IEEE Std C37.63™-2005
(Revision of
IEEE Std C37.63-1997)

IEEE Standards

C37.63™

IEEE Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems

IEEE Power Engineering Society

Sponsored by the
Switchgear Committee

IEEE

3 Park Avenue, New York, NY 10016-5997, USA

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IEEE Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems

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Switchgear Committee
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Approved 6 May 2005

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Abstract: Required definitions (for cutout type sectionalizers), ratings, procedures for performing design tests and production tests, constructional requirements, and application considerations for overhead and pad-mounted, dry-vault, and submersible automatic line sectionalizers for ac systems are specified.
Keywords: sectionalizers: cutout type, dry-vault, pad-mounted; submersible

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Introduction

This introduction is not part of IEEE Std C37.63-2005, IEEE Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems.

This standard has been revised and updated from the 1997 version of ANSI C37.63. This revision incorporates significant improvements that reflect the present state of the art in automatic line sectionalizers. These improvements include changes and additions in the following areas:

— Reorganization of the tests into Clause 6, following a format similar to IEEE Std 1247™-1998 and making reference to IEEE Std 1247-1998 for most of the test procedures.

— Review of underground sectionalizers tank construction by referring to IEEE Std C37.74™.

— General structure of the document has been made similar to other distribution standards.

— Revised limits of temperature and temperature rise to be consistent with circuit breaker standards.

— Radio influence voltage and partial discharge tests have been reviewed and align on IEEE Std C37.60™-2003.

— Replaced dc withstand voltage test by very low frequency tests for all field aged cables, as recommended by IEEE Transmission and Distribution committee and IEEE Std 433™.

— Cutout type sectionalizers ratings have been reviewed and reference made to ANSI C37.42.

— A normative Annex B have been added to cover series coil ratings.

— The notes have been reviewed and those containing normative material have been changed to be included in the main text. The only notes left are informative.

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IEEE Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems

1. Overview

1.1 Scope

This standard applies to all overhead, pad-mounted, dry-vault, and submersible single-pole or multipole alternating-current automatic line sectionalizers for rated maximum voltages from 1000 V to 38 000 V. Voltages above 38 000 V shall be considered special applications.

In order to simplify the terminology in this standard, the term *sectionalizer* has been substituted for *automatic line sectionalizer* wherever possible.

1.2 Purpose

The purpose of this standard is to describe the requirements for sectionalizers. Qualification to this standard should give reasonable assurance to the user that equipment meeting the requirements of this standard will perform in a satisfactory manner, provided that it has been properly selected for the intended application and is installed in accordance with the manufacturer's recommendations.

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 C37.85, American National Standard for Switchgear—Alternating-Current High-Voltage Power Vacuum Interrupters—Safety Requirements for X-Radiation Limits.[1]

ANSI C37.42, American National Standard for Switchgear—Distribution Cutouts and Fuse Links—Specifications.

[1]ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

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ANSI C63.2, American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz—Specifications.

IEC 60270, High-Voltage Test Techniques—Partial Discharge Measurements.[2]

IEC 60502, Extruded Solid Dielectric Insulated Power Cables for Rated Voltages from 1 kV up to 30 kV.

IEC 60694-2002, Common Specifications for High-Voltage Switchgear and Controlgear Standards.

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

IEEE Std 4a™, Amendment to IEEE Standard Techniques for High-Voltage Testing.

IEEE Std 386™, IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V.

IEEE Std 433™, IEEE Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Voltage at Very Low Frequency.[5]

IEEE Std 1247™-1998, IEEE Standard for Interrupter Switches for Alternating Current, Rated Above 1000 Volts.

IEEE Std 1291™, IEEE Guide for Partial Discharge Measurements in Power Switchgear.

IEEE Std C37.09™, IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

IEEE Std C37.24™, IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear.

IEEE Std C37.41™, IEEE Standard Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

IEEE Std C37.60™-2003, IEEE Standard Requirements for Overhead, Pad Mounted, Dry Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems up to 38 kV.

IEEE Std C37.74™-2003, IEEE Standard Requirements for Subsurface, Vault, and Padmounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems up to 38 kV.

IEEE Std C37.100, IEEE Standard Definitions for Power Switchgear.

NEMA 107, Methods of Measurement of Radio Influence Voltage (RIV) of High-Voltage Apparatus.[6]

[2]IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

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3. Definitions

For the purposes of this standard requirements, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms* should be referenced for terms not defined in this clause.

A dagger (†) following the definition indicates that while the term is defined in IEEE Std C37.100™,[7] the two definitions are not identical.

An asterisk (*) indicates that at this time this standard was approved, there were no corresponding definitions in IEEE Std C37.100.

3.1 cutout type sectionalizers: A single-phase automatic line sectionalizer that is very similar in outward appearance to a distribution open dropout type fuse cutout and is used in a distribution cutout mounting. (*)

3.2 minimum actuating current: The minimum actuating current of sectionalizers is the minimum rms current that actuates a counting operation or an automatic operation. (*)

3.3 sectionalizer: A self-contained, circuit-opening device that automatically isolates a faulted, de-energized distribution feeder circuit, sectionalizes the faulted circuit from the unaffected circuit, and allows restoration of the electrical service to the upstream unaffected circuit. It may have a provision to switch or transfer loads. The sectionalizer shall include the necessary control elements to enable this type of operation automatically. (†)

3.4 series coil sectionalizer: A sectionalizer in which main circuit current impulses above a specified value, flowing through a solenoid or operating coil, provide the energy required to operate the counting mechanism.

4. Service conditions

4.1 Usual service conditions

Sectionalizers conforming to this standard shall be suitable for operation at their standard ratings provided that the following conditions are met:

a) The temperature of the ambient temperature does not exceed 40 °C.

b) The ambient temperature is not less than –30 °C.

c) The altitude does not exceed 1000 m.

d) The wind velocity does not exceed 36 m/s.

e) For submersible units, the water head does not exceed 3 m above the base of the enclosure during occasional submersion. Exposure to chemical or electrochemical reactions may be encountered in a subgrade environment. The subgrade environment may contain chemicals that contribute to mild corrosive reactions.

The preferred values for ratings and capabilities are found in Clause 5. The test procedures to establish the ratings and capabilities are found in Clause 6.

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

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4.2 Unusual service conditions

Unusual conditions shall be considered. Examples of such conditions are as follows:

a) Altitudes greater than 1000 m

b) Damaging fumes or vapors, excessive or abrasive dust, explosive mixtures of dust or gases, steam, salt spray, excessive moistures, or dripping water

c) Abnormal vibration, shocks, or tilting

d) Seismic requirements

e) Excessively high or low temperatures

f) Unusual space limitations

g) The application of an outdoor sectionalizer, indoor sectionalizer, or an enclosed sectionalizer for another purpose, which may include concerns regarding weather exposure and restricted heat transfer

h) Unusual operating duty, frequency of operation, difficulty of maintenance, high harmonic content waveforms, unbalanced voltage, and special insulation requirements

5. Ratings

5.1 Ratings information

Sectionalizer ratings shall include the following. For those rating descriptions not given in Clause 5, the descriptions shall be as given in 5.1 through 5.11 of IEEE Std 1247-1998, as appropriate.

a) Rated power frequency (see 5.1 of IEEE Std 1247-1998)

b) Rated maximum voltage (see 5.2.1 of IEEE Std 1247-1998)

c) Rated lightning withstand voltage (see 5.3 of IEEE Std 1247-1998)

d) Rated continuous current (see 5.4.1 of IEEE Std 1247-1998)

e) Rated minimum actuating current (series coil sectionalizers only) (see 5.5 of this standard)

f) Rated peak withstand current (see 5.4.2.1 of IEEE Std 1247-1998)

g) Rated short-time (symmetrical) withstand current and duration (see 5.4.2 of IEEE Std 1247-1998)

h) Rated control voltages (where applicable) (see 5.6 of IEEE Std 1247-1998)

The following switching ratings are optional; they only apply to sectionalizers that are designed for the respective switching ratings.

i) Rated load switching current (see 5.4.4.1 of IEEE Std 1247-1998)

j) Rated line charging and cable charging current (see 5.4.4.3 and 5.4.4.4 of IEEE Std 1247-1998)

k) Rated unloaded transformer switching current (see 5.4.4.5 of IEEE Std 1247-1998)

l) Rated fault-making current (see 5.4.3 of IEEE Std 1247-1998)

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5.2 Rated power frequency

The preferred rated power frequencies are 50 Hz or 60 Hz.

5.3 Rated maximum voltage and rated withstand voltage

Preferred voltage ratings are those shown in Table 1[8] and Table 2. Special ratings for series coil sectionalizers are given in Annex B.

Table 1—Preferred voltage ratings and related test requirements for sectionalizers (except those covered in Table 2)

Line no. (See Note 1)	Rated maximum voltage [kV] (See Note 2)	Rated lightning impulse withstand voltage [kV] (See Note 2)	Rated power-frequency dry withstand voltage (60 s) [kV] (See Notes 2, 3)	Rated power-frequency wet withstand voltage (10 s) [kV] (See Notes 2, 3)
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
1	15.5	95	36	30
2	15.5	110	50	45
3	27.0	125	60	50
4	38.0	150	70	60
11	12.0	75	28	23
12	17.5	95	38	32
13	24.0	125	50	45
14	36.0	170	70	60

NOTE 1—Lines 11 to 14 refer to distribution systems commonly found outside of North America; the test withstand levels were taken from Table 1a of IEC 60694-2002.
NOTE 2—Cutout type sectionalizers usually have ratings that are the same as the distribution cutout mounting in which they are applied. ANSI C37.42 gives preferred values for the distribution cutout mounting.
NOTE 3—When performing tests involving open contacts in vacuum, adequate precautions such as shielding or distance should be used to protect test personnel against the possibility of X-radiation occurrences due, for example, to incorrect contact spacing, or the application of voltages in excess of those specified. For appropriate shielding, distances, and exposure limits, refer to ANSI C37.85.

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

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Table 2—Preferred voltage ratings and related test requirements for pad-mounted, dry-vault, and submersible sectionalizers

Line no. (See Note 1)	Rated maximum voltage [kV]	Rated lightning impulse voltage [kV]	Rated power-frequency dry withstand voltage (60 s) [kV] (See Notes 2, 3)	Rated power-frequency wet withstand voltage (10 s) [kV]	DC withstand voltage (300 s) [kV] (See Note 4)
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
1	15.5	95	35	Not required	53
2	—	—	—	—	—
3	27.0	125	40	Not required	78
4	38.0	150	50	Not required	103
11	12.0	60	28	Not required	42
12	17.5	75	38	Not required	57
13	24.0	95	50	Not required	78
14	36.0	145	70	Not required	103

NOTE 1—Lines 11 to 14 refer to distribution systems commonly found outside of North America; the test withstand levels were taken from Table 1a of IEC 60694-2002.
NOTE 2—When performing tests involving open contacts in vacuum, adequate precautions such as shielding or distance should be used to protect test personnel against the possibility of X-radiation occurrences due, for example, to incorrect contact spacing, or the application of voltages in excess of those specified. For appropriate shielding, distances, and exposure limits, refer to ANSI C37.85.
NOTE 3—The rated power-frequency dry withstand voltage (60 s) [kV] for North America (line 1, line 3, and line 4) is reduced, as compared to Table 1, to take into account the reduced withstand capability of some cable components (i.e., elbows, T connectors).
NOTE 4—DC voltage testing of field-aged cables is not a recommended practice. Very low frequency (VLF) testing is a relatively new practice being used as an alternative to the dc withstand test (see IEEE Std 433™). The dc withstand test requirement on the sectionalizer demonstrates its capability to withstand either dc or VLF testing of connected cables.

5.4 Preferred continuous and load switching current ratings

The preferred continuous and load switching current ratings of sectionalizers shall be as given in Table 3 or as per IEC R10 series (1, 1.25, 1.6, 2, 2.5, 3.15, 4, 5, 6.3, 8, and their product by 10^n). Series coil sectionalizers have special ratings determined by the series coil itself. The continuous current and the load switching current ratings of series coil sectionalizers are given in Annex B (see Table B.2).

Table 3—Preferred continuous and load current ratings

Sectionalizer type	Preferred continuous current ratings [A]
Series coil sectionalizer preferred ratings	See Annex B
Main contact and load switching preferred ratings	50, 100, 200, 250, 315, 400, 500, 630, 800, 1000, 1250

5.4.1 Conditions of continuous current rating

a) Sectionalizers shall be used under the usual service conditions defined in 4.1.

b) Current ratings shall be based on the total temperature limits of the materials used. A temperature rise reference is given to permit testing at reduced ambient.

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c) Sectionalizers designed for installation in enclosures shall have their ratings based on the ventilation of such enclosures and a 40 °C ambient temperature outside the enclosure.

d) Outdoor sectionalizers and indoor sectionalizers without enclosures shall have ratings based on a 40 °C ambient temperature.

5.4.2 Limits of observable temperature rise

At rated current, the observable hottest-spot temperature rise above ambient, and the maximum temperature of each of the various parts, shall not exceed the temperatures listed in Table 4.

Table 4—Temperature limits for contacts, conducting joints, or bushing terminals when clean and bright as used in automatic line sectionalizers

Nature of the part and material[a, b, c]		Total temperature (°C)	Temperature rise at ambient (40 °C)
1. Material used as insulation and metal parts in contact with insulation of these classes[d]	O (90 ºC)	90	50
	A (105 ºC)	105	65
	B (130 ºC)	130	90
	F (155 ºC)	155	115
	H (180 ºC)	180	140
	C (220 ºC)	220	180
	Oil[e]	90	50
2. Contacts[f]	Bare copper and bare-copper alloy		
	—in air	75	35
	—in SF_6 (sulfurhexaflouride)	105	65
	—in oil	80	40
	Silver-coated or nickel-coated[g]		
	—in air	105	65
	—in SF_6	105	65
	—in oil	90	50
	Tin-coated[g]		
	—in air	105	65
	—in SF_6	105	65
	—in oil	90	50
3. Connections, bolted or the equivalent[h]	Bare copper, bare-copper alloy, bare aluminum, or bare-aluminum alloy		
	—in air	90	50
	—in SF_6	115	75
	—in oil	100	60
	Silver-coated or nickel-coated		
	—in air	115	75
	—in SF_6	115	75
	—in oil	100	60
	Tin-coated		
	—in air	105	65
	—in SF_6	105	65
	—in oil	100	60
4. All other contacts or connections made of bare metals or coated with other materials		i	i
5. Terminals for the connection to external conductors by screws or bolts[j]	Bare copper and bare-copper alloy	90	50
	Silver-coated, nickel-coated, tin-coated	105	65
	Other coatings	i	i
6. Metal parts acting as springs		k	k

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The following conditions are applicable to Table 4:

a) According to its function, the same part may belong to several categories as listed in Table 4. In this case, the permissible maximum values of total temperature and temperature rise to be considered are the lowest among the relevant categories.

b) For sealed interrupters, the values of total temperature and temperature-rise limits are not applicable for parts inside the sealed interrupter. The remaining parts shall not exceed the values of temperature and temperature rise given in Table 4.

c) The temperatures of conductors between contacts and connections are not covered in Table 4, as long as the temperature at the point of contact between conductors and insulation does not exceed the limits established for the insulating material.

d) The classes of insulating materials are those given in IEC 60694-2002.

e) The top oil (upper layer) temperature shall not exceed 40 °C rise or 80 °C total. The 50 °C and 90 °C values refer to the hottest-spot temperature of parts in contact with oil.

f) When contact parts have different coatings, the permissible temperatures and temperature rises shall be those of the part having the lower value permitted in Table 4.

g) The quality of the coated contacts shall be such that a layer of coating material remains at the contact area as follows:

   1) After making and breaking tests (if any).

   2) After short-time withstand current tests.

   3) After the mechanical endurance test; according to the relevant specifications for each piece of equipment. (Otherwise, the contacts shall be regarded as “bare”.)

h) When connection parts have different coatings, the permissible temperatures and temperature rises shall be those of the part having the lower value permitted in Table 4.

i) When materials other than those given in Table 4 are used, their properties shall be considered in order to determine the maximum permissible temperature rises.

j) The values of temperature and temperature rise are valid even if the conductor to the terminals is bare.

k) The temperature shall not reach a value where the temper of the material is impaired.

5.5 Preferred minimum actuating current ratings (series coil sectionalizers)

For series coil sectionalizers, the preferred minimum actuating current ratings are given in Annex B.

5.6 Preferred short-circuit withstand current ratings

Preferred peak current withstand shall be 2.6 (60 Hz) or 2.5 (50 Hz) times the preferred short-circuit withstand current. These are based on an aperiodic current time constant of 45 ms, which corresponds to an X/R of 17 for 60 Hz or 14 for 50 Hz.

Preferred short-circuit withstand durations shall be 1 s and 10 s.

Preferred short-circuit withstand currents of series coil sectionalizers shall be as given in Table B.2.

Preferred 1 s short-circuit withstand current of the main circuit of the sectionalizer shall be one of the

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following values: 1 kA, 1.25 kA, 2 kA, 4 kA, 6 kA, 8 kA, 10 kA, 12.5 kA, 16 kA, or 20 kA.

Preferred 10 s short-circuit withstand current shall be 32.5% of the rated 1 s short-circuit withstand current.

For sectionalizers designed for fault-making capability, the rated fault-making current shall be equal to the rated 1 s short-circuit withstand current.

Cutout type sectionalizers usually have ratings that are the same as the distribution cutout mounting in which they are applied. ANSI C37.42 gives preferred values for the distribution cutout mounting.

Cutout type sectionalizers close and latch capabilities depend on skill and speed of the operator. Consult the cutout sectionalizer manufacturer for the capability and the application of the device.

5.7 Preferred control voltage ratings

When measured at the control power terminals of the operating mechanisms with the maximum operating current flowing, rated voltages and their permissible ranges for the control power supply of sectionalizers shall be as shown in Table 5.

Table 5—Preferred rated control voltage and ranges

Direct current[a, c] control voltage ranges[b, c]		
Nominal voltage	**Closing and auxiliary functions**	**Tripping function**
24[d]	—	14–28[e]
48[d]	38–56	28–56[e]
125	100–140	70–140
250	200–280	140–280
Alternating current control voltage ranges[b, c, f]		
Nominal voltage (50/60 Hz) single-phase	**Closing, tripping, and auxiliary functions**	
120	104–127[f]	
240	208–254[f]	
480	416–508[f]	
Polyphase		
208Y/120	180Y/104–220Y/127	
240	208–254	
480	416–508	
480Y/277	416Y/240–508Y/292	

The following conditions are applicable to Table 5:

a) It is recommended that the coils of closing, auxiliary, and tripping devices that are directly connected continually to one dc potential should be connected to the negative control bus so as to minimize electrolytic deterioration.

b) Relays, motors, and other auxiliary equipment that function as a part of the control for a device shall be subject to the voltage limits imposed by this standard, whether mounted at the device or at a remote location.

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c) In some applications, sectionalizers may be exposed to control voltages exceeding those specified herein due to abnormal conditions such as abrupt changes in line loading. Such application requires specific study, and the manufacturer should be consulted. Also, applications of sectionalizers containing solid-state control exposed continuously to control voltages approaching the upper limits of ranges specified herein require specific attention, and the manufacturer should be consulted before application is made.

d) 24 V or 48 V tripping, closing, and auxiliary functions are recommended only when the device is located near the battery or where special effort is made to ensure the adequacy of conductors between battery and control terminals.

e) Sectionalizers having self-contained dc control sources shall operate over the range of 85% to 115% of nominal voltage and Table 5 shall not apply.

f) Includes heater circuits.

5.8 Preferred line charging and cable charging current ratings

The line charging and cable charging interrupting current ratings for sectionalizers having this capability are as given in Table 6.

Table 6—Preferred line charging and cable charging switching current ratings

Rated maximum line voltage (kV) (See Note)	Preferred current (rms Amperes)	
	Line charging, overhead	Cable charging
15.5	2	10
27.0	5	25
38.0	5	40
12.0	2	10
17.5	2	10
24.0	5	25
36.0	5	40
NOTE—The first three lines refer to voltages commonly used in North America. The last four lines refer to distribution systems commonly found outside of North America (see Note 1 of Table 1 and Table 2).		

6. Design tests

6.1 General conditions for tests

Mounting, grounding, and other general conditions for tests shall be as given in 6.1 of IEEE Std C37.60™-2003.

6.2 Withstand voltage tests

Withstand voltage tests shall be performed as given in 6.2 of IEEE Std C37.60-2003.

6.3 Continuous current tests

Continuous current tests shall be performed as given in 8.2 of IEEE Std 1247-1998, except that in 8.2.1 of IEEE Std 1247-1998 the air velocity before the test shall be below 0.5 m/s, as given in 6.5.2 of IEC 60694-2002.

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6.4 Switching tests

Switching tests shall be performed as given in 8.3 of IEEE Std 1247-1998, except for the following:

— Unit testing is not allowed.

— Single-phase testing is not allowed for three-phase sectionalizers.

— Loop switching test is not required.

— Cable charging switching tests, if required (see 5.1), apply only for shielded cables (C_1=C_0 in Figure 7 of IEEE Std 1247-1998).

— The unloaded transformer switching, if required (see 5.1), shall be performed as given in 8.3.2.5 of IEEE Std 1247-1998. Test current shall be between 3% and 4% of continuous current rating of the sectionalizer.

— Shunt capacitor switching tests are not required.

6.5 Short-time withstand current tests

Short-time withstand current tests shall be performed as given in 8.4 of IEEE Std 1247-1998, except that three-phase sectionalizers shall be tested three-phase with the maximum asymmetry on an outer phase and the current in the other outer phase starting with a major loop.

6.6 Fault-making current tests

Fault-making current tests, if required (see 5.1), shall be performed as given in 8.5 of IEEE Std 1247-1998, except for the following:

— Both automatic closing and manual closing tests are required.

— Automatic closing shall be performed at minimum control voltage, if applicable.

6.7 Condition of the sectionalizer after switching tests, short-time withstand current tests, and fault-making current tests

The condition of the sectionalizer, after each test in 6.4, 6.5, and 6.6, shall be as given in 8.6 of IEEE Std 1247-1998.

6.8 Mechanical operation tests

Mechanical operation tests shall be performed as given in 8.8 of IEEE Std 1247, except for the following:

— Five hundred automatic lockout operations are required.

— No terminal loading is required.

— No mechanical operation tests, other than those required by IEEE Std C37.41 and ANSI C37.42, are required for cutout type sectionalizers.

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6.9 Radio influence voltage (RIV) tests

When the primary insulation of the sectionalizer consists of self-restoring dielectric, such as oil or gas (including air), the RIV test shall be performed unless the partial discharge test is performed on the complete sectionalizer. Sectionalizers shall meet the RIV limits when tested in accordance with 6.1 and as follows in 6.9.1, 6.9.2, and 6.9.3.

6.9.1 Test voltages and limits

The test voltage shall be a minimum of 105% of the line-to-ground voltage corresponding to the rated maximum voltage of the sectionalizer. The limit of radio influence in all cases shall be 250 μV at 1.0 MHz.

Sectionalizers having two or more voltage ratings shall be tested on the basis of the highest voltage rating given on the nameplate.

6.9.2 Test conditions

6.9.2.1 Proximity of other apparatus

Any grounded or ungrounded object or structure (except mounting structure when required) shall not be nearer any part of the sectionalizer or its terminals undergoing test than three times the longest overall dimension of the test piece with a minimum allowable spacing of 1 m.

Where space requirements under test conditions do not permit the above clearances to be maintained, the test shall be considered satisfactory if the limits of RIV obtained are equal to or less than those specified in 6.9.1. In such cases, a record should be made of the object, structures, etc., and their distances from the sectionalizer under test; these data are to be kept for future use.

6.9.2.2 Sectionalizer insulating mediums

The tanks of sectionalizers with insulating mediums other than air shall be filled with the correct amount of insulating medium and, in the case of gas, pressurized to the nominal as shipped pressure at 20 °C.

6.9.2.3 Electrical connections

Conductors of the largest size (bare wire) intended for use with the sectionalizer under test shall be connected to each terminal. The length of the conductors, when used, shall be equal to or greater than the longest overall dimension of the sectionalizer, except that the length need not exceed 1.8 m. The free end of any such conductor shall terminate in a sphere having a diameter of twice the diameter of the conductor ±10% or shall be shielded in some other suitable manner to eliminate the effect of the end of the conductor as a source of RIV.

6.9.2.4 Atmospheric conditions

Tests shall be conducted under atmospheric conditions prevailing at the time and place of test, but it is recommended that tests be avoided when the vapor pressure is below 0.67 kPa or above 2.00 kPa.

Since the effects of humidity and air density upon RIV are not definitely known, no correction factors are recommended for either at the present time. However, it is recommended that barometric pressure and dry and wet bulb thermometer readings be recorded so that, if suitable correction factors should be determined, they could be applied to previous measurements.

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6.9.3 Test equipment and procedure

The equipment and general method used in making RIV tests shall be in accordance with the recommendations of NEMA 107 (methods) and IEEE Std C63.2™ (equipment).

6.9.3.1 Procedure

Tests shall be made with the sectionalizer in the closed and open positions. When tests are made with the sectionalizer in the open position, the RIV shall be determined with the pole or group of poles not connected to the measuring apparatus both grounded and ungrounded.

6.9.3.2 Tests on multipole devices

In the case of multipole sectionalizers, one pole or terminal or groups of the same may be tested at one time.

6.9.3.3 Precautions

The following precautions should be observed when making RIV tests:

a) The sectionalizer should be approximately the same temperature as the room in which the tests are made.

b) The sectionalizer should be dry and clean.

c) The sectionalizer should not have been subjected to dielectric tests within 2 h prior to the RIV tests.

d) In some cases, it may be found that the RIV falls off after the rated power-frequency voltage has been applied for a short time. In such cases, it may be desirable to pre-excite the sectionalizer at normal operating voltage for a period not exceeding 5 min before proceeding with the tests.

Failure to follow the above-noted precautions shall not be cause to disqualify a sectionalizer that meets the limits of 6.9.1.

6.10 Partial discharge tests

Partial discharge tests shall be performed on all sectionalizers that use a nonrestoring dielectric as the primary insulation (e.g., solid dielectric). These tests shall be performed in accordance with IEEE Std 1291. The minimum detection sensitivity for which these tests are conducted shall be 10 pC.

6.10.1 Test voltages and limits

The test voltage shall be 105% of the line-to-ground voltage corresponding to the rated maximum voltage of the sectionalizer. Sectionalizers having two or more voltage ratings shall be tested on the basis of the highest voltage rating given on the nameplate.

Partial discharge limits have not been established. The purpose of this design test is to establish a standard test procedure and gather benchmark data for the use of both producers and users of the equipment. It is anticipated that this data will provide guidance for future revisions to this standard.

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NOTE—There is general agreement that partial discharge testing should be performed on all sectionalizers where the primary insulating system may be subject to deterioration due to partial discharge. At a minimum, the data will help to monitor process consistency by the producer and serviceability for the user. The following three reasons have been given for not setting partial discharge test limits at this time: 1) there is not a sufficient body of evidence to establish a cause–effect relationship between partial discharge and performance in distribution switchgear; 2) there is not an agreement as to what the limits should be; and 3) appropriate values will depend on the materials, design, and complexity of the equipment. Partial discharge limits at the test voltage specified in 6.10.1 have been suggested in the 10 pC to 20 pC range for a phase or module tested alone. At the upper end, a partial discharge limit of 100 pC has been recommended for a complete three-phase assembly. The 100 pC value is consistent with the Canadian Standard CAN/CSA C22.2 No. 31-M89.[9]

6.10.2 Conditioning of test sample

The surface of insulators should be clean and dry. The test object should also be at ambient temperature. Mechanical, thermal, or electrical stressing before the test should be avoided.

6.10.3 Test equipment and procedure

The equipment and general method used in making partial discharge measurements tests shall be in accordance with the recommendations of IEEE Std 1291 or IEC 60270.

Tests shall be made with the sectionalizer or test module in the closed and open positions. All surfaces that are normally grounded shall be grounded and all surfaces isolated that are normally isolated.

NOTE—An open gap in a vacuum interrupter may have field emission from rough spots on the cathode contact during partial discharge tests. This emission is not likely to distort the test results at the voltage level specified above. However, even at this voltage, and especially at higher voltage levels, field emission currents may lead to erroneous conclusions about the presence of partial discharge in solid insulation parallel to the vacuum gap. Since field emission is only observed on a cathode, the observation of asymmetrical results with respect to voltage polarity when a dc voltage is applied is then an indication of the presence of field emission in a vacuum gap instead of a partial discharge in the parallel solid insulation.

6.11 Operating duty tests

The standard operating duty shall consist of the following tests made without maintenance in the order named on the same sectionalizer of the highest continuous current rating of a design. These tests shall prove conformance with this standard for all lower current ratings of this design.

6.11.1 Operating duty tests for load-interrupting sectionalizers

For sectionalizers designed to interrupt load current, the standard operating duty shall consist of the following:

a) Twenty automatic lockout operations at rated maximum voltage and actuated by a current whose symmetric value is equal to the rated 1 s current (five operations each at one- and two-shot lockout and ten operations at three-shot lockout).

b) Eighty automatic lockout operations actuated by a current whose symmetric value is equal to the rated 1 s current supplied from a low-voltage source. The shots to lockout shall be such as to give 50% three-shot lockout. The remaining 50% may be divided between one- and two-shot lockout. Tests shall show that the isolating time from current cessation to sectionalizer contact parting does not exceed 0.25 s.

[9] For Canadian Standard Association documents, please visit http://www.csa-intl.org/onlinestore/.

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c) Fifty nonautomatic operations at rated maximum voltage making and interrupting the rated continuous current. A sufficient time interval should be used between nonautomatic operations to prevent the formation of excessive pressures. The power factor of the test circuit shall be as specified in 8.3 of IEEE Std 1247-1998.

d) Sufficient nonautomatic closing operations, in order to obtain one operation with 90% to 100% asymmetry. This test shall be made at rated maximum voltage, with a circuit capable of a current equal to the rated short-circuit current. For three-phase sectionalizers, this test shall be made on a three-phase basis.

e) One nonautomatic opening operation at rated maximum voltage interrupting the rated (load current switching) interrupting current specified in 6.3. The power factor of the test circuit shall be as specified in 8.3 of IEEE Std 1247-1998.

6.11.2 Operating duty tests for nonload-interrupting sectionalizers

For sectionalizers not designed to interrupt load current, the standard operating duty shall consist of the following:

a) Automatic operations as specified in item a) and item b) of 6.11.1

b) Nonautomatic closing operations as specified in item d) of 6.11.1

6.11.3 Operating performance

Sectionalizers shall meet the automatic and nonautomatic duties specified without emitting flame or oil.

6.11.4 Condition after standard operating duty tests

At the end of the standard operating duty tests, the sectionalizer shall be in the following condition:

a) *Mechanical.* Substantially in the same mechanical condition as at the beginning except that the contacts may show some sign of arc pitting

b) *Electrical.* Capable of withstanding rated maximum voltage in the open position and of carrying rated continuous current at rated maximum voltage without thermal runaway but not necessarily without exceeding rated temperature rise in the closed position

6.11.5 Interpretation of standard operating duty tests

After the series of operations equivalent to the standard operating duty, it is not to be inferred that the sectionalizer can again meet its rating without being inspected and, if necessary, repaired.

6.11.6 Cold temperature test

A sectionalizer shall be tested for proper operation and reset at the lowest temperature for which it is designed. After the sectionalizer has come to a steady temperature, minimum actuating current tests shall be performed with the control set for one, two, and three shots to lockout. Heater performance shall be verified during this test.

NOTE—The cutout type sectionalizer is used in a distribution cutout mounting. Consult the cutout type sectionalizer's manufacturer for applications under icing conditions.

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6.11.7 Surge current test—series coil sectionalizers

A sectionalizer shall be capable of withstanding two current surges of 65 000 A crest having a 5 μs × 10 μs wave shape.

6.11.7.1 Test conditions

If a coil bypass device is required, it shall be mounted in the sectionalizer in the same manner as furnished for normal service. The leads from the high-current impulse generator shall be connected to the same terminals of the sectionalizer.

6.11.7.2 Test procedure

Two current surges of the specified current value shall be applied.

Following this test, the sectionalizer shall be tested at the minimum actuating current so as to cause it to go through one automatic operation to lockout.

6.11.7.3 Condition after test

At the end of the test, the sectionalizer and the coil bypass device shall be in the following condition:

a) *Mechanical.* Substantially in the same mechanical condition as at the beginning except for minor arc scars on any gap electrodes of the coil bypass device. There shall be no indication of external flashover of the coil bypass device, from the terminals of the coil bypass device to any other parts of the sectionalizer or of the series coil of the sectionalizer.

b) *Electrical.* With the coil bypass connected in its normal operating position, the sectionalizer shall be capable of withstanding rated maximum voltage in the open position and, in the closed position, of functioning correctly on overcurrent to go through its counting cycle to lockout at the minimum actuating current.

6.11.8 Control elements surge withstand capability tests

Control elements supplied with sectionalizers shall withstand, without damage, voltage surges originating in the low-voltage energy source, in the current or voltage transformers connected to the control elements, or both, or in the control leads connecting the sectionalizer and the control elements. The surge withstand test shall be performed as given in 6.13 of IEEE Std C37.60-2003.

6.12 Minimum actuating current tests

Sectionalizers shall meet the rated minimum actuating current within the specified limits of ±10% when tested as specified in 6.1 and per 6.12.1 and 6.12.2.

6.12.1 Test circuit

The sectionalizer shall be connected to a low-voltage power source of alternating current in series with a means for increasing the current and of delivering successive current impulses to cause operation of the counting mechanism.

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6.12.2 Test procedure

The sectionalizer, set for one-shot lockout, shall be subjected to sufficient current impulses to verify that it does not operate below 90% but does operate at 110% of minimum actuating current.

7. Production tests (routine tests)

Production tests shall be performed as given in Clause 7 of IEEE Std C37.60-2003, except that the calibration test (see 7.1 of IEEE Std C37.60-2003) shall be performed as given in 7.1 of this standard.

7.1 Operational calibration

Sectionalizers shall be subjected to the following calibration, where applicable, for conformance to published operating characteristics. Calibration may be performed on the individual control elements sub-assembly prior to final assembly on the sectionalizer. When the latter is done, the complete assembly shall be tested to assure that the device will open the sectionalizer. The calibration may be performed in any order deemed appropriate by the manufacturer.

a) Sequencing tests as appropriate for the type of control or actuation

b) Actuating delay(s), if applicable

c) Remote features

d) Special features

8. Construction requirements

8.1 Nameplate

The sectionalizer shall be provided with a nameplate that is permanently and indelibly marked with the following information:

a) Manufacturer's name and address

b) Year of manufacture

c) Manufacturer’s model or type designation

d) Serial number

e) Rated maximum voltage

f) Rated continuous current (interrupter rating; may be different from the series coil rating)

g) Rated load switching current

h) Rated lightning impulse withstand voltage

i) Rated power frequency

j) Rated short-circuit withstand current and duration (switch rating; may be different from the series coil rating)

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Series coil sectionalizers shall be provided with a separate nameplate, which can be changed when the coil is changed, that is permanently marked with the following information:

k) Rated continuous current

l) Rated short-circuit withstand currents and durations

m) Rated minimum actuating current

Such nameplates shall be permanently and securely fixed in position and visible from the normal operating position.

8.2 Indicators

8.2.1 Position indicators

Sectionalizers shall be provided with a position indicator or other suitable means that clearly indicates their closed or open position that shall be visible from the surface. For pad-mounted, submersible, or dry-vault sectionalizers, viewing of the position indicator may require opening of the enclosure. If colors are used to indicate an open or closed position, red shall signify closed and green shall signify open, with the words *open* or *closed* in contrasting colors.

8.2.2 Stored energy mechanism charge indicator

When indicators are used on stored energy operating mechanisms, the following colors should be used:

a) Yellow background with the word *charged* in black letters for charged mechanism

b) White background with the word *discharged* in black letters for discharged mechanism

8.3 Accessories

8.3.1 Manual operating provision

Sectionalizers shall be provided with a manual operating lever to open and close the sectionalizer. The operating lever shall be suitable for operation with a hot line stick. The operating lever on a submersible sectionalizer shall be located such that one man standing on the surface can operate it without standing directly over the sectionalizer.

8.3.2 Insulating medium quantity indicator

Where liquid or gas is used as the insulating medium, provision shall be made for personnel to readily determine the insulating liquid level or insulating gas status with the sectionalizer energized. The indicator shall show whether the device is in the safe operating range. Procedures or devices that require exposing the insulating medium to the outside environment shall not be used.

8.3.3 Oil sampling provisions

When oil is used as an insulating medium, provision shall be made to obtain a bottom oil sample.

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8.3.4 Counters

If an operations counter is provided, it shall indicate the total number of tripping operations of the sectionalizer. The counter shall be visible with the sectionalizer in service.

8.3.5 Grounding provisions

A sectionalizer with a metal housing shall have provisions for the connection of a ground lead.

The grounding connector shall accommodate a ground conductor of a size adequate to conduct the rated 1 s current of the sectionalizer.

Pad-mounted, dry-vault, and submersible sectionalizers shall have an additional grounding connection for each three-phase set of cable entrances.

8.4 Instruction

Instruction manuals for sectionalizers shall be supplied with the equipment. These may include directions for inspection, storage, unpacking, assembling, and testing the sectionalizer. Additional information may be contained in maintenance manuals and spare parts lists, which may be available from the manufacturer.

8.5 Conductor terminal

For connection of bare conductors, bushing terminals shall accommodate conductors of a size adequate to conduct the rated continuous current of the sectionalizer without exceeding the appropriate temperature rise given in 5.4.2.

For submersible sectionalizers, bushings shall accommodate cable terminations in accordance with IEEE Std 386™ or IEC 60502, unless specified by the user.

8.6 Tank construction

8.6.1 Tank construction—submersible and pad-mounted sectionalizers

Tank construction shall be as given in 9.9 of IEEE Std C37.74™-2003.

8.6.2 Tank construction—pad-mounted sectionalizers

Tank construction shall be as given in 9.10 of IEEE Std C37.74-2003.

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Annex A

(informative)

X/R ratios

A general understanding of circuit time constant (τ_{cc}) and X/R ratio and associated peak currents is necessary for the proper design, testing, and application of switchgear. The mechanical stresses associated with fault withstand or fault making are in relation to the square of the peak current (i_p^2) and the thermal stress associated with prearcing or fault current interruption is a complex relation of the arc voltage, the arcing time, and the total charge (integral of the arcing current).

A.1 Time constant (τ_{cc}) and X/R ratio

An electrical circuit may be defined by its main series components that are the inductance (L or X) ($X=2\pi fL$) and resistance. The circuit time constant is defined by the ratio L/R. The X/R ratio is frequency dependent (i.e., a time constant of 45 ms will lead to an X/R ratio of 17 at 60 Hz and 14.2 at 50 Hz).

For a three-phase fault, the direct components of the circuit shall be considered ($\tau_{cc} = L_1/R_1$ or $X/R = X_1/R_1$). For a phase-to-ground fault, the direct and zero sequence components shall be considered ($\tau_{cc} = [2L_1+L_0]/[2R_1+R_0]$ or $X/R = [2X_1+X_0]/[2R_1+R_0]$)

where

R_0 is the zero sequence resistance
R_1 is the positive sequence resistance
L_0 is the zero sequence inductance
X_0 is the zero sequence reactance
L_1 is the positive sequence inductance
X_1 is the positive sequence reactance

A.2 Asymmetrical fault current

The maximum asymmetrical current is associated with a fault initiation at zero voltage. This may be associated with lighting flashover or with a switch or a breaker closing or reclosing on a faulted circuit or a temporary ground. If a three-phase switching device is used, an asymmetrical fault current will occur in one of the phases, the value of which will be between 87% and 100% of maximum asymmetrical current.

The instantaneous current of a single-phase circuit can be calculated from the following formula; maximum asymmetry will occur for a fault initiation at zero voltage ($\theta = 0$).

$$i = \sqrt{2}I\left(\sin(\omega t + \theta - \phi) - \sin(\theta - \phi)e^{-t/\tau_{cc}} \right)$$

where

i is the instantaneous current
I is the rms value of the current

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ω is the angular frequency ($2\pi f$)
ϕ is the circuit phase angle = $\tan^{-1}(X/R)$
θ is the angle between voltage zero and fault initiation
t is the time
τ_{cc} is the circuit time constant (L/R or X/Rω) (see Table A.1)

The peak asymmetrical current (i_p) is the maximum of the above formula. The peak factor is i_p/I.

The rms current is defined by the following formula:

$$I_{rmsasym} = \sqrt{I_{rmssym}^2 + I_{dc}^2}$$

where

I_{rmssym} is the rms symmetrical component of the current
I_{dc} is the direct, aperiodic component of the current

and the rms factor can be calculated using the following formula:

$$RMS\,factor = \sqrt{1 + \left(\sqrt{2}e^{-t_p/\tau_{cc}}\right)^2}$$

where

t_p is the time to the peak, or the time to maximum of the previous formula

The following Table A.1 gives, for some typical time constants (τ), corresponding X/R ratios for 60 Hz and 50 Hz and asymmetrical current peak factor. It also gives, for reference purposes only, the rms factor at 60 Hz (this factor has never been used at 50 Hz and in international standards; the 50 Hz value is thus not given here). Note that the mechanical stresses associated with fault withstand or fault making are in relation to the square of the peak current (i_p^2).

Table A.1—X/R ratios: peak factors and rms factors

Time constant [τ]	X/R ratios		Peak factor [i_p/I]		RMS factor
	At 60 Hz	At 50 Hz	At 60 Hz	At 50 Hz	At 60 Hz
10.6	4.0	3.3	2.09	2.00	1.21
21.2	8.0	6.7	2.38	2.31	1.39
31.8	12.0	10.0	2.51	2.46	1.49
45.0	17.0	14.1	2.59	2.55	1.55
60.0	22.6	18.8	2.65	2.61	1.59
90.0	33.9	28.3	2.70	2.68	1.63
120.0	45.3	37.7	2.73	2.72	1.66
150.0	56.6	47.1	2.75	2.74	1.67

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Annex B

(normative)

Ratings for series coil sectionalizers

Series coil sectionalizers have been used globally for many years. Traditionally, series coil designs operate in a current-sensing mode as opposed to a time- or voltage-sensing mode.

The current ratings of series coil sectionalizers are determined by the series coil itself and by the rating of the contacts. The preferred ratings of series coil sectionalizers, as established in earlier revisions of this standard, are given in Table B.1 and Table B.2.

B.1 Rating information

The rating of a series coil sectionalizer shall be as given in 5.1.

B.2 Series coil sectionalizer ratings

The preferred ratings unique to a series coil sectionalizer are given in Table B.1 and Table B.2. Any rating not specifically listed in Table B.1 or Table B.2 shall be taken from the appropriate subclauses of Clause 5 of this standard.

Table B.1—Preferred ratings and performance characteristic for series coil automatic line sectionalizers

Line no.	Rated maximum voltage (kV)	Rate lightning impulse withstand voltage (kV)	Rated power-frequency withstand voltage (kV)		Current (A)	
			60 s dry	10 s wet	Continuous	Load current switching
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7
Single-phase sectionalizers						
1	15.0	95	35	30	140	308
2	15.0	125	42	36	200	200
3	15.0	125	42	36	200	440
4	27.0	125	60	50	200	—
Three-phase sectionalizers						
5	15.5	110	50	45	200	440
6	27.0	125	60	50	200	440

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Table B.2—Preferred current ratings of series coil automatic line sectionalizers

Continuous current 60 Hz (See Note 2)	Minimum actuating current (A, rms symmetrical)	Lines 1, 2, 3, and 4 single-phase sectionalizers (See Note 1)			Lines 5 and 6 three-phase sectionalizer (See Note 1)		
		Momentary and fault making (A, rms, asymmetrical)	1 s (A, rms symmetrical)	10 s (A, rms symmetrical)	Momentary and fault making (A, rms, asymmetrical)	1 s (A, rms symmetrical)	10 s (A, rms symmetrical)
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
5	8	800	200	60	800	200	60
10	16	1600	400	125	1600	400	125
15	24	2400	600	190	2400	600	190
25	40	4000	1000	325	4000	1000	325
35	56	6000	1500	450	6000	1500	450
50	80	6500	2000	650	7000	2000	650
70	112	6500	3000	900	8000	3000	900
100	160	6500	4000	1250	8000	4000	1250
140	224	6500	4000	1800	8000	4000	1800
160 (See Note 3)	256	—	—	—	9000	5700	2600
185 (See Note 3)	296	—	—	—	9000	5700	2600
200 (See Note 3)	320	—	—	—	9000	5700	2600

NOTE 1—For line numbers, refer to Table B.1

NOTE 2—Current ratings are based on 60 Hz systems; refer to the manufacturer for application at other system frequencies.

NOTE 3—Applicable to three–phase sectionalizers only.

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