American National Standard

ANSI C37.32-1996

High-Voltage Air Disconnect Switches Interrupter Switches, Fault Initiating Switches, Grounding Switches, Bus Supports and Accessories Control Voltage Ranges— Schedule of Preferred Ratings, Construction Guidelines and Specifications

NEMA

National Electrical Manufacturers Association

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American National Standard

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AMERICAN NATIONAL STANDARD

High-Voltage Air Disconnect Switches Interrupter Switches, Fault Initiating Switches, Grounding Switches, Bus Supports and Accessories Control Voltage Ranges—

Schedules of Preferred Ratings, Construction Guidelines and Specifications

Secretariat

National Electrical Manufacturers Association

Approved by:

American National Standards Institute

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ANSI C37.32-1996

Foreword (This Foreword is not part of American National Standard C37.32-1996)

The purpose of this revision is to bring the standard up-to-date and in line with present-day requirements. The standard is coordinated with the other American National Standards in the field of high-voltage air switches, insulators, and bus supports:

ANSI/IEEE C37.30, *Standard requirements for high-voltage air switches*

ANSI/IEEE C37.34, *Test code for high-voltage air switches*

ANSI/IEEE C37.35, *Guide for the Application, installation, operation, and maintenance of high-voltage air disconnecting and load interrupter switches*

ANSI/IEEE C37.36b, *Guide to current interruption with horn gap air switches*

ANSI/IEEE C37.37, *Loading guide for AC high-voltage air switches*

This standard has been expanded to include distribution class air switches, a broader coverage of interrupter switches and ANSI C37.33, *Rated Control Voltage and Their Ranges for High Voltage Air Switches*. Circuit switchers are excluded from this standard.

This standard contains three annexes, which are not considered a part of the standard.

Suggestions for the improvement of this standard will be welcome. They should be sent to the National Electrical Manufacturers Association,1300 North 17th Street, Suite 1847, Rosslyn, VA 22209.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Power Switchgear, C37. Committee approval of the standard does not necessarily imply that all members voted for its approval. At the time it approved this standard, the C37 Committee had the following members:

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J. Scott, Executive Vice-Chairman, LV Standards
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High-Voltage Air Disconnect Switches, Interrupter Switches, Fault Initiating Switches, Grounding Switches, Bus Supports, and Accessories Control Voltage Ranges— Schedules of Preferred Ratings, Construction Guidelines and Specifications

1 Introduction

1.1 Scope

This standard provides the schedules of preferred ratings and construction specifications for high-voltage air disconnect, interrupter, fault initiating, and grounding switches rated above 1000 volts. Switch operator control voltage ranges (formerly ANSI C37.33), bus supports and accessories are also covered by this standard. High-voltage air switches included in ANSI/IEEE C37.20.2, ANSI/IEEE C37.20.3, ANSI/IEEE C37.71 and ANSI C37.72 are not covered by this standard.

1.2 References

The following standards are referenced by this text or have content relevant to the apparatus covered by this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI C29.8-1985, *Wet-process porcelain insulators—Apparatus, cap and pin type*

ANSI C29.9-1983, *Wet-process porcelain insulators—Apparatus, post type*

NEMA SG 6-1996, *Power switching equipment*

NEMA 107-1987, *Methods of measurement of radio influence voltage (riv) of high-voltage apparatus*

ANSI/IEEE C37.30-1992, *Standard requirements for high-voltage air switches*

ANSI/IEEE C37.34-1994, *Test code for high voltage air switches*

ANSI/IEEE C37.35-1976 (R1992), *Guide for the application, installation, operation, and maintenance of high-voltage air disconnecting and load interrupter switches*

ANSI/IEEE C37.36b-1990, *Guide to current interruption with horn gap air switches*

ANSI/IEEE C37.37-1979, *Loading guide for AC high voltage air switches (in excess of 1,000 volts)*

ANSI/IEEE C37.38-1989, *Gas-insulated, metal-enclosed disconecting, interrupter, and grounding switches*

IEEE C37.100-1992, *Standard definitions for power switchgear*

ANSI/IEEE 142-1991, *Practice for grounding of industrial and commercial power systems*

IEC 815-1986, *Guide for the selection of insulators in respect of polluted conditions*

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2 Definitions

The definitions of terms contained in this document, or in other standards referred to in this document, are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this standard. An asterisk (*) following a definition indicates that at the time this standard was approved, there was no corresponding definition in IEEE C37.100. Refer to IEEE C37.100 for additional definitions.

2.1 outdoor switch: Switches designated for operation outside buildings or enclosures. Outdoor switches may be exposed to the weather. Outdoor switches experience no restriction of heat transfer to the ambient.*

2.2 indoor switch: Switches designated for operation inside buildings or weather-resistant enclosures which do not restrict heat transfer to the ambient.*

2.3 enclosed switch: Switches designated for operation within a housing restricting heat transfer to the external medium.

2.4 station class: A descriptive term used to denote application or restriction or both to generating stations, switching stations, substations and transmission lines.*

2.5 distribution class: A descriptive term used to denote application or restriction or both to that part of an electric system between the substation and the customer.*

3 Station class outdoor air disconnect switches

3.1 Basis of preferred ratings

The ratings of station class outdoor disconnect switches shall be based upon the definitive conditions specified in ANSI/IEEE C37.30.

3.2 Preferred ratings

3.2.1 Voltage and current

The preferred voltage, continuous current, and withstand current ratings at the rated power frequency of 60 Hz shall be in accordance with tables 1, 2, and 3.

3.2.2 Ice breaking ability

If an outdoor switch has an ice breaking rating, the preferred ratings shall be 3/8 inch (10 mm), and 3/4 inch (20 mm). A switch that has successfully passed the ice test and is rated for a given thickness of ice is also rated for lesser thicknesses.

3.2.3 Mechanical operations

The preferred mechanical operation rating shall be 1000 operations: 900 close-open cycles without terminal loading and 100 close-open cycles with terminal loading as specified in 11.3.2 of ANSI/IEEE C37.34. Refer to table 16 for rated control voltages for motor-operated switches and 11.3.3 of ANSI/IEEE C37.34 for number of operations at minimum and maximum control voltage.

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3.2.4 Terminal loading

The preferred mechanical terminal loadings shall be in accordance with table 4.

3.3 Dielectric test voltages

3.3.1 Energized parts to ground

Outdoor switches in either the open or closed positions shall withstand the voltages specified in table 1, columns 2, 3, and 4. See note 1 of table 1 and table 2 for switching impulse ratings.

3.3.2 Open gap withstand

The air gap of outdoor air switches, when in the full open position, shall withstand voltages that are 10 percent higher than the rated lightning impulse dry withstand and the power-frequency dry withstand voltages given in columns 2 and 3 of table 1. For switches rated 362 kV and higher, the open gap shall also withstand the switching impulse voltages specified in table 2.

Station class outdoor air switches having solid insulation material across the open gap shall withstand 100 percent of the voltages given in table 1 columns 2, 3 and 4.

3.3.3 Corona and radio influence test voltage limits

Switches rated 121 kV and higher when tested under dark conditions at the voltage levels specified in table 1, column 5 shall be free of visible plumes or spikes. The limits of radio-influence voltage are given in column 6. Refer to ANSI/IEEE C37.34, clause 5 and NEMA 107 for testing procedures.

3.4 Construction specifications

3.4.1 Insulators

Insulator units shall have electrical characteristics and leakage distance values equal to or exceeding those listed for equivalent insulation in ANSI C29.8 or C29.9. Refer to clause 3.4 of ANSI/IEEE C37.35 and IEC 815 for insulator creepage distance considerations under contaminated conditions. Insulators shall have sufficient mechanical strength to withstand applicable operating forces, including magnetic forces produced by the rated peak withstand current of the switches for which they are supplied, as specified in table 3.

3.4.2 Arrangement and size of bolt holes in terminal pads

Bolt hole centerlines in terminal pads, when used, shall be as shown in figure 1. Holes shall accommodate bolts with a diameter of 1/2 inch (12.7 mm).

3.4.3 Phase spacing (pole spacing)

Phase spacing for outdoor switches and bus supports shall be as specified in table 5.

3.4.4 Ground clearance

Ground clearance for outdoor switches and bus supports shall equal or exceed that specified in table 5.

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3.4.5 Single-pole switch dimensions

Minimum metal-to-metal, single-pole air gap distances (switch full open position) and centerline-to-centerline spacings of insulator columns are listed in table 6. The air gap distance is based upon being at least 10 percent in excess of the minimum clearance to ground as given in table 5. These dimensions may be modified depending upon dielectric test results (See 3.3.2).

3.4.6 Base mounting holes

Spacing for the base mounting holes for 600, 1200, and 1600 ampere switches should be as specified in table 7. Other spacings can be used. Base mounting holes shall be at least 9/16 inch (14.3 mm) in diameter.

4 Distribution class outdoor air disconnect switches

4.1 Basis of preferred ratings

The ratings of distribution class outdoor air disconnect switches shall be based upon the definitive conditions specified in ANSI/IEEE C37.30.

4.2 Preferred ratings

4.2.1 Voltage and current

The preferred voltage, continuous current and withstand current ratings at the rated power frequency of 60 Hz shall be in accordance with tables 8 and 9.

4.2.2 Ice breaking ability

Refer to 3.2.2 for preferred ratings.

4.2.3 Mechanical operations

The preferred number of mechanical operations shall be as specified in 3.2.3.

4.2.4 Terminal loading

The preferred mechanical terminal loading shall be in accordance with table 4.

4.3 Dielectric test voltages

4.3.1 Energized parts to ground

Outdoor switches in either the open or closed positions shall withstand the voltages specified in table 8, columns 2, 3 and 4.

4.3.2 Open gap withstand

The air gap of outdoor switches, when in the full open position, shall withstand voltages that are 10 percent higher than the rated lightning impulse dry withstand and the power-frequency dry withstand voltages given in columns 2 and 3 of table 8.

Distribution class outdoor air switches having solid insulation material across the open gap shall withstand 100 percent of the voltages given in table 8, columns 2, 3 and 4.

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4.3.3 Corona and radio influence test voltage limits

Switches rated below 121 kV have no corona or radio influence voltage requirements.

4.4 Construction specifications

4.4.1 Insulators

Insulators shall have electrical characteristics and leakage distance values such as to coordinate with the switch dielectric test voltage withstand requirements of 4.3.1. Refer to clause 3.4 of ANSI/IEEE C37.35 and IEC 815 for insulator creepage distance considerations under contaminated conditions. The insulators shall have sufficient strength to withstand the applicable operating force, including magnetic force produced by the rated peak withstand current of the switch to which they are applied, as specified in table 9.

4.4.2 Arrangement and size of bolt holes in terminal pads

Bolt hole centerlines shall be as shown in figure 1. Holes shall accommodate bolts that are 1/2 inch (12.7 mm) in diameter.

4.4.3 Phase spacing (pole spacing)

Phase spacing for distribution class switches and bus supports shall be as specified in table 10.

4.4.4 Ground clearance

Ground clearance for distribution class switches and bus supports shall equal or exceed that specified in table 10.

4.4.5 Single pole switch dimensions

The minimum metal-to-metal single pole air gap distances (switch full open position) shall be as listed in table 11 with possible modifications as noted.

5 Indoor air switches

5.1 Basis of preferred ratings

The ratings of indoor air switches shall be based upon the definitive conditions specified in ANSI/IEEE C37.30, except that they are not subjected to wind loads and they do not have ice breaking ratings.

5.2 Preferred ratings

5.2.1 Voltage and current

The preferred voltage, and preferred continuous and withstand current ratings at the rated power frequency of 60 Hz shall be in accordance with table 12.

5.2.2 Mechanical operations

The preferred number of mechanical operations shall be as given in 3.2.3.

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5.2.3 Terminal loading

Presently, there are no preferred mechanical terminal loadings for indoor switches.

5.3 Dielectric test voltages

5.3.1 Energized parts to ground

Indoor air switches, in either the open or closed positions, shall withstand the dielectric test voltages specified in columns 2, 3, and 4 of table 12.

5.3.2 Open gap withstand

The length of the air gap of indoor air switches, when in the full open position, shall be such that the open gap or gaps will withstand a test voltage that is 10 percent higher than the lightning impulse dry and power-frequency dry withstand test voltages specified in columns 2 and 4 of table 12.

Indoor air switches having solid insulation material across the open gap shall withstand 100 percent of the voltages given in table 12, columns 2, 3 and 4.

5.3.3 Corona and radio influence test voltage limits

Switches rated below 121 kV have no corona or radio influence voltage requirements.

5.4 Construction specifications

5.4.1 Insulators

Insulator units shall have electrical characteristics and leakage distance values such as to coordinate with the switch dielectric test voltage withstand requirements of 5.3. The insulators shall have sufficient strength to withstand the applicable operating force, including the magnetic force produced by the rated peak withstand current of the switch to which they are applied, as specified in table 12.

5.4.2 Arrangement and size of bolt holes in terminal pads

The arrangement of bolt hole centerlines in terminal pads, when used, shall be as shown in figure 1. Holes shall accommodate bolts that are 1/2 inch (12.7 mm) in diameter.

5.4.3 Phase spacing

The minimum metal-to-metal clearance between phases for indoor air switches and bus supports shall be as specified in table 13.

5.4.4 Single pole switch dimensions

The minimum metal-to-metal single pole air gap distances (switch full open position) shall be as specified in table 13 with possible exceptions as noted.

6 Grounding switches

6.1 Basis of preferred ratings

The ratings of high-voltage grounding switches shall be based upon the definitive conditions specified in ANSI/IEEE C37.30.

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6.2 Preferred ratings

6.2.1 Voltage and current

The preferred voltage and withstand current ratings at the rated power frequency of 60 Hz shall be in accordance with tables 1, 3, 8, 9, and 12. Grounding switches have no continuous current ratings but have withstand current ratings which may be equal to or less than the disconnect switch rating.

6.2.2 Ice breaking ability

Refer to 3.2.2 for preferred ratings for outdoor switches. Indoor switches have no ice breaking requirements.

6.3 Electrical clearances

The electrical clearance between the grounding blade and the nearest energized part during ground blade travel shall be equal to or greater than the minimum gap distance listed in table 14. In the fully open position of the grounding blade, the switch shall withstand the voltages listed in columns 2, 3, and 4 of tables 1, 8, and 12.

6.4 Corona and radio influence test voltage limits

Switches rated 121 kV and higher when tested under dark conditions at the voltage levels specified in table 1, column 5 shall be free of visible plumes or spikes. The limits of radio-influence voltage are given in column 6. Refer to ANSI/IEEE C37.34, clause 5 and NEMA 107 for testing procedures.

6.5 Construction specifications

Construction specifications for grounding switches shall be in accordance with the requirements specified in 3.4, 4.4, or 5.4.

7 Fault initiating switches

7.1 Basis of preferred ratings

The ratings of high-voltage fault initiating switches shall be based upon the definitive conditions specified in ANSI/IEEE C37.30.

7.2 Preferred ratings

The preferred fault-making current ratings of fault initiating switches at the rated power frequency of 60 Hz shall be 9.5, 12.5, 20, 25, or 38 kA rms symmetrical. Peak withstand current ratings are 2.6 times the short time (symmetrical) withstand current values.

7.3 Preferred closing time

The preferred closing time which includes blade travel to close the switch, shall not exceed 0.5 seconds.

7.4 Operating life expectancies

The manufacturer should be consulted for operating life expectancies for fault initiating switches.

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7.5 Corona and radio influence test voltage limits

Switches rated 121 kV and higher when tested under dark conditions at the voltage levels specified in table 1, column 5 shall be free of visible plumes or spikes. The limits of radio-influence voltage are given in column 6. Refer to ANSI/IEEE C37.34, clause 5 and NEMA 107 for testing procedures.

7.6 Construction specifications

Construction specifications for fault initiating switches shall be in accordance with the requirements specified in 3.4, 4.4, or 5.4.

8 Outdoor, indoor and enclosed interrupter switches

8.1 Basis of preferred ratings

The ratings of interrupter switches shall be based upon the definitive conditions specified in ANSI/IEEE C37.30.

8.2 Preferred rated power frequency

The preferred rated power frequency of interrupter switches shall be 60 Hz.

8.3 Preferred rated voltages

8.3.1 Rated maximum voltage

The preferred rated maximum voltage shall be as given in column 1 of tables 1, 8, and 12.

8.3.2 Rated loop splitting voltage

The preferred rated loop splitting voltage is 20 percent of the rated maximum voltage.

8.3.3 Rated differential capacitance voltage range

The preferred limits for the differential capacitance voltage range are 100 volts for the lower limit and 4 percent of rated maximum voltage for the upper limit.

8.4 Preferred rated dielectric withstand

8.4.1 Preferred rated power frequency withstand voltages

8.4.1.1 Rated live parts-to-ground dry withstand voltage

Live parts-to-ground withstand voltage shall be as given in table 1, column 3; table 8, column 3; and table 12, column 4.

8.4.1.2 Rated live parts-to-ground wet withstand voltage

Live parts-to-ground wet withstand voltage for outdoor interrupter switches shall be as given in table 1, column 4 and table 8, column 4.

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8.4.1.3 Rated live parts-to-ground dew withstand voltage

Indoor and enclosed interrupter switches shall withstand the test voltages specified in column 3 of table 12.

8.4.2 Preferred rated lightning impulse dry withstand voltage

8.4.2.1 Rated live parts-to-ground withstand voltage

These withstand voltages shall conform to table 1, column 2; table 8, column 2; or table 12, column 2.

8.4.3 Preferred rated switching impulse withstand voltage

Interrupter switches having lightning impulse withstand ratings of 1050 kV and above shall withstand switching impulse voltages as specified in table 2, columns 3 and 4.

8.4.4 Open gap withstand

The air gap of fully open interrupter switches shall withstand 110 percent of the voltages given in table 1, columns 2 and 3; table 8, columns 2 and 3; or table 12, columns 2 and 4. For switches rated 362 kV and higher, the open gap shall also withstand the switching impulse voltages specified in table 2, columns 3 and 4.

Interrupter switches having solid insulation material across the open gap shall withstand 100 percent of the voltages given in table 1, columns 2 and 3; table 8, columns 2 and 3; or table 12, columns 2 and 4.

Outdoor interrupter switches with solid insulation across the open gap shall also withstand the rated wet withstand voltage given in table 1, column 4 or table 8, column 4.

Indoor or enclosed interrupter switches with solid insulation across the open gap shall also withstand the rated dew withstand voltage given in table 12, column 3.

8.4.5 Corona and radio influence test voltage limits

Switches rated 121 kV and higher when tested under dark conditions at the voltage levels specified in table 1, column 5 shall be free of visible plumes or spikes. The limits of radio-influence voltage are given in column 6. Refer to ANSI/IEEE C37.34, clause 5 and NEMA 107 for testing procedures.

8.5 Preferred rated currents

8.5.1 Preferred rated continuous current

The continuous current ratings shall be as given in tables 3, 9, and 12.

8.5.2 Preferred rated withstand currents

The rated withstand currents shall be as given in tables 3, 9, and 12.

8.5.3 Preferred rated withstand current durations

The withstand current durations for the short-time (symmetrical) withstand current test and for the peak withstand current test shall be as given in tables 3, 9 and 12.

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8.5.4 Preferred rated fault-making current

The rated fault-making currents shall be as given in 7.2.

8.5.5 Preferred rated switching currents

Rated switching currents for interrupter switches shall be as specified in table 15.

8.6 Preferred rated switching endurance

Rated switching operation endurances for interrupter switches are dependent on the application and the many different interrupter switch designs. Ratings are established by agreement between user and manufacturer.

8.7 Preferred rated ice breaking ability

The preferred ice-breaking ratings shall be as given in 3.2.2. Indoor and enclosed switches have no ice-breaking requirements.

8.8 Preferred rated control voltage

Rated control voltages and their ranges shall be as given in table 16.

8.9 Preferred rated mechanical operations

Rated mechanical operations of outdoor, indoor, and enclosed interrupter switches shall conform to 3.2.3.

8.10 Preferred rated terminal loading

The preferred rated terminal loadings for outdoor interrupter switches are specified in 3.2.4. Indoor and enclosed switches have no preferred rated terminal loadings.

8.11 Construction specifications

8.11.1 Phase spacing of interrupter switches

The phase spacing shall be in accordance with tables 5, 10, and 13. Interrupter switches having large lateral extensions of live parts beyond the insulators or unconfined switching arcs may require greater phase spacings and the manufacturer should be consulted.

8.11.2 Insulators

Insulators for interrupter switches shall be in accordance with the requirements specified in 3.4.1, 4.4.1, or 5.4.1.

9 Bus supports

9.1 Insulators

Insulators for bus supports shall be in compliance with the requirements specified in 3.4.1, 4.4.1, or 5.4.1.

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9.2 Fittings

The strength classification of fittings for outdoor bus supports, expressed in terms of the gradually applied load that the fitting shall withstand without failure or fracture of any parts, shall be as follows:

Class Designation	Load		Applicable bolt circle	
	pounds	kN	inches	mm
Standard strength	2000	8.90	3 or 5	76.2/127
High strength	4000	17.79	5	127

In all cases, the load shall be applied to the fitting in a plane parallel to its mounting surface, perpendicular to the length of the conductor at its centerline.

9.3 Phase spacing

The phase spacing of bus supports shall be in accordance with columns 3 and 6 of table 5 and table 10 and columns 2 and 3 of table 13.

10 Switch accessories—operating mechanisms and switch hooks

10.1 Rated control voltages for power-operated mechanisms

10.1.1 Control voltages and their ranges

10.1.2 Control voltages

The rated control voltages and their ranges for power-operated mechanisms used on high-voltage air switches shall be as shown in table 16. Operating, auxiliary and tripping functions shall perform satisfactorily when control voltages are within the ranges given in the table.

10.1.3 Voltage range measurement conditions

Voltage measurements shall be made at the control power input terminals of the mechanism. Maximum voltages are measured at no-load* and minimum voltages with operating currents flowing.

* Maximum voltage at no-load recognizes battery charging and equalizing techniques. Control circuits must dielectrically withstand the high voltage which also occurs if maximum voltage is maintained with operating current flowing. It is not necessary to maintain the high voltage level as long as the voltage remains within the specified range. This obviates the need for a higher than maximum voltage to maintain the stated maximum voltage with operating current flowing. However, the minimum voltage must be maintained with operating current flowing to verify proper operation.

10.1.4 Torque requirements

Power-operated mechanisms shall develop the manufacturer's rated torque when operating at the preferred rated voltages given in table 16.

10.1.5 Power-operated mechanism characteristics

Motor-operating mechanisms for outdoor switches shall have a torque at the output shaft under minimum operating voltage adequate to operate the switch under rated ice conditions, eg., 3/8 inch (10 mm) or 3/4 inch (20 mm) as specified in 10.5.2 of IEEE C37.34. Operating time and torque value required should be in accordance with the manufacturer's recommendation.

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10.2 Hook stick lengths and hook dimensions

The lengths of hook sticks in feet (meters) shall be one of the following: 4 (1.2), 6 (1.8), 8 (2.4), 10 (3.0), 12 (3.7), 16 (4.9), 20 (6.1), or 24 (7.3). See figure 2 for hook dimensions.

Table 1–Preferred voltage ratings for station class outdoor air switches

Line Number	Rated Maximum Voltage kV rms	Rated Withstand Voltage			Corona & Radio Influence Voltage	
		Lightning Impulse[1] kV Peak	Power Frequency kV rms		Test[2] Voltage kV rms	Limit of RIV[3] mV @ 1MHz
			Dry 1 minute	Wet 10 second		
	(1)	(2)	(3)	(4)	(5)	(6)
1	8.25	95	35	30	-	-
2	15.5	110	50	45	-	-
3	25.8	150	70	60	-	-
4	38.0	200	95	80	-	-
5	48.3	250	120	100	-	-
6	72.5	250	120	100	-	-
7		**350**[4]	175	145	-	-
8	121	350	175	145	77	500
9		450	235	190	77	500
10		**550**[4]	280	230	77	500
11	145	350	175	145	92	500
12		450	235	190	92	500
13		550	280	230	92	500
14		**650**[4]	335	275	92	500
15	169	450	235	190	107	500
16		550	280	230	107	500
17		650	335	275	107	500
18		**750**[4]	385	315	107	500
19	242[5]	550	280	230	154	500
20		650	335	275	154	500
21		750	385	315	154	500
22		**900**[4]	465	385	154	500
23		1050	545	455	154	500
24	362	1050	545	455	230	500
25		**1300**[4]	610	525	230	500
26	550	1550	710	620	349	500
27		**1800**[4]	810	710	349	500
28	800	2050	940	830	508	750

NOTES

1 For switches rated 362 kV and higher, see table 2 for values of rated switching impulse withstand voltages.

2 The test voltages are 110 percent of the rated maximum line-to-neutral voltage. It is not necessary to retest switches previously tested and acceptable at 105 percent.

3 If equipment of any given rated maximum voltage is used on a circuit of higher voltage rating, the radio influence voltage limit and test voltage for the equipment shall be that corresponding to the rated maximum voltage of the circuit.

4 Modern arrester technology enables use of lower lightning impulse rated equipment in some applications. The traditional values are shown in bold font.

5 The switches listed in lines 19 through 28 are intended for application on systems effectively grounded as defined in ANSI/IEEE 142.

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Table 2–Preferred switching impulse withstand voltage for station class outdoor air switches

Line Number (from table 1)	Rated maximum voltage kV rms	Rated Lightning Impulse kV Peak	Switching Impulse Withstand Voltage kV Peak	
			To ground[1]	Across open gap[2]
	(1)	(2)	(3)	(4)
24	362	1050	750	655 + (295)
25	362	1300	885	825 + (295)
26	550	1550	1050	880 + (450)
27	550	1800	1150	1000 + (450)
28	800	2050	1300	1000 + (650)

NOTES
1 Line-to-ground insulation strength is based upon 97.7 percent probability of withstand where the standard deviation is 6 percent. See ANSI C37.34, 4.4.7.
2 Values in parenthesis are 60 Hz bias voltages expressed in kVp units (column 1 voltage $\times \sqrt{2} / \sqrt{3}$). The summation of this opposite polarity bias voltage and the associated open gap switching impulse voltage is equal to a 97.7 percent probability of line-to-ground flashover (CFO + 2). See C37.34, 4.4.8.

Table 3–Preferred continuous and withstand currents for station class outdoor air switches

Line Number	Continuous Current Rating Amps (1)	Withstand Currents	
		Short-Time Withstand (symmetrical) kA (2)	Peak Withstand kA (3)
1	600	25	65
2	1200	38	99
3	1600	44	114
4	2000	44	114
5	2000	63	164
6	3000	63	164
7	3000	75	195
8	4000	75	195

NOTES
1 The ratio of the peak withstand current to short-time (symmetrical) withstand current is 2.6.
2 Rated duration of the short-time (symmetrical) withstand current is 3 seconds with allowable I^2t variations given in IEEE C37.34.
3 Rated duration of the peak withstand current test is 167 milliseconds.
4 Peak withstand current (kA) ≈ 1.625 times the rms asymmetrical momentary current (kA). Switches previously rated at 40, 61, 70, 100 and 120 kA rms asymmetrical momentary are closely equivalent to the above peak withstand current ratings and do not require retesting.

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Table 4–Terminal loadings for high-voltage switches

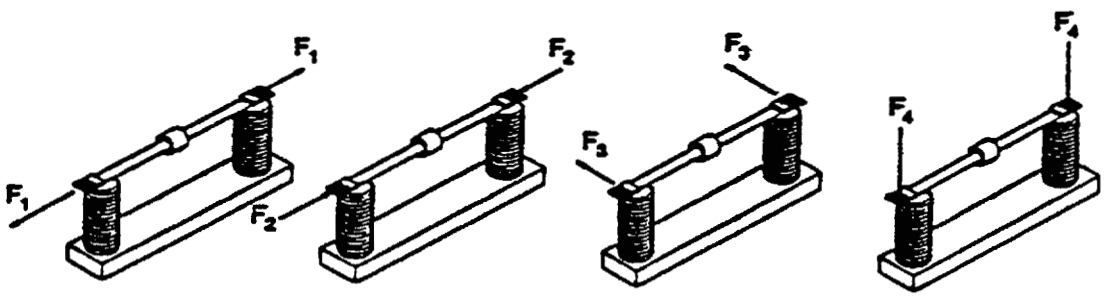
Line Number	Maximum Voltage	Current Rating	F_1 and F_2		F_3		F_4	
	kV	amps	lbs	N	lbs	N	lbs	N
	(1)	(2)	(3)		(4)		(5)	
1	4.8–72.5	200–1200	90	400	30	130	30	130
2		> 2000	90	400	30	130	30	130
3	121–169	600–1600	120	530	40	180	110	490
4		> 2000	120	530	40	180	250	1110
5	242–362	1200–1600	180	800	60	270	375	1670
6		> 2000	230	1020	75	330	685	3040
7	≥ 500	All	450	2000	150	670	750	3330

NOTES

1 Terminal loadings F_1, F_2, F_3, and F_4 incorporate considerations for weight of typical connected bus conductors having ice and wind loads, expansion loads, and limited moment forces. It is recommended that the manufacturer be consulted on forces that exceed those given in table 4. These higher forces may be due to long bus spans rigidly connected to switches, extra high short-circuit current forces, bus spans other than aluminum tube conductors, and other forces not considered.

2 These loadings were derived for the mechanical operations requirement of IEEE C37.34, clause 11 and do not necessarily represent the mechanical loading limit on terminals. Consult the manufacturer when actual values are needed.

3 At 242 kV and above, F_4 forces may be reduced by 40% for switches with hinged or pivoting type terminals.



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Table 5–Phase spacing and ground clearance for station class outdoor air switches and bus supports

Line Number	Rated Maximum Voltage kV rms (1)	Rated Lightning Withstand Voltage[1] kV Peak (2)	Min. Metal-to-Metal Distance Disconnecting Switches, Bus Supports and Rigid Conductors[2] (3)		Ground Clearance[3] Recommended (4)		Ground Clearance[3] Minimum (5)		Centerline-to-Centerline Phase Spacing[4] Vertical Break Disconnecting Switches and Bus Supports (6)		Side Break (Horizontal Break) Disconnecting Switches (7)		All Horn Gap Switches (Vertical and Side Break) (8)	
			Inches	mm	inches	mm	inches	mm	Inches	mm	Inches	mm	Inches	mm
1	8.25	95	7	178	7.5	191	6	152	18	457	30	762	36	914
2	15.5	110	12	305	10	254	7	178	24	610	30	762	36	914
3	25.8	150	15	381	12	305	10	254	30	762	36	914	48	1220
4	38.0	200	18	457	15	381	13	330	36	914	48	1220	60	1520
5	48.3	250	21	533	18	457	17	432	48	1220	60	1520	72	1830
6	72.5	250	21	533	18	457	17	432	48	1220	60	1520	72	1830
7		**350**	31	787	29	737	25	635	60	1520	72	1830	84	2130
8	121	350	31	787	29	737	25	635	60	1520	72	1830	84	2130
9		450	44	1118	39	991	34	846	72	1830	91	2310	103	2620
10		**550**	53	1350	47	1193	42	1067	84	2130	108	2740	120	3050
11	145	350	31	787	29	737	25	635	60	1520	72	1830	84	2130
12		450	44	1118	39	991	34	846	72	1830	91	2310	103	2620
13		550	53	1350	47	1193	42	1067	84	2130	108	2740	120	3050
14		**650**	63	1600	52.5	1333	50	1270	96	2440	132	3350	144	3660
15	169	450	44	1118	39	991	34	846	72	1830	91	2310	103	2620
16		550	53	1350	47	1193	42	1067	84	2130	108	2740	120	3050
17		650	63	1600	52.5	1333	50	1270	96	2440	132	3350	144	3660
18		**750**	72	1830	61.5	1562	58	1473	108	2740	156	3960	168	4270
19	242	550	53	1350	47	1193	42	1067	84	2130	108	2740	120	3050
20		650	63	1600	52.5	1333	50	1270	96	2440	132	3350	144	3660
21		750	72	1830	61.5	1562	58	1473	108	2740	156	3960	168	4270
22		**900**	89	2260	76	1930	71	1803	132	3350	192	4870	192	4870
23		1050	105	2670	90.5	2299	83	2108	156	3960	216	5500	216	5500
24	362	1050	105	2670	90.5	2299	84	2134	156	3960	216	5500	216	5500
25		**1300**	119	3020	106	2692	104	2642	174	4430	See Note 5	See Note 5	240	6100
26	550	1550	See Note 5		See Note 5		124	3150	See Note 5		See Note 5		300	7620
27		**1800**	See Note 5		See Note 5		144	3658	See Note 5		See Note 5		324	8230
28	800	2050	See Note 5		See Note 5		166	4216	See Note 5		See Note 5		600	15240

NOTES

1 Close lightning arrester coordination may allow lower lightning impulse values. Traditional values shown in bold font.

2 Minimum metal-to-metal distance may be modified providing proof of performance is substantiated by dielectric tests.

3 Ground clearance for switches with voltages 362 kV and above are based on switching surge voltage levels. Refer to bibliography, Annex C.

4 The phase spacings in columns 6, 7, and 8 are recommended values. Overall width of switch and bus support energized parts, angle of opening of side break switches, etc., may allow a reduction in phase spacing dependent upon voltage concentration on sharp projections. Resultant metal-to-metal distances between phase energized parts should not be less than that shown in column 3.

5 Values not yet established.

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Table 6–Station class outdoor air switch—pole unit dimensions

Line Number	Rated Maximum Voltage kV rms (1)	Rated Lighting Impulse withstand voltage kV Peak (2)	Length of break minimum metal-to-metal[1] (3) Single break distance inches	(mm)	(4) Double break distance inches	(mm)	Insulator centerline-to-centerline spacing inches minimum[1] (mm) (5) Single break Insulator strength Standard	(mm)	(6) Single break Insulator strength High	(mm)	(7) Double break Insulator strength Standard	(mm)	(8) Double break Insulator strength High	(mm)
1	8.25	95	7	(178)	--		12	(305)	15	(381)	--		--	
2	15.5	110	10	(254)	--		15	(381)	18	(457)	--		--	
3	25.8	150	12	(305)	--		18	(457)	21	(533)	--		--	
4	38.0	200	18	(457)	12	(305)	24	(610)	27	(686)	18	(457)	21	(533)
5	48.3	250	22	(559)	15	(381)	30	(762)	33	(838)	23	(585)	24	(610)
6	72.5	250	22	(559)	15	(381)	30	(762)	33	(838)	23	(585)	24	(616)
7		350	32	(813)	22	(559)	42	(1067)	45	(1140)	30	(762)	34	(864)
8	121	350	32	(813)	22	(559)	42	(1067)	45	(1140)	30	(762)	34	(864)
9		450	See Note 2		See Note 2		51	(1295)	54	(1370)	35	(889)	--	
10		550	50	(1270)	32	(813)	60	(1520)	--		42	(1067)	--	
11	145	350	32	(813)	22	(559)	42	(1067)	45	(1140)	30	(762)	34	(864)
12		450	See Note 2		See Note 2		51	(1295)	54	(1370)	35	(889)	--	
13		550	50	(1270)	32	(813)	60	(1520)	--		42	(1067)	--	
14		650	60	(1520)	38	(965)	72	(1830)	--		48	(1220)	--	
15	169	450	See Note 2		See Note 2		51	(1295)	54	(1470)	35	(889)	--	
16		550	50	(1270)	32	(813)	60	(1520)	--		42	(1070)	--	
17		650	60	(1520)	38	(965)	72	(1830)	--		48	(1220)	--	
18		750	68	(1730)	44	(1120)	84	(2030)	--		54	(1370)	--	
19	242	550	50	(1270)	32	(813)	60	(1520)	--		42	(1067)	--	
20		650	60	(1520)	38	(965)	72	(1830)	--		48	(1220)	--	
21		750	68	(1730)	44	(1120)	84	(2130)	--		54	(1370)	--	
22		900	84	(2130)	50	(1270)	96	(2440)	--		68	(1730)	--	
23		1050	104	(2640)	57	(1450)	116	(2950)	--		75	(1900)	--	
24	362	1050	104	(2640)	57	(1450)	116	(2950)	--		75	(1900)	--	
25		1300	120	(3050)	66	(1680)	132	(3350)	--		84	(2130)	--	
26	550	1550	See Note 2		--		See Note 2		--		--		--	
27		1800			--				--		--		--	
28	800	2050	--		--		--		--		--		--	

NOTES

1 The design of some switches may be such that minimum metal-to-metal distances and centerline-to-centerline spacing conflicts. Where this occurs, minimum metal-to-metal distance should be used. Minimum metal-to-metal distances may be modified provided proof of performance is substantiated by dielectric tests.

2 Values have not yet been established.

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Table 7–Station class outdoor air switches preferred mounting hole spacing for 600, 1200, and 1600 ampere switches

Line number	Rated maximum Voltage kV rms	Hook stick A		Hook stick B		Single side break A		Single side break B		Vertical break A		Vertical break B	
		inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
	(1)	(2)		(3)		(4)		(5)		(6)		(7)	
1	8.25	18	(457)	2 or 7	(50.8 or 178)	24	(610)	3 or 7	(76.2 or 178)	36	(914)	3 or 7	(76.2 or 178)
2	15.5	21	(533)	2 or 7		24	(610)	3 or 7		36	(914)	3 or 7	
3	25.8	24	(610)	2 or 7		27	(686)	3 or 7		39	(991)	3 or 7	
4	38.0	30	(762)	2 or 7		33	(838)	3 or 8-1/4	(76.2 or 210)	48	(1220)	3 or 8-1/4	(76.2 or 210)
5	48.3	39	(991)	3 or 8-1/4	(76.2 or 210)	39	(991)	3 or 8-1/4		54	(1370)	3 or 8-1/4	
6	72.5	51	(1290)	3 or 8-1/4		51	(1290)	3 or 8-1/4		69	(1750)	3 or 8-1/4	
7	121.0	66	(1680)	3 or 8-1/4		72	(1830)	8-1/4	(210)	87	(2210)	8-1/4	(210)
8	145.0	78	(1980)	3 or 8-1/4		84	(2130)	8-1/4		99	(2510)	8-1/4	
9	169.0	90	(2290)	8-1/4	(210)	96	(2440)	8-1/4		111	(2820)	8-1/4	

NOTES
1 "A" Is the dimension along the length of the base and "B" is the dimension along the width of the base in inches.
2 Dimensions for switches above 169 kV have not yet been established.

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Table 8–Preferred voltage ratings for distribution class outdoor air switches

Line Number	Rated Maximum Voltage kV rms	Rated Withstand Voltage		
		Lightning Impulse kV Peak	Power Frequency kV rms	
			dry	wet
	(1)	(2)	(3)	(4)
1	8.25	75	28	24
2	15.0	95	38	30
3	27.0	125	50	45
4	38.0	150	70	60

Table 9–Preferred continuous and withstand currents for distribution class outdoor air switches

Line Number	Continuous Current Rating amps	Withstand Currents	
		Short-Time (symmetrical) kA	Peak kA
	(1)	(2)	(3)
1	200 or 600	12.5	32.5
2	600 or 1200	25	65
3	1200	38	99

NOTES
1 The ratio of the peak withstand current to short-time (symmetrical) withstand current is 2.6.
2 Rated duration of the short-time (symmetrical) withstand current is 1, 2 or 3 seconds.
3 Rated duration of the peak withstand current test is 167 milliseconds.

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Table 10–Phase spacing and ground clearance for distribution class outdoor air switches and bus supports

Line Number	Rated maximum voltage kV rms	Rated lightning impulse withstand voltage kV Peak	Minimum metal-to-metal distance, all disconnecting switches, bus supports, and rigid conductors		Ground clearance				Centerline-to-centerline phase spacing					
					recommended		minimum		Vertical break disconnecting switches and bus supports		Side break (horizontal break) disconnecting switches		All horn gap switches (vertical and side break)	
			inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
	(1)	(2)	(3)		(4)		(5)		(6)		(7)		(8)	
1	8.25	75	5	(127)	4.5	(114)	4.0	(102)	12	(305)	18	(457)	24	(610)
2	15.0	95	7	(178)	6.0	(152)	5.0	(127)	18	(457)	22	(559)	28	(711)
3	27.0	125	9	(229)	7.5	(191)	6.5	(165)	24	(610)	26	(660)	38	(965)
4	38.0	150	12	(305)	10.0	(254)	9.0	(229)	30	(762)	32	(813)	44	(1,118)

NOTE—The phase spacings in columns 6, 7 and 8 are recommended values. It is recognized that at certain points of application these values may be reduced. Overall width of switch and bus support energized parts, angle of opening of side-break switches, and the like, may allow a reduction in phase spacing, depending on voltage stress concentration on sharp projections. Minimum metal-to-metal distances may be modified provided proof of performance is substantiated by dielectric tests.

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Table 11–Distribution class outdoor air switches—pole unit dimensions

Line Number	Rated maximum voltage kV rms	Rated lightning impulse withstand voltage kV Peak	Length of break minimum metal-to-metal				Insulator centerline-to-centerline spacing minimum			
			Single break distance		Double break distance		Single break distance		Double break distance	
			inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
	(1)	(2)	(3)		(4)		(5)		(6)	
1	8.25	75	5	(127)	-		9	(229)	-	
2	15.0	95	7	(178)	-		11	(279)	-	
3	27.0	125	9	(229)	-		13	(330)	-	
4	38.0	150	12	(305)	8	(203)	16	(406)	12	(305)

NOTE— The design of some switches may be such that the minimum metal-to-metal distances and the centerline-to-centerline spacing conflict. Where this occurs, the minimum metal-to-metal distance should be used. Minimum metal-to-metal distances may be modified provided proof of performance is substantiated by dielectric test.

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Table 12–Preferred ratings for indoor air switches

Line Number	Rated maximum voltage kV rms	Rated withstand voltage			Continuous current rating (amperes, rms)								
		Lightning Impulse kV Peak	Power Frequency kV rms		200	400	600	1200	2000	3000	4000	5000	6000
			Dew 10 seconds	Dry 1 minute	Short-time (symmetrical) current ratings, thousands of amperes rms[1]								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	4.8	60	15	19	12.5	12.5	25	38	50	63	-	-	-
2	8.25	75	24	26	12.5	12.5	25	38	50	63	75	100	125
3	15.0	95	26	36	12.5	12.5	25	38	50	63	75	100	125
4	15.5	110	30	50	12.5	12.5	25	38	50	63	75	100	125
5	25.8	125	40	60	-	12.5	25	38	50	63	75	100	-
6	38.0	150	-	80	-	12.5	25	38	50	63	75	-	-

NOTES
1 Withstand current ratings include a peak withstand current rating as well as a short-time (symmetrical) withstand current rating as shown.
2 The ratio of the peak withstand current to short-time (symmetrical) withstand current is 2.6.
3 Rated duration of the short-time (symmetrical) withstand current is 3 seconds with allowable I^2t variations given in IEEE C37.34.
4 Rated duration of the peak withstand current test is 167 milliseconds.

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Table 13–Indoor air switches and bus supports—Phase spacing and length of break

Line Number	Rated Maximum Voltage kV rms	Phase Spacing Minimum Metal-to-Metal Clearance Disconnecting Air Switches and Bus Supports[1]		Length of break minimum metal-to-metal single-break distances[2]	
		Inches	(mm)	inches	(mm)
	(1)	(2)		(3)	
1	4.8	4.5	(114)	4.5	(114)
2	8.25	6.0	(152)	6.0	(152)
3	15.0	7.5	(190)	7.5	(190)
4	15.5	9.0	(229)	9.0	(229)
5	25.8	13.0	(330)	13.0	(330)
6	38.0	18.0	(457)	18.0	(457)

NOTES

1 Barriers may be used to provide additional safety during operation by preventing accidental contact with live parts. The provision of adequate insulating barriers may allow a modification of these clearances. These minimum clearances may be modified provided proof of performance is substantiated by dielectric test (with due consideration to the effects of electromagnetic forces) in accordance with the values shown in columns 2 and 4 of table 12. When indoor switches are mounted in equipment covered by other standards, minimum clearances may be modified by such standards.

2 Minimum metal-to-metal distances may be modified from the values listed above provided proof of performance is substantiated by the dielectric tests in accordance with Clause 4 of C37.34.

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Table 14–Grounding switch electrical clearance

Line Number	Rated maximum voltage kV rms	Rated lightning impulse withstand voltage kV Peak	Minimum gap – grounding switch to live parts	
			inches	mm
	(1)	(2)	(3)	
INDOOR				
1	4.8	60	2.0	50.8
2	8.25	75	2.0	50.8
3	15.0	95	2.0	50.8
4	15.5	110	2.0	50.8
5	25.8	125	3.0	76.2
6	38.0	150	4.0	102
DISTRIBUTION CLASS OUTDOOR				
7	8.25	75	2.0	50.8
8	15.0	95	2.0	50.8
9	27.0	125	3.0	76.2
10	38.0	150	4.0	102
STATION CLASS OUTDOOR				
11	8.25	95	2.0	50.8
12	15.5	110	2.0	50.8
13	25.8	150	4.0	102
14	38.0	200	6.0	152
15	48.3	250	9.5	241
16	72.5	250	9.5	241
17		350	14.0	367
18	121	350	14	367
19		450	18	457
20		550	22	559
21	145	350	14	367
22		450	18	457
23		550	22	559
24		650	27	686
25	169	450	18	457
26		550	22	559
27		650	27	686
28		750	31	787
29	242	550	22	559
30		650	27	686
31		750	31	787
32		900	38	965
33		1050	44	1118
34	362	1050	47	1194
35		1300	50	1270
36	550	1550	75	1905
37		1800	85	2159
38	800	2050	112	2845

NOTE–These gap distances are not a requirement for grounding blades that operate in a plane perpendicular to the main switch base.

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Table 15–Preferred rated switching currents for interrupter switches[1]

Line Number	Rated maximum voltage kV rms	Load and loop current amps	Unloaded Transformer current amps	Line-charging current		Isolated Capacitor bank current amps[6]	Cable-charging current amps
				Quick-break amps[4]	Interrupter amps[5]		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	8.25	RCC 2)	See Note 3	10	10	400	10
2	15.0, 15.5	RCC 2)	See Note 3	10	10	400	15
3	25.8, 27.0	RCC 2)	See Note 3	10	10	400	20
4	38.0	RCC 2)	See Note 3	10	10	250	20
5	48.3	RCC 2)	10	10	10	250	50
6	72.5	RCC 2)	10	13	15	630	80
7	121.0	RCC 2)	10	10	35	315	90
8	145.0	RCC 2)	8	8	50	315	100
9	169.0	RCC 2)	8	7	75	400	100
10	242.0	RCC 2)	8	5	150	400	115
11	362.0	RCC 2)	5	–	350	–	–

NOTES

1 Interrupter switches may have one or more specifically assigned switching ratings. Refer to Annex A for typical system values.

2 RCC = rated continuous current from tables 3, 9 or 12 ie., 200, 400, 600, 1200, 1600, 2000, 3000, 4000, 5000 and 6000 amps.

3 These switches are capable of switching unloaded transformers rated 2500 kVA or less provided the switches have demonstrated their ability to switch their rated load current. For larger transformers or switches not having load switching ratings, consult manufacturer.

4 These devices are typically high-velocity whips or rigid arm devices, having unconfined arcs with air as the dielectric medium and are usually inserted in the circuit during the opening process.

5 These devices are interrupters with gas, vacuum, or oil as the interrupting medium.

6 Values given are for station class switches. Preferred ratings for distribution class switches have not been established. Consult manufacturer.

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Table 16–Preferred rated control voltages and their ranges[1, 2, 3]

Rated Voltage, Volts	Voltage Range, Volts	
	Operating and Auxiliary Function[4]	Tripping Function[5]
Direct Current[6, 7]		
12[8]	10–14	7–14
24[8]	20–28	14–28
48[8]	36–56	28–56
125	90–140	70–140
250	180–280	140–280
Single-Phase Alternating Current (60 Hz)[9]		
120	104–127	–
240	204–254	–
480	416–508	–
Poly-Phase Alternating Current (60 Hz)		
208Y/120	180Y/104–220Y/127	–
240	208–254	–
480	416–508	–
480Y/277	416Y/240–508Y/292	–

NOTES

1 Electrically operated motors, contactors, solenoids, valves, and the like, need not carry a nameplate voltage rating that corresponds numerically to the rated voltage shown in table 16 as long as these components perform the intended duty cycle (usually intermittent) in the voltage range specified.

2 Relays, motors, or other auxiliary equipment that function as 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.

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

4 Operating functions include (a) the opening and closing power mechanisms, and (b) the means (coils, contactors, seal-in relays, and the like) to actuate the power mechanisms. Auxiliary functions include all functions except operating and tripping.

5 Tripping is the release of the holding means that permits stored energy to open a device such as an interrupter switch or close a device such as a fault initiating switch.

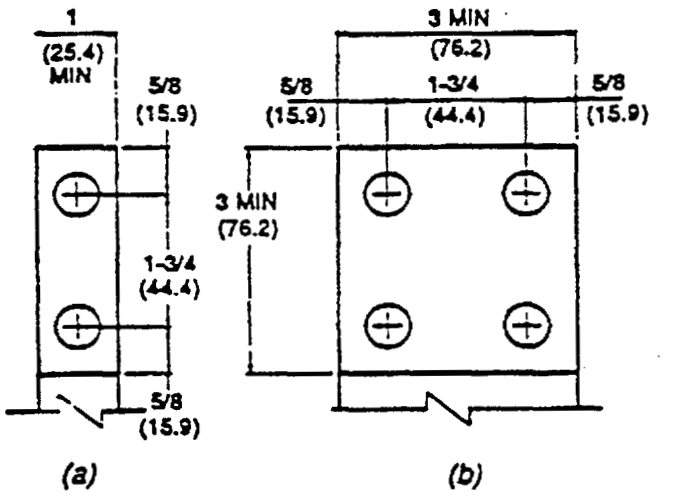
6 It is recommended that the coils of operating, auxiliary, and tripping devices that are connected permanently to one direct-current potential should be connected to the negative control bus to minimize electrolytic deterioration.

7 Power-operated mechanisms utilizing 12 and 24 V self-contained direct-current control sources shall operate over the range of 85 percent to 115 percent of the rated voltage.

8 12, 24, or 48-volt tripping, operating, and auxiliary functions may present special consideration to factors particularly affecting low voltage systems. Self contained or close location of the power source is recommended.

9 Includes heater circuits.

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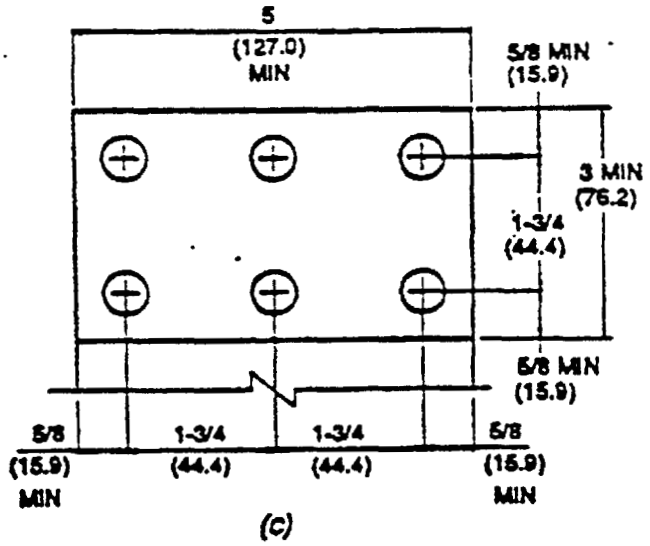


Figure 1–Arrangement of bolt hole centerlines in terminal pads

NOTES
1 Two or more interleaved 4-hole pad configurations can be used as shown in figure 1(b).
2 All dimensions are in inches and millimeters.

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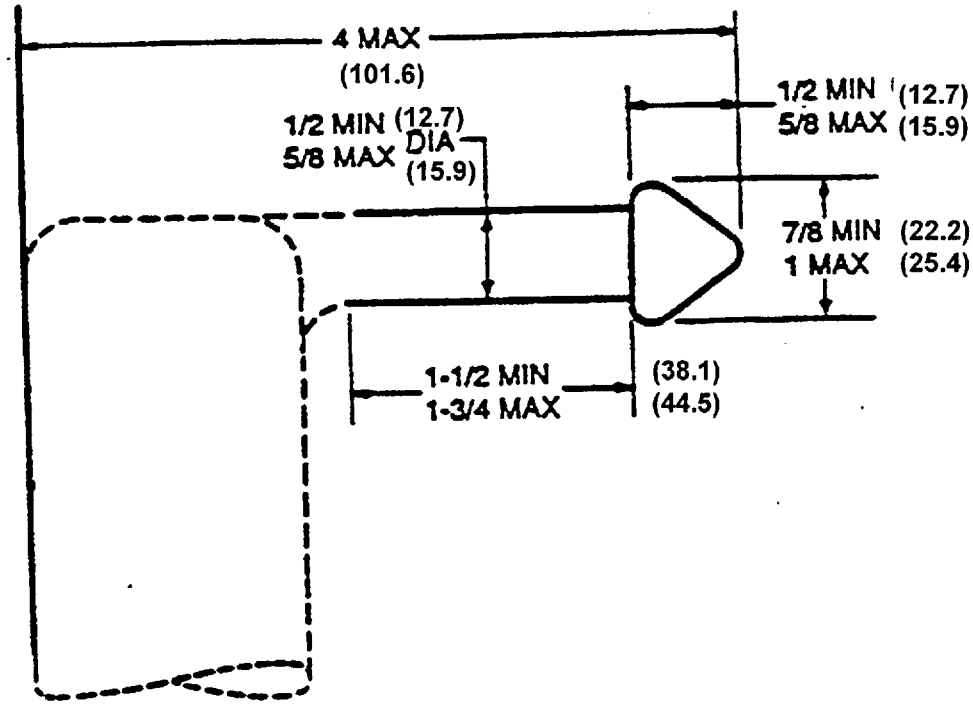


Figure 2–Outdoor air switch hook dimensions

NOTES

1 All dimensions are in inches (mm values are approximate).
2 Dimensions that are not shown are optional.

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Annex A
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Reference data

A.1 Peak withstand current replaces momentary current and short-time (symmetrical) withstand current replaces 3 second current.

A.2 Typical system values for cable and line charging currents

Rated Maximum Voltage kV rms	Overhead Line Current A/mile	Typical Line Length miles	Line Charging Current Amps	Cable Charging Current A/mile
8.25	0.03	10	0.3	1.5
15.0, 15.5	0.06	10	0.6	2.8
25.8, 27.0	0.10	20	2.0	3.2
38.0	0.14	30	4.2	3.5
48.3	0.17	30	5.1	9.8
72.5	0.28	50	14.0	15.7
121.0	0.44	80	35.2	18.2
145.0	0.52	100	52.0	19.4
169.0	0.61	120	73.2	20.0
242.0	0.87	170	147.9	22.3
362.0	1.31	250	327.5	-

A.3 Short-time (symmetrical) withstand current and electromagnetic force equations

A.3.1 Calculation of short-time (symmetrical) withstand current limits

The following formulas may be used as guides for calculating short-time (symmetrical) withstand current capability of uniform conductors based on thermal capacities assuming no heat loss during the time of current flow.

The formula for aluminum is written for conductivities between 40 to 65 percent of the International Annealed Copper Standard (IACS). The formula for copper is written for conductivities of 95 to 100 percent IACS.

$$I_{al} = 0.144 \times 10^6 \times A \sqrt{\frac{1}{t} \log_{10} \frac{\theta_2 - 20 + (15150 / G)}{\theta_1 - 20 + (15150 / G)}}$$

$$I_{cu} = 0.22 \times 10^6 \times A \sqrt{\frac{1}{t} \log_{10} \frac{\theta_2 - 20 + (25400 / G)}{\theta_1 - 20 + (25400 / G)}}$$

Where:

I_{al}= maximum rms amperes for aluminum conductor
I_{cu} = maximum rms amperes for copper conductor
A = cross-sectional area in square inches
t = the duration of constant current flow in seconds
θ_2 = the temperature limit (degrees Celsius)
θ_1 = is the starting temperature (degrees Celsius)
G = the conductivity in percent IACS

NOTES

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1 The temperature limit (θ_2) of materials may be determined by mechanical requirements since annealing of heat-treated or hard drawn material occurs in relatively shorter time as temperature is increased.

For current carrying parts when t=3 seconds and I_{al} or I_{cu} = symmetrical rms amperes associated with the short-time (symmetrical) withstand current ratings from table 3, 9 or 12, typical temperature values to minimize annealing are:

θ_2 = 250°C for heat-treated aluminum alloy
θ_2 = 300°C for hard-drawn copper

2 θ_1 should be no more than θ_{max} of ANSI/IEEE C37.30, table 3.

3 Other materials available for current-carrying parts may have other values for θ_1 and θ_2. Such materials are acceptable provided it can be demonstrated that the switch meets the requirements of 3.5 of ANSI/IEEE C37.30 and 8.6 of IEEE C37.34.

A.3.2 Calculation of electromagnetic forces

The electromagnetic force exerted between two current-carrying conductors is a function of the current, its decrement rate, the shape and arrangement of conductors, and the natural frequencies of the complete assemblies, including mounting structure, insulators, and conductors.

Obviously, it is not feasible to cover every case with one simple equation, even if some approximations are made, because of the large number of variables involved including the wide range of constants for support structures.

The force calculated by the following equation is that produced by the maximum peak current. In most cases, the calculated force is higher than that which actually occurs due to inertia and flexibility of the systems, and this fact tends to compensate for the neglect of resonant forces. The equation, therefore, is sufficiently accurate for usual practical considerations.

$$F = M\left(\frac{5.4 \times I^2}{S \times 10^7}\right)$$

F = force in pounds per foot on conductor
M = multiplying factor shown in following table
I = short-circuit current in amperes expressed in terms shown in table
S = spacing between center-lines of conductors in inches

Multiplying factor (M) for calculation for electromagnetic forces

Circuit	Amperes (I) expressed as	Multiplying factor (M)
dc	maximum peak	1.0
ac, 3-phase	maximum peak	0.866
ac, 3-phase	rms asymmetrical	$(0.866 \times 1.63^2) = 2.3$
ac, 3-phsae	rms symmetrical	$(0.866 \times 2.82^2) = 6.9$
1 phase of 3-phase or 1-phase	maximum peak	1.0
1 phase of 3-phase or 1-phase	rms asymmetrical	$(1.63^2) = 2.66$
1 phase of 3-phase or 1-phase	rms symmetrical	$(2.82^2) = 8.0$

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Annex B
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Historical Data

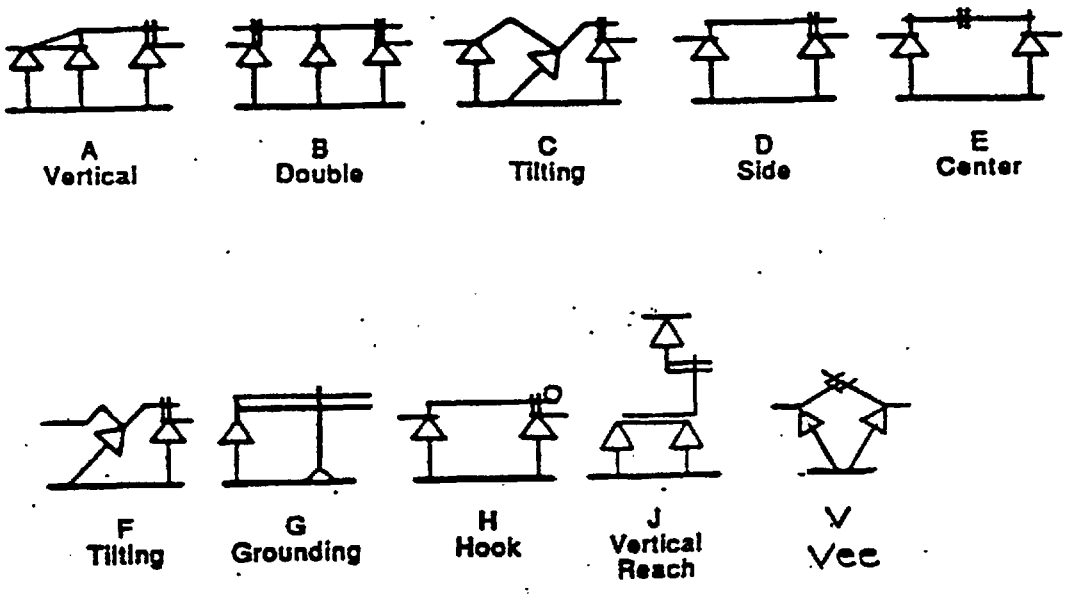


Figure B-1–Typical construction classification of station class outdoor air disconnect switches

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Annex C
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