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(Revision of
IEEE Std C37.35-1976)

IEEE Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Interrupter Switches

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Abstract: Guidance for users in the application, installation, operation, and maintenance of high-voltage air switches and interrupter switches is provided.
Keywords: high-voltage air switches, disconnecting switches, outdoor switches, interrupter switches

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Introduction

(This introduction is not a part of IEEE Std C37.35–1995, IEEE Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Interrupting Switches.)

This publication is revised to recognize various construction and maintenance techniques. This document has also been updated in accordance with certain local codes. It is one of a series of seven standards on high-voltage air switches as follows:

ANSI C37.32-1990, American National Standard Schedule of Preferred Ratings, Manufacturing Specifications, and Application Guide for High-Voltage Air Switches, Bus Supports, and Switch Accessories.

IEEE Std C37.30-1992, IEEE Standard Definitions and Requirements for High-Voltage Air Switches (ANSI).

IEEE Std C37.34-1994, IEEE Standard Test Code for High-Voltage Air Switches (ANSI).

IEEE Std C37.36b-1990, IEEE Guide to Current Interruption with Horn-Gap Air Switches (ANSI).

IEEE Std C37.37-1979, (Reaff 1993), IEEE Standard Loading Guide for AC High-Voltage Air Switches (in excess of 1000 volts) (ANSI).

IEEE PC37.39 (P1247) (draft 11/5-95), Interrupter Switches for Alternating Current, Rated above 1000 Volts.[a]

[a]This IEEE standards project was authorized but not approved by the IEEE Standards Board at the time this publication went to press. For information about obtaining a draft, contact the IEEE.

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Contents

IEEE Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Interrupter Switches

1. Overview

1.1 Scope

This guide presents suggestions on application, installation, operation, and maintenance as an aid to obtaining satisfactory performance of indoor and outdoor high-voltage air disconnecting and interrupter switches rated in excess of 1000 Vac.

It is offered in recognition of the continuing need for general guidelines to supplement, but not replace, the manufacturer's or user's detailed instructions on installation, operation, and maintenance of disconnecting and interrupter switches.

1.2 General terminology

In this guide, the term *switches* shall mean indoor and outdoor high-voltage air disconnecting switches, unless qualified by other descriptive terms. The term *interrupter switches* shall mean indoor and outdoor high-voltage interrupter switches, unless qualified by other descriptive terms.

2. References

This guide shall be used in conjunction with the following standards. When the following standards are superseded by an approved revision, the revision shall apply.

Accredited Standards Committee C2-1993, National Electrical Safety Code (NESC).[1]

ANSI C37.32–1990, Schedules of Preferred Ratings, Manufacturing Specifications, and Application Guide for High-Voltage Air Switches, Bus Supports, and Switch Accessories.[2]

IEEE Std C37.100–1992, Definitions for Power Switchgear (ANSI).[3]

IEEE Std C37.30–1992, Requirements for High-Voltage Air Switches (ANSI).

IEEE Std C37.36b–1990, IEEE Guide to Current Interruption with Horn–Gap Air Switches (ANSI).

OSHA Rule 1910.269–1994, Electric Power Generation, Transmission, and Distribution: Electrical Protective Equipment.[4]

3. Definitions

The definitions of the terms used in this document are found in IEEE Std C37.100-1992.

4. Application

4.1 Usual service conditions

Usual service conditions for switches are defined in 2.1 of IEEE Std C37.30-1992. These conditions specify limits in altitude and in ambient air temperature.

4.2 Unusual service conditions

Unusual service conditions are listed in 2.2 of IEEE Std C37.30-1992. Table 1 of IEEE Std C37.30-1992 lists altitude correction factors for rated withstand voltages, rated continuous currents, and ambient air temperatures for altitudes above 3300 ft (1000 m).

4.3 Other conditions

Other conditions affecting the application of switches are listed in IEEE Std C37.30-1992. For these and other conditions, the switch manufacturer should be consulted.

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[1]The NESC is available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[2]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[3]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[4]OSHA publications are available from the OSHA Publications Office, U.S. Department of Labor, 200 Constitution Avenue, N.W., Room N3I01, Washington DC 20210.

4.4 Selection of insulation level

The selection of the insulation level for air switches on systems of various nominal voltages is a function of the degree of surge protection, the insulation level of associated equipment such as circuit breakers and transformers, and the degree of airborne contamination anticipated. Since insulators may have different levels of creepage distance for a given lightning impulse withstand voltage, the creepage distance should be selected separately to provide adequate service under expected atmospheric contamination conditions. In the bibliography in annex A, [B3][5] provides guidelines for selecting creepage distance.

Switches should be selected on the basis of both rated maximum voltage and lightning impulse withstand voltage. The preferred rated maximum voltages (given in kilovolts, rms) for switches and bus supports, and their corresponding power frequency withstand ratings and lightning impulse withstand ratings, are given in tables 1 and 6 of ANSI C37.32-1990.

ANSI C37.32-1990 requires that the open-gap withstand be at least 110% of rated withstand to ground, and that the phase-to-ground withstand be at least 100% of the rated withstand to ground. There is no upper limit placed on withstand voltages, which means it is possible that the phase-to-ground withstand could be higher than the open-gap withstand.

If a switch is overinsulated, that is, if the withstand capability of the switch insulation to ground is higher than the withstand capability of the switch open gap, rod gaps or surge protective devices may be installed at or adjacent to the switch to ensure that overvoltages that might otherwise flashover the switch gap are limited by conduction to ground. See 2.4.3 and 3.4.3 of ANSI C37.32-1990. For voltages 362 kV and above, switching surge levels may be the determining factor in the selection of insulation level.

5. Receipt and preparation

5.1 Handling

Trucking and handling of power switching equipment, after it is received at its destination, should be done with due regard based on the fact that porcelain is used in practically all switching equipment and that it is easily broken.

Switching equipment should be properly stored to protect it from damage. Indoor switches should be stored in a dry, clean location and should remain in the shipping container during the storage period.

5.2 Unpacking

When unpacking switching equipment, it should be remembered that many parts are fragile and can be broken by sudden jars and careless handling. Therefore, care should be exercised to prevent breakage or the distortion of parts of equipment, which could result in trouble, delay, or inconvenience in assembly. All parts should be inspected before assembly.

5.3 Assembly and rigging

Power switching equipment should be fully assembled and adjusted before it is placed in position insofar as possible in order to facilitate (minimize) final adjustments.

[5]The numbers in brackets correspond to those bibliographical items listed in annex A.

Rigging, which is used for erecting the equipment, should be adequate and proper for the equipment involved and should be attached to the bases unless otherwise instructed by the manufacturer. Lifting by insulator units, contacts or operating parts may cause damage. Attachment should be made to live or other parts only for stabilizing. Switches should be secured in the closed position before lifting.

6. Installation

6.1 Personnel safety during installation

Follow the National Electrical Safety Code (NESC) (ANSI C2-1993), as well as manufacturer instructions, user practices, and local and OSHA requirements (see OSHA Rule 1910.269–1994). Safety precautions should be carefully followed.

6.2 Instructions for assembly

For satisfactory service, equipment drawings and manufacturer's instructions for switch assembly should be carefully followed.

6.3 Alignment

Switches should be carefully aligned on the supporting structure. Most switches require that the surface on which the bases are mounted should be flat and true; otherwise, the bases may become twisted when bolted to the structure. Such twisting could cause the switch to be difficult to operate, cause operating parts to be out of alignment, and cause undue strain on the insulator stacks. See 5.9 for adjustment considerations.

6.4 Rigidity

All switch bases and associated stationary parts should be rigidly bolted in place.

6.5 Line conductors

Conductors bolted to the switch terminals should not subject the switching equipment to undue mechanical forces that could cause contact misalignment. Terminal pad mechanical load ratings are given in table 3 of ANSI C37.32-1990.

6.6 Bus conductors

Bus conductors are acted upon by mechanical forces due to dimensional changes with temperature and by electromagnetic forces. Bus conductors should be so supported and connected to the switches that these forces will not impair the electrical or mechanical function of the switches. Terminal pad mechanical load ratings are given in table 3 of ANSI C37.32-1990.

6.7 Equipment connections

Contact surfaces should be clean and smooth. Excess mechanical forces should be carried by auxiliary supports. Terminal pad mechanical load ratings are given in table 3 of ANSI C37.32–1990.

When dissimilar metals are combined in a current-carrying joint, adequate protection against galvanic and chemical action shall be provided. Bolted connections should be adequately torqued as recommended by the switch manufacturer.

6.8 Ground connections

The bases and operating handles of substation switches should be grounded in accordance with the NESC.

The bases and operating handles of some distribution switches are not grounded. These installations should follow well-established user practice. The user should be aware that the grounded base may have been used to establish a predetermined relationship between the phase-to-ground and open-gap withstand voltage values.

6.9 Adjustments

When the equipment is in place, adjustment should be made with normal weight or strain on the insulators and current-carrying parts.

6.10 Cleaning equipment

After the switching equipment has been installed, connected, and adjusted, the insulators, contacts, and moving parts should be cleaned in accordance with the manufacturer's instructions.

6.11 Inspection

After being installed, but before being placed in service, the equipment should be carefully inspected, checked, and adjusted in accordance with the applicable drawings. The following are suggested as important inspections and checks:

a) Examine all insulator units for cracked or defective parts.

b) Check all contacts for any damage that affects fit, proper pressure, and alignment. If recommended by the manufacturer, lubricate the contacts.

c) Check all bolted connections for tightness.

d) Examine all switch locks for security, function, and ease of operation.

e) Check operating mechanism for proper operation, travel, and recommended lubrication; also check for lost motion or binding, excessive deflection of controls or mounting, and check mechanical connections.

f) Check the adjustment of horns on horn-gap switches.

g) As a final inspection, check break distances, clearances between live parts and travel of all switches. Check phase-to-phase clearances and phase-to-ground clearances between live parts of switching equipment and adjacent structures.

6.12 Interrupter switches

In addition to applicable inspections in 6.11, follow the manufacturer's instructions for erection and adjustment of interrupter switches.

7. Operation

7.1 Air switches

High-voltage disconnecting switches, grounding switches, and horn-gap switches are given no interrupting rating. Low levels of current may be interrupted per the guidelines given in IEEE Std C37.36b-1990. Interrupter switches may have various types of interrupting ratings dependent upon application duty.

7.1.1 General

Appropriate safety rules should be followed, and the subsequent general rules apply:

a) Instructions and procedures for opening and closing an air switch, whether by direct hookstick or indirect operating handle, gear box, or power operator, should be given to every person who will operate the switch.
b) After operating a switch, each blade should be checked visually to verify that it is fully closed and latched or fully open, as intended.
c) Undue force should not be used to operate a switch. The operating mechanism is designed properly for the switch, and any undue force in the nature of an extension of the operating handle, or an extra person on the operating handle of the switch, may cause severe damage to the switch or operating mechanism. A few sharp raps on the vertical operating pipe or sudden applied tugs on the operating handle may help to free an iced switch mechanism.
d) Power-operated switches should be operated to be sure that the switches and their mechanisms and control features are functioning properly. Where circuit conditions will not permit operating an energized switch and where the circuit cannot be de-energized for this purpose, the operating mechanism should be disengaged from the linkage. The control circuits and mechanism should be checked in this manner unless the overall adjustments are affected.

7.1.2 Disconnecting, grounding, and horn-gap switches

a) Prior to operating a disconnecting or horn-gap switch, a check should be made to confirm that no load is being carried by the switch, and that a switch flashover will not extend to the switch operator.
b) Prior to opening a grounding switch, a check should be made to determine that operation does not remove necessary safety grounds. Prior to closing, check the circuit to confirm that it is not energized.
c) Disconnecting switches should be operated rapidly to reduce arcing time and possible burning of contacts. The operator should be informed that opening or closing of a disconnect switch may cause arcing in normal switching.

It is common practice to use these devices for interrupting small currents such as the charging current of a short length of transmission or distribution line, transformer magnetizing currents, parallel and loop currents, and light load currents. Such operations result in unconfined arcs that, under unfavorable weather or circuit conditions, may cause a system fault. These duties impose varying degrees of severity upon the switch. If circuit interruption is contemplated, care should be taken to understand the circuit conditions to determine what degree of success may be expected. Particular regard should be given to the current magnitude and the transient recovery voltage that will appear across the switch immediately following current interruption.

Devices such as arcing horns, quick-break horns, and air or gas blast attachments, are available for extending the interrupting capability of a disconnecting switch. It should be recognized that some of these switching duties may require the use of an interrupter switch. IEEE Std C37.36b-1990, along with [B1], [B2], [B4], and the NESC, provide valuable information on this subject. For specific current interrupting applications, the switch manufacturer should be consulted.

7.2 Interrupter switches

Interrupter switches have specific ratings for switching one or more of the following circuit types: 0.8 minimum lagging power factor load; parallel or loop load and transformer magnetizing; line charging, cable charging, or capacitor bank current.

The manufacturer's instructions should be followed when operating interrupter switches. Interrupter switches with fault-closing ratings are intended to provide adequate performance when closing into a short-circuit up to the fault-closing rating of the switch when applied and operated in accordance with the manufacturer's recommendation. As with other switches, mounting considerations and spacings should apply to interrupter switches with fault-closing ratings.

8. Maintenance

8.1 Disconnecting switches

Due to operating criteria and mounting configurations, these switches are not readily serviced at frequent intervals. This does not, however, relieve the user of the responsibility for care and inspection. Frequency of inspection will be a function of atmospheric contamination, use of contamination control coatings, frequency of operation, fault current exposure, etc., and a suitable program should be established and followed by the user.

If a switch cannot be maintained on a periodic basis, its service life may be affected. Whenever the switch is operated it should be opened and closed several times if practicable in order to clean the contacts and free the moving parts. A visual inspection of a switch when wet, or the use of a temperature-scanning detector may indicate hot spots that are possible sources of trouble. Directional microphones or ultrasonic detectors can be used to locate local corona sources on switches, and these sources can then be eliminated during normal switch maintenance. Well established live-line servicing and maintenance procedures may be used in accordance with user practices and local and OSHA regulations (see OSHA Rule 1910.269–1994).

Otherwise, the following procedures are suggested for maintaining de-energized switches:

a) The switch should be disconnected from all electric power sources before servicing.
b) Ground leads or their equivalent should be attached to both sides of the switch. Local and applicable OSHA regulations, including all safety precautions of 5.1, should be followed.
c) Inspect the insulators for breaks, cracks, burns, or cement deterioration. Clean the insulators particularly where abnormal conditions such as salt deposits, cement dust, or acid fumes exist. This is important to minimize the possibility of flashover as a result of the accumulation of foreign substances on the insulator surfaces.
d) Check the switch for alignment, contact pressure, eroded contacts, corrosion, and mechanical malfunction. Replace damaged or badly eroded components. If contact pitting is of a minor nature, smooth the surface with clean, fine sandpaper (not emery) or as the manufacturer recommends. If recommended by the manufacturer, lubricate the contacts. Inspect arcing horns for signs of excessive arc damage and replace if necessary.
e) Check the blade lock or latch for adjustment.
f) Inspect all live parts for scarring, gouging, or sharp points that could contribute to excessive radio noise and corona. Check corona balls and rings for damage that could impair their effectiveness.
g) Inspect interphase linkages, operating rods, levers, bearings, etc., to assure that adjustments are correct, all joints are tight, and pipes are not bent. Clean and lubricate the switch parts only when recommended by the manufacturer. Check for simultaneous closing of all blades and for proper seating in the closed position. Check gear boxes for moisture that could cause damage due to corrosion or

ice formation. Inspect the flexible braids or slip-ring contacts used for grounding the operating handle. Replace braids showing signs of corrosion, wear, or having broken strands.

h) Power-operating mechanisms for switches are usually of the motor-driven, spring, hydraulic, or pneumatic type. The particular manufacturer's instructions for each mechanism should be followed. Check the limit switch adjustment and associated relay equipment for poor contacts, burned out coils, adequacy of supply voltage, and any other conditions that might prevent the proper functioning of the complete switch assembly.

i) Inspect overall switch and working condition of operating mechanism. Check that the bolts, nuts, washers, cotter pins, and terminal connectors are in place and in good condition. Replace items showing excessive wear or corrosion. Inspect all bus cable connections for signs of overheating or looseness.

j) Inspect and check all safety interlocks while testing for proper operation.

8.2 Interrupter switches

Interrupter switches should be periodically inspected to make certain that they are in condition to function properly. Many interrupter switches are so designed that material is ablated from the surfaces exposed to the electric arc. Particular attention should be given to such parts, and they should be maintained or replaced in accordance with the manufacturer's instructions.

In addition, since interrupter switches sometimes include all the features of disconnecting switches, the maintenance procedures for such interrupter switches should include the procedures outlined in 8.1.

Annex A

(informative)

Bibliography

The following are suggested for further study and better understanding of the material presented in this guide.

[B1] Andrews, F.E., Janes, L.R., and Anderson, M.A., "Interrupting Ability of Horn-gap Switches," *American Institute of Electrical Engineers Transactions,* vol. 69, part II, pp. 1016-1027, 1950.

[B2] "A Committee Report on Transformer Magnetizing Current and its Effect on Relaying and Air Break Switch Operation," *American Institute of Electrical Engineers Transactions,*" vol. 70, 1951, part II, pp. 1733-1740.

[B3] IEC 815 (1986), Guide for the Selection of Insulators in respect of Polluted Conditions.

[B4] "Results of Survey on Interrupting Ability of Air Break Switches," *IEEE Transactions on Power Apparatus and Systems,* vol. PAS-85, no. 9, pp. 1008-1019, Sept. 1966.

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