms* [B3][6] and IEEE Std C37.100-1992 [B7] should be referenced for terms not defined in this clause.

definite-purpose switching device (DPS device): An assembly comprised of a drawout frame or structure, a contactor, short-circuit protective current-limiting fuses, and ancillary devices, which is designed for use in a compartment of low-voltage metal-enclosed power circuit breaker switchgear in a manner similar to a low-voltage power circuit breaker. The DPS device is characterized by the following necessary features:

a) A power-operated contactor intended to switch normal load currents and overload currents

b) Short-circuit protective current-limiting fuses, intended to interrupt short-circuit currents above the capabilities of the contactor

c) Overcurrent (overload) protection, either integral or as part of the low-voltage metal-enclosed switchgear assembly

d) Drawout construction elements (e.g., primary and secondary disconnecting devices, interlocks, racking mechanism, etc.)

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[5] UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (http://global.ihs.com/).
[6] The numbers in brackets correspond to those of the bibliography in Annex A.

4. Normal service conditions

A DPS device conforming to this standard shall be suitable for operation up to and including all of its ratings, provided the following usual service conditions exist:

a) The temperature of the air surrounding the DPS device is not below –30 °C. (See 7.1.)

b) The altitude does not exceed 2000 m (6600 ft).

c) The relative humidity of the air surrounding the DPS device is such that there will be no condensation on the DPS device parts at any time.

d) None of the unusual service conditions as listed in 9.4.2 prevails.

For application of DPS devices under service conditions other than those above, see Clause 9.

5. Ratings

5.1 General

The ratings of a DPS device are the designated limit of operating characteristics based upon the service conditions in Clause 4. The ratings shall include the following, as applicable:

a) Rated maximum voltage or voltages

b) Rated power frequency or frequencies

c) Rated continuous current

d) Rated short-circuit current at each rated maximum voltage

e) Maximum current-limiting fuse rating

f) Rated control voltage or voltages

The designated ratings in ANSI C37.16-2000 are preferred, but are not considered restrictive.

Where DPS devices are used in metal-enclosed low-voltage power circuit breaker switchgear containing low-voltage power circuit breakers, the DPS device assembly short-circuit rating shall be equal to or greater than the short-circuit rating of the switchgear assembly.

5.2 Rated maximum voltage

The rated maximum ac voltage of a DPS device is the highest rms voltage, three-phase or single-phase, at which it is designed to perform. The switching device shall be rated at one or more of the following maximum ac voltages: 600 V, 508 V, or 254 V and shall meet the requirements of Clause 8.

NOTE—Maximum rating limited to 600 V (ac) to correspond to the maximum rated voltage of fuses used in the device.[7]

[7] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

5.3 Rated power frequency

The rated power frequency of a DPS device is the power frequency at which it is designed to operate. Preferred frequencies are 50 Hz and 60 Hz. Applications at other frequencies should receive special consideration.

5.4 Rated continuous current

The rated continuous current of a DPS device is the designated limit of rms current at rated power frequency that it shall be required to carry continuously without exceeding the temperature limitations designated in Clause 7. The preferred continuous current ratings of the various frame sizes are listed in ANSI C37.16-2000. The rated continuous current of a DPS device, equipped with current-limiting fuses of a lower continuous current rating than the DPS device, is determined by the continuous current rating of the fuses.

5.5 Rated short-circuit withstand current

The rated short-circuit current of a DPS device is the designated limit of available (prospective) current at which it shall be required to perform its short-circuit current duty cycle at rated voltage under the prescribed test conditions. The short-circuit current duty cycle consists of an open (O) followed by a close-open (C-O) operation. The time between the O and C-O operations is the time necessary to replace fuses and to reset the open-fuse trip device. This current is expressed as the rms symmetrical value of current measured from the available current wave envelope at a time half-cycle after short-circuit initiation.

DPS devices shall be capable of withstanding 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 of 4.9 or less).

The switching element of the DPS device shall have a short-circuit current withstand rating, the preferred values of which are listed in Table 1 of ANSI C37.16-2000, for a system nominal voltage up to 600 V. The fuses are required to operate for short-circuit currents at or below the short-circuit current withstand ratings of the switching device up to the ratings in Table 17 of ANSI C37.16-2000.

For fuses with peak let-through current (I_p) and I^2t limits established for several different short-circuit current levels, the maximum fuse size selected shall not exceed the maximum I_p and I^2t limits for the contactor. See UL 248-1 (2000) for fuses with maximum I_p and I^2t limits.

5.6 Rated control voltage

The rated control voltage is the voltage at which the mechanism of the DPS device is designed to operate when measured at the control power terminals of the operating mechanism with the highest operating current flowing. The rated control voltages and their ranges shall conform to the values for low-voltage power circuit breakers listed in Table 23 of ANSI C37.16-2000.

6. Functional components

The functional components required are listed in Table 1. Additional accessory devices may be available. The manufacturer should be consulted for specific information.

Table 1—Functional components

Functional component	Required
1) Short-circuit protective current-limiting fuses, one per pole complying with UL 248-1 (2000) and UL 248-8 (2000), UL 248-10 (2000), or UL 248-12 (2000)	X[a]
2) Overload (overcurrent) protection	X[b]
3) Local means of opening	X
4) Contact position indicator in accordance with 6.2	X
5) Stored-energy indicator in accordance with 6.3	X[c]
6) Power-operated mechanism, with anti-pump feature for devices mechanically latched in the closed position	X
7) Shunt trip device with necessary control auxiliary switches for devices mechanically latched in the closed position	X
8) Open-fuse trip device complying with IEEE Std C37.13	X
9) Blocking/rejection interlocks	X
10) Locking provisions in accordance with 6.4	X
11) Secondary disconnecting device	X
12) Primary disconnecting devices	X
13) Frame grounding device	X
14) Nameplate(s), with markings in accordance with 6.1	X

[a] Short-circuit protection (current-limiting fuses) shall be provided as an integral part of the DPS device.
[b] If the DPS device is not provided with overcurrent protection as an integral part of the drawout (removable) element, then suitable overcurrent protective devices must be provided as part of the low-voltage metal-enclosed power circuit breaker switchgear.
[c] Required only on closing mechanisms that provide for stored-energy operation when the mechanism can be left in the charged position.

6.1 Nameplate(s)

The following minimum information shall be given on the nameplate(s) of all DPS devices:

a) Manufacturer's name
b) Manufacturer's type designation
c) Rated continuous current
d) Rated maximum voltage(s)
e) Rated short-circuit current at each rated voltage
f) Maximum fuse size and type
g) Rated power frequency (or frequencies)
h) Rated control voltage
i) Year of manufacture, by date
j) Identification number (serial number)
k) Manufacturer's data sheets or instruction book reference

6.2 Contact position indicator

A mechanical contact position indicator that can be easily read by a local operator shall be provided. The indicator shall show the words ON/OFF or CLOSED/OPEN. The following colors shall be used:

a) Red background with the word CLOSED or ON in white or aluminum (contrasting) letters to indicate closed contacts;

b) Green background with the word OPEN or OFF in white or aluminum (contrasting) letters to indicate open contacts.

6.3 Stored-energy indicator (for stored-energy-type closing mechanisms only)

A stored-energy indicator is required only when the mechanism can be left in the charged condition. The indicator, if required, shall be a mechanical indicator that is visible with the door closed. The indicator shall show the words CHARGED/DISCHARGED.

The following colors shall be used:

a) Yellow background with black lettering to indicate that the closing mechanism is charged

b) White background with black lettering to indicate that the closing mechanism is discharged

6.4 DPS device retention and locking

Provisions shall be made for locking the DPS device in the disconnected position complying with same retention and locking requirements as required for circuit breakers in 7.11.2 of IEEE Std C37.20.1-2002.

Locking provisions shall be suitable for an individual lock, either keyed or combination.

6.5 Interlocks

Interlocks shall be provided as follows:

a) To prevent moving the DPS device to or from the connected position when the DPS device is in the closed (ON) position.

b) To prevent closing the DPS device unless the primary disconnecting devices are in full contact or are separated by a safe distance.

c) DPS devices equipped with stored-energy mechanisms shall be designed to prevent the release of the stored energy unless the mechanism has been fully charged. Operators and service personnel shall be protected from the effects of accidental discharge of the stored energy by any of the following means:

    1) Interlocks provided in the housing to prevent the complete withdrawal of the DPS device from the housing when the stored-energy mechanism is charged

    2) A suitable device provided to prevent the complete withdrawal of the DPS device until the closing function is blocked

    3) A mechanism provided to automatically discharge the stored energy during the process of withdrawing the DPS device from the housing

    4) Construction such that all stored-energy mechanisms and contact assemblies are isolated within the DPS device and access to moving parts is not possible until the DPS device stored-energy mechanism has been discharged

6.6 Secondary disconnect devices

Secondary contacts conform to the requirements of the secondary disconnect device requirements of 7.11.6 of IEEE Std C37.20.1-2002.

6.7 Blocking/rejection interlocks

Blocking/rejection interlocks shall conform to the requirements of 7.11.4 of IEEE Std C37.20.1-2002.

7. Temperature limitations and classification of insulating materials

7.1 Temperature limits

The characteristics of the insulating materials used and the metals that are used in current-carrying parts and springs determine the temperature limits on which the ratings of DPS devices are based.

When applied in metal-enclosed low-voltage power circuit breaker switchgear, the DPS device shall operate within a switchgear ambient temperature of –30 °C and +40 °C as specified in IEEE Std C37.20.1-2002 and meet the requirements of 7.2 and 7.3 in this standard.

7.2 Limits of temperature rise

The temperature rise of the various parts of the DPS device above the temperature of the air surrounding the DPS device test enclosure shall not exceed the values given in Table 2 when subjected to temperature tests in accordance with this standard. This table applies to all conducting joints, moving or fixed.

7.3 Classification of insulating materials

The temperature limits on which DPS device ratings are based depend on the character of the insulating materials used. Methods of establishing temperature limits of insulating materials are described in IEEE Std 1-1986 [B2]. Relative thermal indices (RTI) of specific materials may be found in databases made available by manufacturers or testing agencies.

8. Tests

The tests described in this standard cover the performance of the complete DPS device. It should be recognized that the tests may not cover some component parts of the DPS device. The DPS device components shall be subject to test as required by the standards applicable to the component, e.g., UL 248-10 (2000) for Class L fuses.

Table 2—Limits of temperature rise

	Limit of hottest-spot temperature rise (°C) (see Note 1)	Limit of hottest-spot total temperature (°C)
Insulating materials (see Note 2)		
Class 90 insulation	50	90
Class 105 (A) insulation	65	105
Class 130 (B) insulation	90	130
Class 155 (F) insulation	115	155
Class 180 (H) insulation	140	180
Class 200 (N) insulation	160	200
Class 220 (R) insulation	180	220
Class 240 (S) insulation	200	240
Buses and connections, silver or tin surfaced [a]	65	105
Buses and connections with unplated copper connecting joints	30	70
Terminal connections (see Note 3)	55	95
Cable connections [b]	45	85
Other parts	65	105
Fuses		
Class J – contacts < 100 A	40	80
Class J – contacts > 100 A	60	100
Class R – contacts < 100 A	40	80
Class R – contacts > 100 A	60	100
Class L – contacts ≤ 2500 A	60	100

NOTE 1—Temperature rise based on 40 °C ambient. Fuse temperature rise is normally based on 25 °C but are converted to 40 °C ambient for this table. [See UL 248-1 (2000), UL 248-8 (2000), UL 248-10 (2000), and UL 248-12 (2000).]

NOTE 2—Letters in parenthesis are thermal classification for the class temperature listed according to IEEE Std 1-1986 [B2].

NOTE 3—Terminal connection temperatures are based on connections to bus in low-voltage metal-enclosed switchgear.

NOTE 4—Temperatures other than fuses based on information in IEEE Std C37.20.1-2002.

[a] Aluminum buses and connections shall be silver or tin surfaced. Welded bus connections are not considered connecting joints.

[b] Cable connections are based on 90 °C insulated cables.

8.1 Design (type) tests

8.1.1 Required tests

The DPS device shall successfully complete all of the following design tests:

a) Overload overcurrent protective device calibration check test (see 8.1.2)

b) AC dielectric withstand-voltage test (see 8.1.3)

c) Continuous current test (see 8.1.4)
d) Overload switching test (see 8.1.5)
e) Switching mechanism endurance tests (see 8.1.6)
f) Drawout mechanism endurance tests (see 8.1.7)
g) Short-circuit current tests (see 8.1.8)

8.1.2 Overload, overcurrent protective device calibration check test

Both integrally and separately mounted overload, overcurrent protective devices are to be set and checked according to the manufacturer's instructions to assure proper operation at the following values of current:

a) 100% of rated tripping current—device pickup to provide ultimate tripping
b) 200% of rated tripping current—device trips within 8 min
c) 600% of rated tripping current—device trips within 20 s

8.1.3 AC dielectric withstand-voltage test

The dielectric withstand test in this subclause shall be performed in accordance with 3.5 of ANSI C37.50-1989 (Reaff 2000). The method of voltage measurement shall be in accordance with IEEE Std 4.

Each configuration and frame size DPS device shall be capable of withstanding, without flashover or damage, the following power frequency voltage 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 power frequency of the DPS device being tested.

a) Primary circuit, including devices connected to the primary circuit, of a new, completely assembled DPS device, 2200 V
b) Secondary control wiring, except as required in item c), item d), or item e), 1500 V
c) Solenoid coils shall be tested at 1000 V plus twice the rating of the coil
d) Control devices and circuitry operating at 80 V (ac) rms [110 V (dc)] or less and not connected directly to primary or external secondary control circuits, 500 V
e) For undervoltage trip devices operating at a voltage above 250 V (ac), twice rated voltage plus 1000 V
f) After interruption of a short-circuit current duty cycle and before servicing, the withstand test voltage shall be 80% of the values in item a) through item e)

8.1.4 Continuous current test

The DPS device shall be tested as described in 3.6 of ANSI C37.50-1989 (Reaff 2000) for circuit breakers. Temperature rises shall not exceed those shown in Table 2 of this standard.

8.1.5 Overload switching test

The DPS device shall be tested as described in 3.7 of ANSI C37.50-1989 (Reaff 2000) for circuit breakers with the following modification:

a) The test current shall be no less than 600% of the rated continuous current of the DPS device.

b) During each operation, the DPS device shall be opened, either by the overcurrent protective device if integrally mounted, or by means of a separate opening signal when the overcurrent protective device is separately mounted.

Exception: This test is not required if the DPS device has previously been subjected to a switching test at a minimum of six times continuous current rating of the DPS device for the number of operations required in Table 3 of ANSI C37.16-2000.

8.1.6 Switching mechanism endurance test

The switching mechanism endurance test shall be performed as described in 3.8 of ANSI C37.50-1989 (Reaff 2000) with the number of electrical and mechanical switching operations as specified by the manufacturer. The number of operations shall be no less than those shown in Table 4 of ANSI C37.16-2000. Servicing shall not be performed during the test sequence. At the conclusion of the test, the DPS device shall be in a condition to continue testing with the short-circuit current test without repair or replacement of parts.

8.1.7 Drawout mechanism endurance test

Mechanical endurance tests shall be the same as for circuit breakers and shall be performed in accordance with 6.2.6 of IEEE Std C37.20.1-2002.

8.1.8 Short-circuit current test

The DPS device shall be subjected to a duty cycle according to 5.5.

The minimum duration of the first O operation is 0.067 s or the time permitted by the current-limiting fuses. The C-O duration shall continue until the current-limiting fuse opens the circuit. The contactor shall be given a signal to open half-cycle after fault initiation.

The contacts of the DPS device, including the contacts of the contactor, shall not weld during any portion of the test. The no welding requirement of the contactor is demonstrated by the ability of the contactor to fully open after each duty cycle. If it does not fully open, it has failed the test.

The DPS shall pass dielectric withstand test in item f) of 8.1.3 after the short-circuit current test.

8.2 Production (routine) tests

The DPS device shall successfully complete all the following production tests utilizing the applicable references:

a) Control, secondary wiring, and device check test (see 8.2.1)

b) Functional test (see 8.2.2)

c) Interlock test (see 8.2.3)

d) AC dielectric withstand-voltage test (see 8.2.4)

e) No-load operation test (see 8.2.5)

8.2.1 Control, secondary wiring, and device check test

Control, secondary wiring, and devices shall be checked to make sure that all connections are made correctly. Devices and relays, if used, shall be checked by actual operation where feasible. Those circuits, for which operation is not feasible, shall be checked for continuity.

8.2.2 Functional tests

Tests shall be conducted to verify proper operation of devices including overload protection and trip functions.

8.2.3 Interlock tests

Tests shall be performed to ensure the proper functioning of the interlocks required by 6.5 and 6.7. These tests shall ensure the interchangeability of removable elements designed to be interchangeable.

8.2.4 AC dielectric withstand-voltage test

Dielectric withstand tests in item a) through item e) of 8.1.3 shall be performed. The duration of the test may be reduced 1 s for production tests if voltages 20% greater than that specified in 8.1.3 are used.

8.2.5 No-load operations test

The DPS device shall be subjected to no-load operations test as described for circuit breakers in 6.5.1 of ANSI C37.50-1989 (Reaff 2000).

8.3 Field dielectric test

After storage or installation in the field, a DPS device that has not been subjected to a short-circuit current interruption or has been serviced after interruption shall withstand 80% of the values listed in item a) through item e) of 8.1.3. See item f) of 8.1.3 for test after a short-circuit.

9. Application guide

This clause covers the application of DPS devices on low-voltage ac systems and applies to DPS devices rated in accordance with Clause 5.

9.1 General

DPS devices should be applied within their assigned voltage(s), power frequency, continuous current, and short-circuit ratings as defined in this standard with proper consideration given to the service conditions stated in Clause 4 and 9.4. They should be selected to provide the protection required by the other components of the circuit. For applications not covered by this standard, the manufacturer should be consulted.

9.1.1 Voltage

The voltage of the system to which DPS devices are applied, including any possible variations, should not exceed the rated maximum voltages listed in 5.2. For application voltages between those listed, a DPS device should be selected based on the next higher rated maximum voltage. See Table 1 and Table 2 of ANSI C37.16-2000.

9.1.2 Power frequency

The normal applicable power frequency for DPS devices is 60 Hz (see 5.3). Application at 50 Hz may require recalibration of devices and consideration must be given to the operation of all electromechanical devices. Application at nominal power frequencies other than 50 Hz or 60 Hz may require that consideration be given to the performance of the switching device element itself.

9.1.3 Continuous current

The DPS device should be applied to a circuit having a maximum continuous-load current no greater than the continuous current rating of the DPS device. If the DPS device is not provided with overcurrent protection as an integral part of the drawout (removable) element, then suitable overcurrent protective devices shall be provided as part of the low-voltage metal-enclosed switchgear.

The heat produced by the DPS device operating at its continuous current rating should not require greater derating of existing breakers than indicated in the cumulative circuit breaker load clause of IEEE Std C37.20.1-2002.

9.1.3.1 Forced-air cooling

It is recognized that a DPS device may continuously carry current more than its self-cooled continuous current rating if the DPS device is forced-air cooled by means such as a blower or fan. The manufacturer of the assembly in which the DPS device and forced-air cooling means are to be installed should be contacted to obtain information about the increased capability. Suitable protection schemes should be utilized to assure that excessive temperatures do not result from air filters becoming clogged or from failure of the forced-air cooling means to provide sufficient cooling. Settings of the overcurrent protective device should be reevaluated in this circumstance.

9.1.3.2 Lower than 40 °C ambient temperature

If the ambient temperature outside the DPS device enclosure is maintained at less than 40 °C, the DPS device may be capable of carrying current more than its continuous current rating. However, since the long-time performance and useful life of the DPS device may be affected by such an increase in continuous current, the DPS device manufacturer should be consulted concerning any increased capability. Settings of protective devices should be reevaluated in this circumstance.

9.1.4 Short-circuit current

DPS devices may be applied on a system only when the calculated maximum available short-circuit current on the source side of the DPS device, modified by the power factor considerations in 9.1.4.3, is not more than the short-circuit current rating of the DPS device.

For three-phase ac circuits, the available current calculated is the maximum rms symmetrical value of the three phases at an instant 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 DPS device is applied in such a way on a single-phase circuit that the system voltage impressed across a single pole is not 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.

When a DPS device is applied in such a manner on a three-phase system that the voltage impressed across a single pole exceeds 58% of the rated maximum voltage, the maximum available short-circuit current shall be limited to 87% of the corresponding three-phase short-circuit rating as listed in Table 1 and Table 2 of ANSI C37.16-2000.

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

a) Source contribution
b) Motor contribution
c) Effects of power factor
d) Types of operating mechanism
e) Duty cycle
f) Overload, overcurrent trip devices
g) Effect of remote protective devices

Recommended guidance in calculating short-circuit currents is given in IEEE Std 141-1993 [B4], IEEE Std 241-1990 [B5], and IEEE Std 242-2001 [B6].

9.1.4.1 Source contribution

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

9.1.4.2 Motor contribution

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

Induction and synchronous motors, connected to the bus, act as generators, and at half-cycle after the short-circuit occurs, contribution current may be calculated using the subtransient reactance of the motor plus the impedance of the interconnecting cable. Where the impedance for the installation is 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:

a) 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.
b) For nominal system voltages of 240 V to 600 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.

9.1.4.3 Power factor considerations

Normally the short-circuit power factor (X/R) of a system need not be considered in application. This is because the power factors, on which the ratings of the DPS devices in this standard have been established, cover most applications. Ratings for DPS devices in this standard are based on a 20% power factor (X/R ratio of 4.9), which is consistent with the standards established for fuses. The high short-circuit current rating of fused DPS devices makes the need to consider power factor even more unlikely. There are, however, some specific applications when the available short-circuit current approaches 80% of the DPS device short-circuit current rating, which may require additional consideration because of lower short-circuit power factors. These considerations are as follows:

a) Local generation at DPS device voltage in unit sizes greater than 500 kVA
b) Gas-filled and dry-type transformers in sizes 1000 kVA and above; all types 2500 kVA and above
c) Transformers with impedance lower than those specified in the ANSI C57 series of standards
d) Current-limiting reactors at DPS device voltage in source circuits

Table 3 gives appropriate multiplying factors, *MF*, for these types of systems where the power factor may be less than 20%. The values in Table 3 are based on total rms current (asymmetrical) calculated in accordance with Equation (1) as follows:

$$MF = \frac{\sqrt{1 + 2e^{-2\pi/(X/R)}}}{1.25} \qquad (1)$$

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

a) If the short-circuit *X*/*R* ratio of the power system is known, the appropriate multiplying factor can be selected from Table 3 and multiplied by the calculated value of rms symmetrical current.
b) If the short-circuit *X*/*R* ratio of the power system has not been determined, a ratio of 20 should be assumed and the calculated value of rms symmetrical current should be multiplied by the appropriate multiplying factor selected from Table 3.

Table 3—Selection of multiplying factor for short-circuit current

System short-circuit power factor (%)	System *X*/*R* ratio	Multiplying factor for calculated short-circuit current
20	4.9	1.00
15	6.6	1.07
12	8.27	1.12
10	9.95	1.15
8.5	11.72	1.18
7	14.25	1.21
5	20.0	1.26
Source: Table 3 of IEEE Std C37.13-1990 (values for fused circuit breakers).		

9.1.4.4 Short-circuit duty cycle application

The applicable short-circuit current duty cycle for DPS devices consists of an opening operation followed by a C-O operation. See 5.5 and 8.1.8. The time between these operations is the time necessary to replace the DPS current-limiting fuses and to reset any protective devices, such as an open-fuse trip device.

As soon as possible after performance at or near its rated short-circuit current, a DPS device should be removed from service and inspected, cleaned and, if necessary, otherwise maintained before being returned to service. Prior to returning to service, the DPS device shall be dielectric tested to the test values of 8.3.

9.1.4.5 Effect of remote protective devices

DPS devices should be applied in accordance with the assigned short-circuit current ratings. The preferred values are listed in Table 2 of ANSI C37.16-2000.

9.1.4.6 Protection coordination of connected equipment

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

It should be noted that the DPS device does not have any current-limiting effect until the current associated with the fault exceeds the threshold current of the current-limiting fuse. When fuses of relatively low continuous current rating and relatively low peak let-through current rating are selected to give protection to downstream equipment, there is increased likelihood that they will open at currents below the switching device element short-circuit current rating. If the full coordination study for the protection of connected equipment is made known to the manufacturer, then the best combination of overcurrent protective device and fuses may be selected. Non-optimum combinations can lead to needless fuse opening. In no case should combinations of overcurrent protective devices and fuses that are not approved by the manufacturer be installed.

Where fuses of different manufacture are being considered for the same distribution system, the characteristics of all the fuses and switching devices 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 between manufacturers.

9.2 Application of DPS devices to full-voltage starting and running duty of three-phase 60 Hz motors

The power ratings in horsepower apply to all motors having full-load current ratings between the minimum and maximum currents shown in Table 18 of ANSI C37.16-2000. The DPS device continuous current rating should be at least 115% of the maximum full-load current of the motor.

9.3 Application of DPS devices for capacitance switching

Switching devices used for capacitor switching should meet the requirements given in 8.3, Part 2, of NEMA ICS 2-2000 [B9]. DPS devices are not recommended for capacitor switching except in cases where surge capacitors are used as part of a motor installation or where the DPS device is tested to meet the specified assigned duty.

9.4 Service conditions affecting DPS device applications

9.4.1 Altitude correction

When applied at altitudes greater than 2000 m (6600 ft), the DPS devices should have their dielectric withstand, continuous current, and rated maximum voltage ratings multiplied by the correction factors shown in Table 4 to obtain values at which the application is made. The short-circuit current ratings are not affected by altitude. However, the short-circuit current should not exceed that of the voltage rating prior to derating in accordance with Table 1 and Table 2 of ANSI C37.16-2000.

Table 4—Altitude correction factors

Altitude [a]		Rated continuous current	Rated voltage
Feet (ft)	Meters (m)		
6 600 and below	2 000 and below	1.00	1.00
8 500	2 600	0.99	0.95
13 000	3 900	0.96	0.80
Source: Table 4 of IEEE Std C37.13-1990.			

[a] Values for intermediate altitudes may be derived by linear interpolation.

9.4.2 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 DPS device. Inclusion of heaters, filters, placement in controlled atmosphere areas, or other steps should be taken to nullify the deleterious effect of the following:

a) Exposure to damaging fumes or vapors, excessive or abrasive dust, explosive mixture of dust or gases, steam, salt spray, excessive moisture, dripping water, radiation, and other similar conditions

b) Exposure to abnormal vibration, shocks, seismic occurrences, or tilting

c) Exposure to excessively high or low temperature

d) Exposure to unusual transportation or storage conditions

e) Exposure to extreme solar temperatures

f) Unusual operating duty, frequency of operation, and difficulty of maintenance

g) Load currents of nonsinusoidal waveforms

h) Temperature of DPS device parts that falls below the dew point of the surrounding air, causing moisture condensation on the parts

i) Applications where voltage may be present on both sides of DPS device contacts when the device is in the open or off position

9.5 Repetitive duty operations and normal maintenance

Power-operated DPS devices, when operating under service conditions listed in Clause 4, can be expected to exceed the number of operations specified in Table 19 of ANSI C37.16-2000. (See 8.1.6.)

The numbers of operations apply to all parts of a DPS device that function during normal operation. They do not apply to other parts, such as overcurrent protective trip devices, open-fuse trip devices, or fuses that function only during infrequent abnormal circuit conditions.

The following paragraphs referenced in the column headings of Table 5 of ANSI C37.16-2000 are applicable to the number of operations listed:

a) Servicing consists of adjusting, cleaning, lubricating, tightening, etc., as recommended by the manufacturer. The operations listed are based on servicing at intervals of 12 months or less.

b) When closing and opening no-load.

c) With rated control voltage applied.

d) Frequency of operation not to exceed 20 operations in 10 min or 30 operations in 1 h. Rectifiers or other auxiliary devices may further limit the frequency of operation.

e) Servicing at no greater intervals than shown in Column 2 of Table 5 of ANSI C37.16-2000.

f) No functional parts should have been replaced during the listed operations.

g) The fused DPS device should be in a condition to carry its rated continuous current at rated maximum voltage and perform at least one opening operation at any current not exceeding rated short-circuit current. The ability of the fuses to limit fault current should be unimpaired. After completion of this series of operations, functional part replacement and general servicing may be necessary.

h) When closing and opening current up to the continuous current rating of the DPS device at voltages up to the rated maximum voltage and at 85% power factor or higher.

i) When closing currents up to 600% and opening currents up to 100% (80% power factor or higher) of the continuous current rating of the DPS device at voltages up to the rated maximum voltage.

j) When closing currents up to 600% and opening currents up to 600% (50% power factor or less) of the continuous current rating of the DPS device at voltages up to rated maximum voltage, the number of operations shown shall be reduced to 10% of the number listed.

k) If a fault operation occurs before the completion of the listed operations, servicing is recommended and possible functional part replacement may be necessary, depending on previous accumulated duty, fault magnitude, and expected future operations. Replacement of unblown fuses should be considered when continuity of service is critical because the time-current characteristic of the fuse could be affected.

Annex A

(informative)

Bibliography

[B1] ANSI C37.17™-1997, American National Standard for Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers.[8]

[B2] IEEE Std 1™-1986, IEEE Standard General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation.[9, 10]

[B3] IEEE Std 100™, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition.

[B4] IEEE Std 141™-1993, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book).

[B5] IEEE Std 241™-1990 (Reaff 1997), IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (IEEE Gray Book).

[B6] IEEE Std 242™-2001, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book).

[B7] IEEE Std C37.100™-1992, IEEE Standard Definitions for Power Switchgear.

[B8] NEMA ICS 1-2000, Industrial Control and Systems General Requirements.[11]

[B9] NEMA ICS 2-2000, Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated 600 Volts.

[B10] UL 508 (1999), Standard for Industrial Control Equipment.[12]

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